

An Evolutionary Approach to Spatial Knowledge

Theoretical Developments

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Abstract

The purpose of this paper is to present Developmental Syntax (DS), its wider theoretical background and application to the field of spatial knowledge research.

DS is a contribution to the theory of spatial knowledge, produced as part of a recently completed (1999) PhD thesis and currently at Salford University. DS uses the unit of the 'person in surroundings' as its unit of analysis. This unit is used to conjecture relationships between the person and surroundings. The resulting model provides one basis for the study of spatial knowledge, the link between the 'knower' and the 'known'. 'Spatial knowledge' is used as a term to denote the relationship between thought and things contributing to any understanding of behaviour and behavioural settings at the social, urban and global scale.

DS links methods used in space syntax to a research field of 'emergence'. The techniques link large scale mathematical modelling with adaptive learning systems and can be reduced to three significant categories:-

Firstly mathematical systems and statistical analysis

Second, lawful algorithms linking random members of a social group to place in context, known as transactional relationships with phenomena such as scripted behaviours and behavioural settings

Third, the incremental associations, selections and conjectures of adaptive learning mechanisms and phenomena brought about by ecological perception, which is the focus of DS.

Space syntax significantly represents a holistic approach linked to lawful social and spatial functions, listed above as the first and second categories in emergence. The third category must, in any detailed analysis, be linked to the other two. Individuals acting in their surroundings have degrees of choice or selection and these influence their physical circumstances even though those degrees of selection are constrained in various ways.

Ongoing research at the Centre for Virtual Environments at Salford University is using emergence as a philosophy in Urban Modelling. This philosophy seeks to link large-scale environmental phenomena and social and spatial knowledge systems to selective individual choices. Advances in understanding the links between all three categories should prove useful to urban modelling and the increasing democratisation of the urban realm linking individual and local group interactions to the wider horizons of urban and global planning.

Introduction

Space syntax argues that a lawful relationship between people and space can be linked to properties of whole configurations (Major M D, 1997). Space syntax makes these links by creating theory out of the correlation between descriptions retrieved from mathematical models of space (acquired through the application of an appropriate methodology) and

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descriptions of social functions and cultural meaning (Hillier B, 1997). This is to say mathematical models of space and social function can be related to a theory of human behaviour, which is agreed, the question is how?

There is a convergence between what people do and how physical mass is configured that leads to a rich harvest of inferences regarding social functions and cultural meaning for those who use space syntax methodology (Peponis J, 1997). There is a claim that having made an analysis it follows that we are able to make a conjectural proposal which in its theoretical condition enriches the architectural repertoire for design (Hillier B, 1997a). Theoretically the evidence that space and people are linked together allows such a link to work both ways linking research to design. The question, in this paper, regarding such an argument and its supporting evidence is how and to what degree might we encourage it?

The question seems necessary because although we may identify a way to remove the dichotomy between theory and practice, we are arguing that the two are at least theoretically connected up. Thus to examine the link is to bind theory and practice together.

People and Mass

People exhibit a propensity to link themselves to physical mass in ways familiar to most people within everyday experience. We can have a home 'belonging' to us, a personal place in that home which can be in a town 'known' to us more or less well as a whole town and a 'home' town (Lynch K, 1960). The physical mass of the town can be 'known' differently and in different ways by different individuals (Gould P, 1986). One explanation of this is that individuals capture any image of their surroundings developmentally and differently.

Whole towns do not appear as whole configurations from the point of view, the literal viewing point, of the individual located within the town at mean ground level. Nor do occupants of a complex set of spaces, such as those surrounded by opaque walls perceive the total contents of the building by occupying just one of 'its' rooms. Yet people capture more than the space they occupy once they start moving around. Humans have a propensity for memory of a kind allowing part/whole relationships to be 'carried' by individuals and these are used in order to locate themselves within the whole with some degree of success (Passini R, 1996).

The evidence produced by research using space syntax methodology indicates that whole configurations modelled mathematically become 'as if' known to individuals after moving around within it or through it (Peponis J, 1990). This in turn indicates that individuals may be either collecting up elements with similar features of the mathematical model or else are predisposed to such modelling in some way. It becomes theoretically possible that ecologically minded psychologists (Gibson J J, 1974) might have some explanation in terms of perceptual links to the characteristics of mass as perceived (Penn A, 1997).

Link Values

That perception linked to an individual consciousness acquired consciously, unconsciously, or a mixture of both, acquires values unique to the person/place relationship 'as if' linked is now well accepted as a probable feature of the central nervous system (Oomes S, 1998). The link is not of the two parts each having a value, the person and the place, but one value as link. It is not one value connected to another value but a link-value.

Unique link-values allow the individual to identify what would otherwise constantly appear, or be assumed to appear, as novel. Evidence from outside space syntax supports the view that topological elements such as the lines called 'axial lines' in space syntax provide individuals with link-values (Lindberg E, 1984). Link-values for topological elements such as axial lines would assist any ability we might have to create topological models within our central nervous system (Portugali J, 1997).

Links between the geometry of urban and architectural plan drawings, topological elements and their structures are established characteristics of mathematical modelling (Piaget J, 1971) and also a basic tenet of space syntax (Peponis J, 1989). However we need more detail of this relationship before we have a theory linking the individual to the whole. Is the process one way or reversible? Can we learn to occupy anything or should we build for specific occupants?

The answer must rely on a satisfactory description of the person and environment model of behaviour. The need for such a description was known within the field of space syntax in its early stages (Hillier B, 1990) as in the field of environmental behaviour (Ittelson W, 1978). In the latter case the situation has not much improved (Sime J, 1999). The difficulty as described within the field of space syntax research has always been linking the mathematical to the selective individual without incurring the labels deterministic or metaphysical.

The Link-Value Unit of Analysis

A recently completed PhD thesis (Thompson W J, 1999) adopted initial observations by earlier research into a unit of analysis suitable for use in the study of environmental behaviour (Wapner S, 1987). This eventually acquired the name Developmental Syntax (Thompson B, 2000).

Wapner had pointed out the failure to engage with the person in space as a unit of analysis. This failure seemed to result from the segregation of various philosophical and psychological research families or groups each trying to individually explain environmental psychology as a phenomenon. Thompson noted that phenomenological investigations (Moustakas C E, 1994) and aspects of consciousness and the unconscious (Barrs B J, 1988) were particularly segregated (Seamon D, 1979). Wapner's model of the person in space adopted work by Dewey on the nature of interactive and transactional modes of knowing (Dewey J, 1949). DS applies these to spatial phenomena.

The focus of research is moved away from what was called self-action and interaction, the cause and effect mechanism, beyond transaction as a field and analysis relationship towards the operation of the agent making selections at the interface between perception and action. Similar attempts had been made in transactional approaches such as Personal Construct Theory (PCT) originated by George Kelly in 1955 (Fransella F, 1988). Kelly was highly critical of the reduction of behaviour to cause-effect mechanisms and looked for 'constructive alternativism' (Bannister D, 1977).

The PCT 'unit' is as if a scientist in a laboratory of perception informed by experience. The meaning of any event becomes linked to its immediate past and eventual future (Bannister D, 1970) and to the specific individual who experiences it as a contextual relationship. Such a model is supported by research in the field of neuroscience as the most likely material explanation of what the central nervous system is doing, whether we are conscious of the system doing its work or not (Frackowiack R S J, 1997).

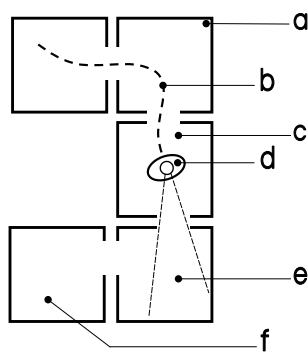


Figure 1: The occupant (d) moves (b) through topological units of space (a) creating three kinds of spatial relationship, occupied, (c) which includes spaces previously moved through (see b), adjacent space/s (e) and unknown space/s (f). These spatial relationships are considered to be developmental regarding the propensity to create link values between potentials carried by both occupant and topological space in their unique exposure (and lack of exposure) to each other. Other individuals form part of any link value relationships, their propensities, potentials and creation.

The person/surroundings unit of analysis is needed to demonstrate the part/whole relationship spatially rather than linguistically. This reflected a desire expressed in the original space syntax 'manual' (Hillier B, 1990a) and a more general worry that linguistic and philosophical models had lost their ability to sustain credible explanations of architecture (Diani M, 1988). In a paper called "Escape Syntax" (Thompson B, 1998) a person/surroundings unit of analysis was introduced to the topological spatial analysis of 'convex spaces' in Space Syntax.

An application of DS

DS was applied to work within the field of research considering provisions for means of "Escape from Fire". Experience of buildings on fire is limited to specialist groups such as firemen or else actual victims of circumstance and a theoretical approach in means of escape behaviour is necessary. Those who experience fires other than as arsonists and who expect to be in the situation in which they find themselves are a minority human group. Evidence shows that training for means of escape in case of fire is like riding a bicycle, what is retained depends upon the relationship between the individual doing the learning and what is available to be known (Schwalm N D, 1981).

Subjects who have been in a fire before, are related to a person who died in fire, related to specialist fire fighters, had often thought about being in such a situation and even those who were simply more able to construct a plan all did 'well' in tests when compared to others lacking those attributes. Schwalm noted that practically any reduction in uncertainty led to improved performance, at least the propensity for an improved performance over situations where certainty was decreased. An alternative way of putting this, supported by empirical evidence, is that 'ambiguity' demands resolution of some sort (Buffart H, 1983).

The link between the person and the complex surroundings was a product of time, education, training and experience. Individuals 'who found themselves in a fire' and lacked experience of the building in which they were located preferred to retrace their steps rather than use fire escapes provided by building codes and controls for their means of escape in case of fire (Sime J D, 1985).

The Topological Morphology

DS sought to represent a topological morphology of the escapee retracing their steps.

Spaces were given the developmental relationships of:

Occupied space - the unit of analysis in which encoding is able to or has taken place,

Adjacent space - the space adjacent to occupied spaces,

Unknown space - which has been not been occupied, is not adjacent - not spatially known.

Figure two shows how movement from topological space to topological space alters the relationship between occupied spaces and total available topological spaces. The difference between the spatial experience of the individual in space and the analysis made available by the use of a mathematical analysis of topological units is represented quite clearly.

Figure three shows that a person conjecturing on route alternatives within their own immediate experience, their interactive location, have many possible alternatives in order to arrive at a suitable outcome (escape from the building - to get out). The only possible transactional basis on which they can act to reduce ambiguity to a minimum is to retrace their

steps, all things being equal. The concept of decision making can be turned on its head by considering choice as the resolution of ambiguity rather than a selection process based on logical reasoning using a model of taxonomic preferences.

Limitations of the Physical

We can look at what happens in Figure 3 in another way which takes account of a concept of the link value relationship. Figure four shows that the occupied spaces can be valued as within a boundary condition of 'known' as opposed to unknown space. Some link value is possible having been occupied.

The spaces adjacent to the occupied space can be valued as interactive spaces with a boundary condition such that they are outside of the boundary yet have some kind of relationship. We can refer to this as a horizon, the spaces are interactive within a horizon such that they can be 'known about' and used as if they are known given certain conditions, that they are linked spatially, which is perceived from the occupied space, and are either like or unlike other spaces so far encountered.

We can also see in Figure four that other spaces are beyond the horizon. Spatially obscured by surrounding surfaces they will not be perceived. However it is possible to provide analogous or metaphoric knowledge by using speech utterances (Searle J R, 1995). These have the effect of placing topological units between the horizon condition and the boundary of occupied/visited space as social constructs, based on the use of language or some other form of representation shared through some value system other than a spatial relationship.

Issues of Relativity

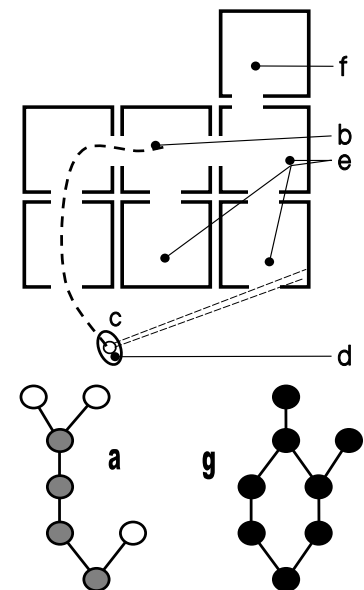
DS exposes spatial relationships unique to conjecture at the individual interactive location in surroundings and provides insights into the way such relationships turn into actions in context. The context itself is variable even though the physical mass is remarkably similar. The physical mass of the building can hardly bring any variables to bear within its own physical mass. We are well aware after Freud and psychoanalytic theories generally that the individual should be considered as a veritable bundle of different boundary conditions and horizon types (Harre R, 1997, 1998). Thus although it appears to be architecture which forces us to confront in a very immediate way some of the deepest problems of philosophy (Hillier.B.1997b.) it is its part in any link-value system which does this.

If boundaries and horizons were only mechanically and deterministically linked to our surroundings then we could perhaps deny the philosophical altogether. However we quickly learn as new born infants that what lies 'beyond' has an impact on our present location both as coming from our surroundings and as our own intervention upon what surrounds us (Winnecott D W, 1988). Developing individuals undergo both genetic and environmental changes whilst they occupy their surroundings over time (Millar S, 1994). Occupation becomes our link between what surrounds and all interactions occurring in that location including our own interventions.

Thus experience is not perception but interaction with perception and action. Interactions on some occasions generated from within (embodied) and on some occasions generated from our surroundings (embedded) which arrive at resolution. The ability of the body to act, and act upon surroundings indicates an ability to alter the whole configuration in some way by experiencing more or less 'time' for that resolution to take place.

Figure.2: The occupant (d) has moved (b) through topological units of space with the potential to embody the morphology shown in (a). Space (f) is unknown, spaces shown (e) are adjacent, one from occupied space (c) and two from the end of the occupied spaces through which the occupant has moved (b). The comparative morphology of the entire set of spaces shown in (g) is very different to the embodied morphology shown in (a).

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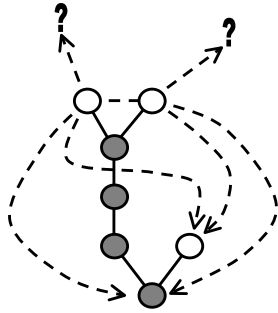


Figure.3: The many alternative movements possible linking the spaces which have been embodied, the high level of ambiguity for any outcome, provided by the profusion of alternatives shown as dotted lines is resolved by moving through the occupied topological spaces (shown as the darker spaces).

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For some time the development of consciousness was thought to be largely and inevitably controlled (programmed) either by genetic or by environmental circumstance (the nature nurture issue). The Chomsky/Skinner controversy (Aitchison J, 1996) refined the 'debate' to innate mechanics (genetics) or acquired mechanics as a result of training and education (conditioning). Issues of conscious intervention by a developing consciousness as a knowable phenomenon (experience and the self) were set aside until genetic determination and learning ceased to be useful models of psychological enquiry (Millar S, 1994). A deeper understanding of empirical evidence on the interplay between sense, cognition and action leads to questions of contextual or relative relationships over and above any direct mechanical links to either person or place alone (Neisser U, 1976).

Emergent skills, in spatial and other environments, develop out of interactions and lead to considerations of propensities and potentials rather than abilities as innate or acquired mental or physical constructs. This is a perfectly reasonable consequence of considerations regarding local global relationships in systems. If the system is open, as opposed to closed, then the local-to-global relationship will be affected by any extension or reduction in the system. Thus link values depend upon the closed system which when open alters the values not simply proportionately but profoundly at certain crucial points, thus philosophically.

Legibility

The idea of conscious environmental knowledge in the field of environmental design refers frequently to the concept of legibility (Weisman J, 1981). Legibility of the surroundings has become part of the same provenance as that shared by the field of environmental behaviour known as cognitive mapping (Gould P, 1986), (Kitchen R, 2000). The model used by Cognitive Mapping dominates research into spatial reasoning.

The analogous use of 'map making in the head' has not gone unquestioned (Lloyd R, 2000), (Couclelis H, 1997). The map in cognitive mapping is meant to reside within the individual and relate to the surroundings. The map made by the individual depends upon the relationship of the surroundings to the individual as a system or order. Where there is no change and the relationships remain the same then it seems that the mapping model is adequate. However where there is change, either in the surroundings or the individual, then the model is unable to describe what is happening because the actual link value relationship is dynamic rather than static under certain conditions of change in local global relationships.

The Evolution of Topological Morphologies.

The continual accumulation of knowledge relates well to the mapping metaphor but not to empirical studies in the way individuals perceive data, retain it and then use it. Systems do emerge, order can be perceived, knowledge can improve to expert status. However a static model would ignore the more profound changes which occur in our abilities (Perner J, 1991). The individual is not only a 'learning machine' but must somehow take part in, which means adapt, the process of remembering (Baddeley A D, 1982) so that it is a remembering machine and an adaptive machine as well.

One of the problems in deciding quite how much of each is an empirical matter which needs more research into 'in space' conditions of interaction (Cohen G, 1996). Given that the environment changes beyond our development boundaries, to what degree can an individual understand, remember and adapt to order imposed on spaces outwith any personal experi-

ences?. To what degree does that order actually exist? Rather than a stimulus-response interaction we should look to understand a constant dynamic interaction between the individual and their personal boundaries and horizon conditions with the larger spatial system.

The suggestion by Boulding in the preface to Zeleny's work (Zeleny M, 1980) is that the evolution of features of dynamic interaction are such that planning appears to have taken place - whilst in fact no plan has been made. The relationship between individual and surroundings in this model is as if a link value relationships emerge out of random interactions. Reid (Reid A K, 1998) talks about 'reward cycles' relating to behaviours which appear to demand insight or some kind of overview and yet can be shown to emerge without any global plan. Thus individuals can appear to be part of a grand plan whilst being ignorant of any such phenomenon.

Tolman (Tolman E C, 1946) talks of the relationship between the location of the individual within a boundary of a known configuration and their ability to form judgements as to their location within that configuration. Tolman distinguishes between the stimulus response form of this relationship by suggesting that rather than respond to stimuli the individual is able to make judgements which differ according to differing relationships as they present themselves to the individual and its bounded experience against new horizon conditions.

Tolman uses the term expectations, suggesting that the similarities between symbolic interaction and goal based behaviours are sub sets of the overall ability to form link values between the unit of self in surroundings and the bounded sets of known surroundings which allow expectations to be attached to embodied phenomena. Recent research in neuroscience indicates that Tolman's model is an appropriate description for a sentient being with a brain of the size and type of our human brain in our human body (Blakemore C, 1998), (Damasio A R, 1995), (Devlin K, 1997).

Basic Concepts of Emergence

How might we have reduced the larger scale phenomena of world conditions to an understandable lexicon of orders? Our major resource in this regard seems to be access to the brain cells which we have in abundance which provide us with feedback from our long and/or short term memory (Powers W T, 1989). We have a need to embrace ways in which we can come to terms with the evolutionary behaviour of complex adaptive systems (Lyons P, 1998). We need to consider the individual as an agent whose experience is an evolutionary configuration of the embodied central nervous system.

The idea of social models created unconsciously out of individual action is a foundation stone of Artificial Life producing examples of 'social' order emerging from simple individual rule based interactions (Epstein J M, 1996). Such examples illustrate the possibility of what we already recognise as society and culture, phenomena existing prior to knowing that they do so.

A recent appreciation of concepts relevant to the study of emergent order (Holland J H, 1998) suggested three basic concepts as a formal framework for the academic study of emergence as a field of research. These concepts are;

* Purely mathematical concepts: for example space syntax analysis would be categorised under this category or basic concept as a social and spatial logic.

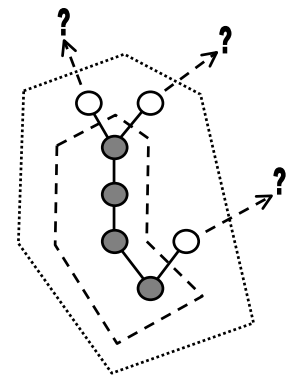


Figure 4: The occupied spaces (shown as darker circles representing topological spaces that have been occupied or are occupied) can be thought of as within a boundary (heavy dotted boundary). This is the transactional boundary within which some link action values have been established by being exposed through occupation and embodied, space and person link values established (to some degree yet to be established by empirical enquiry). The adjacent spaces (lighter circles) are between the transactional and an outer boundary (lighter dotted boundary) indicating an interactive limit. The occupant may adopt link values from other occupants through transactions of speech, but spatially the topological spaces are not transactional but interactively known, not embodied fully and not fully capable of use with any intentional action on the part of the occupant. Estimates of any interaction beyond the interactive boundary are coincidental and open to serious error, thus the interactive boundary can be understood as a horizon to spatial knowledge.

* Concepts closely tied to systems and games: for example the work of Epstein in *Artificial Societies* would be under this category as would several of the computer based transactional and construct theory types of approach in environmental behaviour.

* Core concepts: (Tooby J, 1992) those which have played a key role at every stage of development in the study of emergence as a phenomenon. These are:

* Building blocks - such as topological phenomena capable of manipulation to provide order out of complexity.

* Morphologies - orders or structures made up of building blocks.

* Agencies - the 'control' making up morphologies and manipulating building blocks.

Building Blocks and Morphologies As Phenomena of Emergence

Developmental Syntax (DS) models the individual as an adaptive agent. We can term the combination of body and brain, the Embodied. The configuration of any embodied will differ from any other embodied for a number of reasons however the configuration of physical mass is limited to knowable relationships of mass and action. These configurations are altered in ways which can be quantified with great precision if we care to do so.

Whilst the capacity of the embodied to contain any number of configurations is considered infinite (Churchland P, 1995) the capacity of the surroundings to provide for them is limited by the means of quantification and effort. The conscious experience of certainty is an assumed link value between the embodied and surrounding space. Cognition links the embodied to surroundings using a morphology or morphologies which are links between surroundings and configurations of the nervous system. These morphologies are embodied in the individual and embedded in the space around them over time.

The narrowing down from infinite possibility (and error) to reasonable assumption (and certainty) is the mechanics of a dynamic process of interaction leading to a default condition of link values (Reason, J. 1992). Thus it would seem that what impoverishes the morphology is a lack of experience, what enriches the morphology is diversity and effort with boundary conditions relating to normal, expected and the unknown.

The speeds at which various morphologies come into consciousness relate to a number of factors, some of which are known, some of which remain obscure. Familiarity, consistent exposure of consistent order, are major factors in strengthening cognition, but not the only ones. Rather than incremental changes in discrete units of time and space there are complex alterations in value and complex and multiple links between many systems which develop both genetically and environmentally as a species and as individuals (Milner A D, 1996), the global has an important influence on the local.

The individual develops unique configurations of itself as a consequence of its lifespan development (Magnussen D, 1996) so that rather than mental operations one should think of embodiment as the phenomenon dynamically interacting with surrounding phenomena and including both social and spatial factors at the neural level. There is some evidence that those who engage in deliberate effort acquire an interactive skill as a direct result of their extra exposure (Hazen N L, 1982). How conscious this process might be would seem to depend on the set of circumstances in which individuals find themselves free to do so, encouraged to do so, culturally inclined to do so etc.

The emerging model implies an agent capable but not necessarily obliged or willing to embody morphologies yet able to do so and able to acquire the necessary resources merely through exposure (which may in some cases become cultivated as with scientists seeking

'knowledge' (Grandy R E, 1992)). It would seem that the individual is acquiring new configurations in the nervous system, and has the capacity to make more complex configurations by raising levels of ambiguity, requiring more time allowing more exposure within the neural configuration just as we might allow more time and more exposure in the spatial configuration, as a hypothesis for future research.

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