124

Ecological space and cognitive geometry:

Linking humans and environment in space syntax theory

Lars Marcus
Chalmers University of Technology
lars.marcus@chalmers.se

Abstract

There are two fundamental links necessary to establish for a robust theoretical foundation of space syntax methodology. The first concerns the relation between humans and the environment, where space syntax has contributed to the development of what may be called a cognitive geometry for the analysis of spatial form. The second is the relation between humans and humans in the environment, that is, the role of spatial form for social processes, where space syntax has demonstrated how spatial form is essential for the distribution of human co-presence in space and with sociological support argued the vital importance of such co-presence for social processes. Nevertheless, these issues are far from exhausted in space syntax theory or even always convincingly argued. It is therefore the aim of this paper to further contribute to the first of these issues and in a parallel paper to contribute also to the second.

While James Gibson's theory of affordances often is referred to in this regard, his larger framework of an ecological approach to visual perception is far less addressed in space syntax research. This paper conducts a close reading of Gibson's theory on perception in the aim to demonstrate its close links and high relevance to space syntax theory. Its more recent development by other writers, such as Harry Heft and Anthony Chemero, will also be referred to. More precisely, it will be argued that Gibson's theory forms a most apposite ontological framework for space syntax theory and methodology that supports its novel conceptualisation of the relation between humans and the environment and, not least, presents a firm theoretical foundation for its particular form of geometric representations, such as the axial map. Importantly, Gibson's ecological ontology distinctly contrasts with the typical conception of space, borrowed from physics, found in most spatial analysis and urban modelling.

Keywords

Space syntax theory, geometry, cognition, affordance, ecological space.

1. Introduction: the humans-environment relation

All forms of urban modelling are based on some idea or theory about the relation between humans and the environment, whether made explicit or not; the issue is how appropriate and well-founded it is. It is only natural then that this relation is a reoccurring theme in the early texts of space syntax where the significant argument is made that the humans-environment split is necessary to overcome if there is to be further theoretical advancement (Hillier & Leaman 1973; Hillier & Hanson 1984). Since then this relation has given rise to an extensive discussion in the space syntax literature, however following several strands that not are immediately congruent. On a methodological level we find aims to base this discussion in phenomenological geography (e.g. Seamon 2007), systems biology (Griffiths and Quick 2005) or neuroscience (Peponis et al. 2015); empirically there are attempts through real-life observation (Hillier & Iida 2005), virtual simulations (e.g. Turner and Penn 2002) and experiments with test persons (Haq & Zimring 2003). However, the most repeated reference is to psychologist James Gibson (e.g. Hanson 2000), and especially his *Theory of affordance* (1977). Yet, Gibson's broader theory concerning *An ecological approach to human perception* (1986), of which his affordance theory is part, has never been thoroughly discussed in relation to space syntax theory, despite the great affinity between the two theories on the matter of the humans-environment relation.

Gibson's theory is part of what is generally called *embodied cognition*, which actually is an umbrella term for many directions that have in common a far less distinct separation between, first, the mind and the body, where the body rather is seen as part of the perceiving organ and as such essential for human experience and consciousness. Second, a far less distinct separation between the human mind/body and the environment, where the environment, especially when it comes to human artefacts, actually can be conceived of as an extension of the mind/body (Ibid., p. 115). This is rather obvious when it comes to things such as tools but can also concern larger artefacts including the built environment (Ibid., p 116). This particular field has also bee extensively discussed in the space syntax literature; most interestingly for this article by Conroy Dalton (2005) and her introduction of the term *embodied diagrams*. Even so, the particular take on this by Gibson in his ecological approach remains rather unnoticed by the field, despite the frequent reference to his concept affordances. This is unfortunate since the latter clearly is dependent on the former and together they present, it is argued here, an unusually strong ontological conception of the humans-environment relation with great affinity to space syntax.

2. Ecological space: entering the world of meaningful things

Gibson's particular point of departure, which is captured quite well by the title of his most important book: An Ecological Approach to Visual Perception (1986), is quite unusual in comparison to mainstream psychology. The term 'ecological' here marks a distinct break with physicist conceptions of the environment: "Every animal […] is a perceiver *of* the environment and a behaver *in* the environment. But this is not to say that it perceives the world of physics or that it behaves in the space and time of physics" (Ibid., p. 8). Our tendency to speak about the environment as the physical world and, as a consequence, the risk of uncritically adopting a conception of the environment according to the discipline of physics, is here addressed at its fundament. In contrast to this conception he states the rather obvious fact that from the point of view of psychology: "we are concerned here with things at the ecological level, with the habitat of animals and men". While this standpoint on the surface of things is quite uncontroversial, its consequences for urban modelling – the fact that It implies a different conception of space as well as new forms for its representation – has generally not been recognised.

Gibson' theory "provides a counterbalance to those theories of cognitive mapping that have focused mainly or only on the internal cognitive processing of environmental information, to the exclusion of any interaction of the individual and the environment" (Ibid., p. 13). For instance, while we recently have seen a keen interest in the neuro science side of cognition, that is, studies of the brain to understand how we *conceive* the environment, which puts emphasis on the direct mind-environment relation, there is also the possibility to emphasise how we *perceive* the environment, which brings in the body and all the senses as a sort of active interface between mind and

environment. More precisely, it opens for an understanding of the body as an extension of the mind together constituting an integrated perceptual system, rather than a sequence where one follows upon the other (Ibid., p.). It also explains Gibson's unwillingness to make a distinction between perception and cognition: "To perceive the environment and to conceive it are different in degree but not in kind" (Ibid. p. 258). His argument here is: "Our reasons for supposing that seeing something is quite unlike knowing something come from the old doctrine that seeing something is having temporary sensations one after another at the passing moment of present time, whereas knowing is having permanent concepts stored in the memory" (ibid. p. 258). Gibson's alternate strategy here has been nicely summarised as: "Ask not what's inside your head, but what your head's inside of" (Mace 1977).

To achieve his goals, Gibson constructs a new ontology, which he argues to be based in an ecological conception of the world rather than a physical one. That does not mean that physical laws do not apply, but ecological facts: "are facts of a higher order that have never been made explicit by [physics] and have gone unrecognized. The science of the environment has its own facts" (Gibson 1986, p. 17-18). To give an example of what the difference here implies, we can compare the isotropic conception of space in physics, defined by an x, y and z-axis, with ecological space, conceptualised as what surrounds living organisms, where the latter immediately need to acknowledge the primacy of the ground, for instance, that is, the plane perpendicular to the forces of gravitation; for an experiencing human there simply is no spatial isotropism, the way physics try to convince us. In Gibson's words: "The world of physical reality does not consist of meaningful things. The world of ecological reality, as I have been trying to describe it, does" (Ibid. p. 33).

First of all Gibson instigates the mutuality of *animal*, which includes humans, and *the environment*, the fact that: "each term implies the other" (Ibid. p. 8). Again, this mutuality contrasts to the typical conception in physics where an animal rather is conceptualised as an object, however complex, in physical space: "This way of thinking neglects the fact that the animal-object is surrounded in a special way, that the environment is ambient for a living object in a different way from the way that a set of objects is ambient for a physical object" (Ibid. p. 8). This conception of mutuality between animal an environment gives rise to the basic elements of his ontology: *medium*, *substances* and the *surfaces* that separate them, where the typical 'media' are air and water, which allow animal locomotion, while the earth, and other hard materials that do not allow such locomotion, are 'substances', which also includes the bodies of animals. Interfaces between these, whether between different media or different substances or between a medium and a substance, all constitutes 'surfaces' (Ibid. p. 16). The latter plays a critical role for perception in that they give structure to the light that surrounds us and thus allows for vision. Gibson calls this *ambient light*, which maintains its particular property from the fact that it concerns light in an environment, which causes rays of light, even though we assume a primary source of light such as the sun, to continuously reflect so that we can think of them as coming from every direction, thus filling the medium. However, this also implies that an environment, constituted by a particular configuration of surfaces, typically will structure the ambient light in a certain way and give rise to what Gibson calls an *ambient optic array* that, in principle, is unique for every location (Ibid. p. 51). It is this structured array of light that enables light to carry information that can specify the environment for a perceiving animal, that is, that light from a point of observation simply will have different form in different directions.

3. Affordances: overcoming the subject-object dichotomy

Of specific importance to architecture and urban design is Gibson's discussion about how the structure and shape of the environment creates what he famously has called *affordances* (Ibid., pp. 127-143). This concerns how a given environment affords, that is, presents certain potentials for behaviour depending on the constitution of the bodies of different animals: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or for ill" (Ibid., p. 127). Gibson here makes a comparison to the notion of niches in ecology: "A species of animal is said to utilize or occupy a certain *niche* in the environment. This is not quite the same as the *habitat* of the species; a niche refers more to *how* an animal lives than to *where* it lives. I suggest that a niche is a set of affordances." He continues: "The niche implies a kind of animal and the animal implies a kind of niche" (Ibid., p. 128). Gibson's idea of affordances is incredibly fruitful for

the disciplines of architecture and urban design. While we primarily may think of affordances as given by the natural environment it is obvious that many species, not only humans, invest a lot of energy and resources into transforming the environment according to their purposes, that is, they transform the environment to increase its affordance in relation to the needs of their own species. As Gibson notes (Ibid., p. 37), this can also concern the creation of obstacles in the environment, a form of 'disaffordance', to protect from or exclude other species or members of the own species, why we here also can sense a potential political dimension to the concept. When it comes to the human species, such investments in affordances have taken on tremendous proportions transforming large parts of the Earth's surface.

What becomes apparent here is how Gibson's conception of the animal-environment relation consistently bridges the subject-object dichotomy. He persistently conceptualise the two together: the animal implies the environment and the environment implies the animal; the niche implies a kind of animal and the animal implies a kind of niche; the subject always implies the object and the object always implies the subject. This is far from conventional conceptions, whether found in the cognitive sciences or elsewhere, where the human subject typically perceive an objective world that it somehow is detached from. A case in point is his discussion about tools, which taken by themselves are typical detached objects. However: "When in use, a tool is a sort of extension of the hand, almost an attachment to it or a part of the user's own body, and thus is no longer a part of the environment of the user. […] This capacity to attach something to the body suggests that the boundary between the animal and the environment is not fixed […] More generally it suggests that the absolute duality of 'objective' and 'subjective' is false. […] When we consider the affordances of things, we escape this philosophical dichotomy" (Ibid., p. 41).

Gibson's shift towards a conception of the mind and the body as an integrated perceptual system also implies that movement is essential to any kind of perception; from the movement of the eye balls in the head, over to the movement of the head at the top of the neck, to the movement of the body through the environment by means of walking: "Vision is a whole perceptual system"; in short, even though: "one surely *looks* with the eyes […] one does not *see* with the eyes" (Ibid., p. 205). With the idea of the body as a perceptual system, Gibson makes a decisive break with conventional cognitive science, especially as developed in neuro science, where the body and the head in many experiments, at least traditionally, were forced to keep still in the aim to investigate the brains reaction to different controlled stimuli. The point here is that these experiments may be useful if we want to understand how the brain works, but they are not realistic if we want to understand how humans perceive their environment. In the latter case movement is essential, and in the end what distinguishes animals from other organisms is that they can move – it simply is their competitive advantage – why it not makes sense to study them as if they were plants.

Human movement, especially bodily locomotion, is what sets Gibson's ontology into action, so to speak. The medium affords human locomotion but is structured by substances. The substances, however, are not mere obstacles but offer permanence against which movement can be sensed and controlled. More specifically this happens through the changing configuration of surfaces that continuously come into and move out of the field of vision, hence structuring and restructuring the ambient light which thereby carries information about the environment to the perceiving human. From the information point of view the tension between change through human locomotion and permanence offered by the environment is critical: "The optic array changes, of course, as the point of observation moves. But it also does *not* change, not completely. Some features of the array do not persist and some do. The changes come from the locomotion, and the nonchanges come from the rigid layout of the environmental surfaces. Hence, the nonchanges specify the layout and count as information about it; the changes specify locomotion and count as another kind of information, about the locomotion itself" (Ibid., p. 73). We here see parts of Gibson's argument of why perception does not concern 'momentary sensations one after another', but rather implies a great degree of permanence: "One arrangement does not become a wholly different arrangement by a displacement of viewpoint. There is no jump from one to the other, only a variation of structure that serves to reveal the nonvariation of structure" (Ibid., p. 73). As a matter of fact, all individual perception is in this sense continuous, why each moment of perception, in principle, happens against the background of earlier moments of perception, why these are part of the present moment of perception. We simply cannot exclude memory from perception and, therefore, the distinct divide

between perception and cognition proves difficult to sustain. Rather we sense how this dualistic conception of perception is a result of the form of experiments that has dominated cognitive science; the discontinuous stimulation of sense organs kept fixed. Gibson concludes this discussion: "The environment seen-at-this-moment does not constitute the environment that is seen. Neither does the environment-as-seen-from-this-point constitute the environment that is seen. The seen-now and the seen-from-here specify the self, not the environment" (Ibid., p. 195).

If we acknowledge the fact that human's primarily perceive the environment under movement and that arrested vision rather is the limiting case, this proves to have quite radical implications. First, as we have seen, that the past somehow is present in the present, so to speak; what we just saw help us perceive what we see now, that is, that we cannot discount memory in perception. While this way of understanding perception, hence, dislocates the *moment* of observation, as it were, it similarly, second, also dislocates the *point* of observation: "Seeing the world at a travelling point of observation, over a long enough time for a sufficiently extended set of paths, begins to be perceiving the world at *all* points of observation, as if one could be everywhere at once" (Ibid., p. 197). While this at first seems to be an odd conclusion, upon reflection it seems to be a rather apposite description. What we perceive when we move around the environment cannot really be said to be a series of images of this environment, but rather a complete conception of that environment, however imperfect, where certain parts stand out more than others, that is, something closer to what we earlier have referred to as a cognitive map. While Gibson avoids this concept, since it typically implies a separation between perception and cognition that raises the critical question of who actually is reading the cognitive map (Ibid., p. 198) – what is called the homunculus problem (Deacon 2013) – he still give hints about how this perception/cognition 'model' of the environment is constructed: "The underlying invariant structure has emerged from the changing perspective structure" (Gibson 1986, p. 197), that is, by varying the points of observation we define the invariants, somewhat like a 3D-scanner.

4. Cognitive geometry: representing human-environment relations as things

Apart from aiming to more distinctly extract the implications of Gibson's ecological approach to perception, this discussion hopefully also start to hint at how this conception could be represented in a model. Most interestingly in this respect, Gibson states: "An observer who is getting around in the course of daily life sees from what I will call a *path* of observation" and, furthermore: "the medium can be thought of as composed not so much of points as of paths" (Ibid., p. 197). If we earlier have seen how what Gibson calls the medium, in an urban setting is structured by particular configurations of surfaces into spatial form, we can see how what Gibson is saying here is that such spatial form, rather than being represented by a set of points, can be represented by a line, or, potentially, a set of lines.

Gibson develops this idea, by discussing it in the context of animal orientation. He disregards both response chains from stimuli and cognitive maps as possible approaches to explaining the capability of orientation, found in all animals, including humans. Rather he sees the way forward in what he calls the theory of *reversible occlusion*. He describes this in great detail that proves most clarifying for our current attempt to strengthen the theoretical framework for space syntax, why we choose to quote extensively:

"An alley in a maze, a room in a house, a street in a town and a valley in a countryside each constitutes a place, and a place often constitutes a vista, a semienclosure, a set of unhidden surfaces. A vista is what is seen from here, with the proviso that 'here' is not a point but an extended region. Vistas are serially connected since at the end of an alley the next alley open up […]. To go from one place to another involves the opening up of the vista ahead and closing in of the vista behind […] When the vistas have been put in order by exploratory locomotion, the invariant structure of the house, the town, or the whole habitat will be apprehended. […] It is not so much having a bird's-eye view of the terrain as it is being everywhere at once". (Ibid., p. 198)

It is this perception under movement and the sense of the environment it generates that he means explains the capability of orientation: "To the extent that one has moved from place to place, from vista to vista, one can stand still in one place and see where one is, which means where one is

relative to where one might be" (Ibid., p. 200). Gibson's approach here also resolves the puzzle how different observers, which obviously cannot occupy the same point in space, even so are able to perceive the same world: "If a set of observers move around, the same invariants under optical transformations and occlusions will be available to all. To the extent that the invariants are detected, all observers will perceive the same world" (Ibid., p. 200). Since what we do is to continuously scan the environment rather than take snapshots of it, we are in the end able to generate a, more or less, common perception of the world.

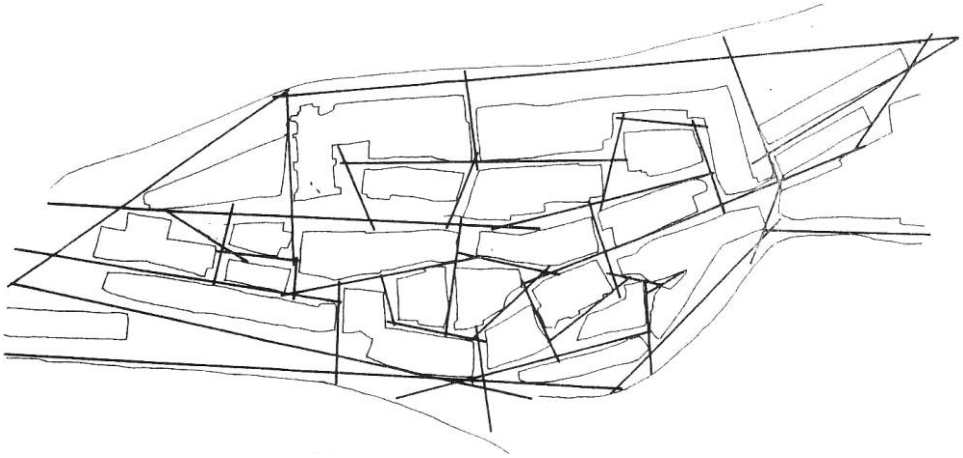

Figure 1: The axial map as a representation of spatial form (Hillier & Hanson 1984).

To anyone familiar with space syntax, the close review of Gibson's theory undoubtedly rings a lot of bells. In space syntax we find a methodology where the means of description have been a primary concern from the beginning and where the aim more specifically has been, exactly, to develop geometric representations of space based in human cognition and where, finally, the invention of the *axial map* (Figure 1), and subsequent developments of it,[1] has been instrumental for the empirical success of the field. Upon closer examination, the axial map turns out to be something that comes very close to Gibson's description above; a network representation of spatial form from the point of view of what we may call a cognitive subject, that is, a perceiving human being moving through space. Given his conception of humans experiencing the environment as 'a path of observation' and the medium as 'composed not so much of points as of paths', it is, for instance, highly interesting to see how the axial map colloquially is defined as the least amount of straight lines that cover all accessible urban space in the area of description, where each straight line (*axial line*) in the map represents an urban space that is possible to visually overlook and physically access for a human being. Hence, we can understand the axial map as a geometric representation of the least amount of perceptual units in the area under study where, moreover, each such unit is a component in a network of such units covering all accessible urban space in the area under study.

This is almost an identical description to the one we find when Gibson attempts to illustrate his theory of reversible occlusion (Figure 2) (Ibid., p. 199). In the figure we see how the 'perceptual spatial unit' continuously changes as the observer moves through space (the medium), due to the physical structure of built form (the substance), that is, particular configurations of built form (surfaces) come into and goes out of sight for the observer, creating a continuous set of vistas. This makes it very clear how we do not perceive a sequence of discrete vistas when moving through the environment but rather a spatial continuum where large parts of the environment typically remain invariable so that what we develop is a conception of the environment as perceived from everywhere, according to Gibson.

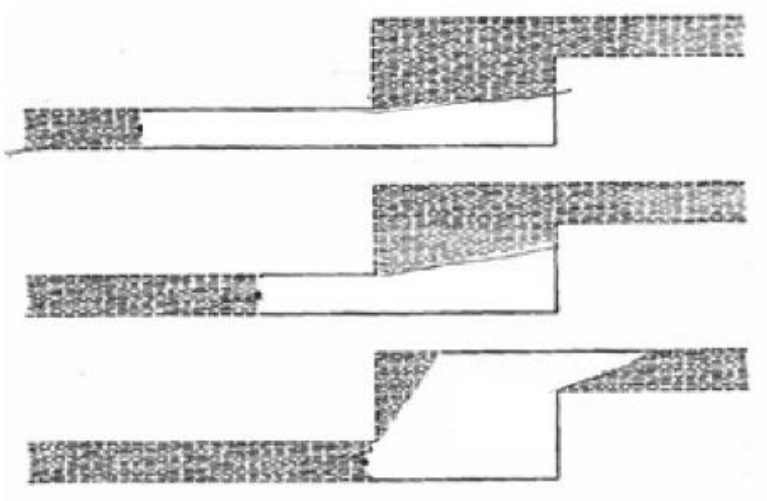

Figure 2: The opening up of a vista at an occluding edge, as seen from above (Gibson 1986).

Now, what we find in the axial map is not a representation of such a spatial continuum but the least amount of 'perceptual spatial units' that cover the area we want to represent. These units are represented as lines distinctly crossing each other as to both connect to each other as a form of continuous path and to not leave any space possible to access and perceive out of the representation. The axial map thus constitutes a kind of representation, of the greatest economy, of what an urban environment *affords* the visibility and accessibility of a human. The representation of this continuous medium in the form of the least possible amount of 'spatial units' of course represents a reduction of reality, typical for any modelling, but the gain is that the continuous medium of space, which is highly difficult to analyse as such, is transformed into a distinct set of elements possible to represent as a network and analyse as a system.

Of particular interest here is the ontological nature of the axial map, informed by the discussion above. Is it a mental map, that is, a physical representation of an inner image of the environment (a cognitive map) or is it an ordinary map, that is, a representation of the physical reality, however of an unusual kind. Against the background of the human-environment relation and, more specifically, the subject-object duality, we may ask: is it a representation of the human subjects conception of urban space or is it a representation of the environmental object's spatial reality. We propose, that it is neither, or rather both, that is, exactly, a representation of urban space that by starting in the perception of a human moving in such space, captures what the environment affords its perception. Clearly this is in line with Gibson's conception: "[A]n affordance is neither an objective property nor a subjective property; or it is both if you like" (Gibson 1977, p. 129) This also pushes us closer to a proper definition of the ontology of affordances, a topic central to Anthony Chemero's intention to extend and reinforce Gibson's theory of affordances (Chemero 2003). He argues that affordances are not a property of the environment or a perception in humans but rather constitute the relation between the two. He builds his argument on a distinction between 'features' and 'properties', where, for instance: "there is a dent in the car", refers to a property of a particular *thing*, but: "it is raining", not refers to a property of things, but to a feature of a particular *situation* (Ibid., p. 185). According to Chemero, this supports a conception of affordances as neither properties or features of the environment in itself, but rather features of situations as a whole, typically constituted by an environment and the presence of humans (Ibid., p. 185). Hence, affordances are neither part of the environment or of humans, but rather belong to a human-environment system; however Chemero takes it one step further: "I argue for something more specific: that affordances are relations" (Ibid., p. 186).

Chemero also argues that being a relation in this sense does not imply that affordances are not real. By reference to Harry Heft's interpretation of Gibson's theory as a descendant to William James radical empiricism, where everything experienced is equally real, he concludes that this would also include relations despite the fact that they are not things in the usual sense (Ibid., pp. 186-187). More precisely then, affordances are relations between environmental features and human abilities

that emerge in situations between the two and where these relations need to be understood as real. Chemero concludes: “Each of an animal’s [including humans] abilities will have a set of situations in which it can be exercised” (Ibid., p. 192). What is fore-fronted here is then neither things nor ideas but *situations*, that is, a spatially located set of relations.[2]

Chemero here brings us to, an intriguing understanding of what actually is represented in axial maps, and similar geometric representations typical for space syntax methodology. They represent neither properties nor features of the environment, nor human abilities or dispositions, but rather a particular set of relations that we may call affordances, which emerge in situations constituted by both environmental features and human abilities. In the case of the axial map this set is more precisely defined by the particular human ability of visibility and bodily movement and the particular features of the environmental setting or spatial form under study that these relate to. The axial map is then not only a representation of a spatial network where the individual lines represent different spatial units tied together at their crossings, but rather a network of affordances, that is, a series of human-environment relations, where each line in itself represents such a relation between humans and the environment; hence the human subject is written into the axial map to the same degree as the physical environment.

Finally it may be added that Chemero most interestingly argues, by way of reference to psychologist Edward Reed, that: “all other abilities will depend on basic orienting abilities, abilities to maintain posture and the like” (Reed 1996). We here therefore also find a connection to the concept of generic function in space syntax, in that visibility and movement constitute more generic abilities that other human abilities depend upon. It is exactly such basic orienting abilities in humans (visibility and mobility) and the related features of the environment, which give rise to a particular set of affordances, which are represented in the axial map and other geometric representations typical for space syntax.

5. Conclusions: linking humans to the environment through geometric representation of affordances

From the discussion above we can draw some important conclusions for space syntax theory. First, in contrast to most, if not all, forms of urban modelling space syntax concerns ecological space rather than physical space. Second, what is the central object of study in space syntax is not space but rather the situated affordances that emerge at the encounter between human abilities and environmental features, which, on the one hand, relieves space syntax from the ubiquitous but utterly confusing references to ‘space’ in current urban theory in favour of something much more specific and essential for the understanding of human behaviour in urban environments. Third, that the link between humans and the environment in space syntax is understood to be constituted by such affordances, why space syntax modelling is not part of the highly criticised subject-object dualism typical for most urban modelling. Fourth, it means that we more precisely can point out what the axial map, and other similar geometric representations typical for space syntax, actually represents, that is, affordances and especially affordances of a generic kind such as those constituted by the human abilities of visibility and movement. Finally, the idea of affordances as particular situations where relations between humans and the environment emerges, directly connects to the idea of situations central for the second link necessary to establish for space syntax methodology, that is, the link between humans and humans, something discussed in a parallel paper.

References

Chemero, A., (2003), ”Outline of a theory of affordances”, *Ecological psychology*, 15(2), pp. 181-195.
Conroy Dalton, R., (2005), “Space syntax and spatial cognition”, World Architecture 185 (41-47), 107-111.
Deacon, T., (2013), *Incomplete Nature: How Mind emerged from matter*, Norton, New York, USA.
Gibson, J.J., (1986), *The ecological approach to visual perception*, Psychology Press, New York, NY, USA.
Griffiths, S., and Quick, T., (2005), "How the individual, society and space become structurally coupled over time", Proceedings 5th International Space Syntax Symposium, TU Delft.
Hanson, L., 2000, “Urban transformations: a history of design ideas”, *Urban Design International*, Volume 5, Number 2, 1 August 2000, pp.97-122(26).
Haq. S.,Zimring, C., (2003), “Just Down the Road Apiece: The development of Topological Knowledge of Building Layouts”, Environment and Behavior, 53: 132-160.
Hillier, B and Leaman, A.,(1973), “The man-environment paradigm and its para-
Doxes”, *Architectural Design*, August, p. 507-511.
Hillier, B., Hanson, J., (1984). *The social logic of space*, Cambridge University Press, Cambridge.
Hillier, B., and Iida, S., (2005), “Network and Psychological Effects in Urban Movement”, Spatial Information Theory: Lecture Notes in Computer Science, Volume 3693, 2005, pp 475-490.
Hillier, B., (2009), "Studying cities to learn about minds: some possible implications of space syntax for spatial cognition." Environment and Planning B.
Mace, W. M.,(1977), “James J. Gibson's strategy for perceiving: Ask not what's inside your head, but what your head's inside of”, In Shaw, R. E. and Bransford, J. (Eds.), *Perceiving, acting, and knowing*, Erlbaum, Hillsdale, NJ, USA.
Reed, E.S., (1996), *Encountering the world*, Oxford University Press, Oxford, UK.
Cognitive mechanisms underlying instructed choice exploration of small city maps
Sakellaridi, S., Christova, P., Chrisopoulos, V., Vialard, A., Peponis, J., Georgopoulos, A., (2015), “Cognitive mechanisms underlying instructed choice exploration of small city maps”, Front. Neurosci.,
Seamon, D., (2007), "A lived hermetic of people and place: phenomenology and space syntax." Proceedings, 6th International Space Syntax Symposium. Istanbul.
Turner, A., Penn, A., (2002), “Encoding natural movement as an agent-based system: an investigation into human pedestrian behaviour in the built environment”, *Environment and Planning B: Planning and Design*, volume 29, pages 473-490

[1] We will only refer to the axial map here, while keeping in mind the general implications of our argument for other geometric representation typical for space syntax, such as the segment map or the isovist.
[2] This conception of affordances as situations of particular relations is of great interest also for our parallel discussion about the human-human relation in space syntax theory, that is, its relation to social process, which is continued in a parallel paper.