

Chapter 4.3

Cognitive Maps and Spatial Behaviour: Process and Products

Roger M. Downs and David Stea

Editors' overview

At the start of the 1970s, it was intellectually fashionable amongst behavioural geographers to investigate the significance of cognitive maps, and their impacts on people's spatial behaviour. Downs and Stea's book was probably the most influential overview of the field and brought together papers from almost all of the leading exponents of this kind of research. We have excerpted Chapter 1, which explores the dimensions of cognitive mapping, distinguishing between cartographic images and the cognitive constructs that are the focus of their attention. This conceptual piece is informed by a communications model of information transmission and explores processes and defines concepts underpinning research. The authors define the concepts of perception, cognition, attitude and preference, before explaining the differences between what people need to know and what they actually know. Amongst other concepts they focus on differences between locational and attribute information, the role of incomplete, distorted, schematised, and augmented cognitive maps, and some of the behavioural reasons for the mismatch between theory and practice. They conclude by urging further experimental investigation of behavioural evidence of cognitive mapping.

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Introduction

A surprising fact is associated with studies of cognitive mapping: although the emergence of this vigorously developing research area has been recent, we are not discussing

something newly discovered [...]. Instead, we are concerned with phenomena so much part of our everyday lives and normal behaviour that we naturally overlook them and take them for granted.

[...]

We find that planners try to alter cognitive maps, astronauts need them, the news media use them, and advertisers tempt us with them; they are part of our everyday lives. [...] We offer a formal definition: cognitive mapping is a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena in his everyday spatial environment.

In this paper we will expand this definition and examine the conceptual frameworks which are subsumed within it.

An analysis of cognitive mapping processes

Cognitive maps and adaptive behaviour

Underlying our definition is a view of behaviour which, [...] can be reduced to the statement that *human spatial behaviour is dependent on the individual's cognitive map of the spatial environment*. That this formulation is necessary is indicated by a comparison of the characteristics of the individual with those of the spatial environment.

The environment is a large-scale surface, complex in both the categories of information present and in the

number of instances of each category. Things are neither uniformly distributed, nor ubiquitous; they have a 'whereness' quality. In contrast the individual is a relatively small organism with limited mobility, stimulus seeking capabilities, information processing ability, storage capacity and available time. The individual receives information from a complex, uncertain, changing and unpredictable source via a series of imperfect sensory modalities, operating over varying time spans and intervals between time spans. From such diversity the individual must aggregate information to form a comprehensive representation of the environment. This process of acquisition, amalgamation and storage is cognitive mapping, and the product of this process at any point of time can be considered a cognitive map.

Given a cognitive map, the individual can formulate the basis for a strategy of environmental behaviour. We view cognitive mapping as a basic component in human adaptation, and the cognitive map as a requisite both for human survival and for everyday environmental behaviour. It is a coping mechanism through which the individual answers two basic questions quickly and efficiently: where certain valued things are, and how to get to where they are from where he is.

Cognitive maps and spatial behaviour

[...] We believe that a cognitive map exists if an individual behaves as if a cognitive map exists (Stea and Downs 1970). [...] Normal everyday behaviour such as a journey to work [...] would be impossible without some form of cognitive map. [...] Admittedly, much spatial behaviour is repetitive and habitual [...] but even this apparent stimulus response sequence is not so simple: you must be ready for the cue that tells you to 'turn here' [...]. You are thinking ahead and using your cognitive map. In human spatial behaviour we consider even a series of stimulus-response connections as a 'simple' (or impoverished) form of a cognitive map, in which the general aspects of spatial relationship implicit in cognitive mapping play a minimal role. [...] The person knows that an object is valued and one way of getting to it, but knowledge of the whereness in relation to the location of other objects is absent. [...] Thus someone who knows only one route knows more about that route than just the appropriate responses at certain choice points and, because he thinks ahead, is also engaging in cognitive mapping. We are postulating the cognitive map as the basis for deciding upon and implementing any strategy of spatial behaviour.

However, we must make it perfectly clear that a cognitive map is not necessarily a 'map'. [...] We are using the term 'map' to designate a functional analogue. The focus of attention is on a cognitive representation,

which has the functions of the familiar cartographic map but not necessarily the physical properties of such a pictorial graphic model (Blaut *et al.* 1970). [...] The cartographic map has a profound effect on our concept of a cognitive map.

Spatial information can be represented in a variety of ways. [...] All media share the same function not structure, and thus cognitive maps are derived from analogies of process, not product.

Cognitive mapping signatures and cognitive representations

[...] All of the media rely upon the same sort of spatial information, and all are employed in the same sorts of spatial behaviour: thus the inputs and outputs are specified, while the intervening storage system (the black box) is not. The way in which spatial information is encoded (mapmaking) and decoded (map reading or interpreting) gives rise to a set of operations called the signature of a given mapping code. Thus a cartographic map signature is dependent upon three operations: rotation of point of view to a vertical perspective, change in scale, and abstraction to a set of symbols [...]. Many other signatures are feasible; we have no reason to anticipate that cognitive maps should necessarily have the same form of signature as cartographic maps. Above all, we should avoid getting locked into a form of thinking through which we as investigators force a subject to produce a cartographic cognitive map and which we then verify against an 'objective' cartographic map. [...]

The issue of mapping signatures involves some fundamental theoretical and methodological issues. [...] Underlying the whole approach is the basic question: How is information derived from the absolute space of the environment in which we live, transformed into the relative spaces that determine our behaviour? The transformation can be viewed [...] as involving any or all of three fundamental operations: change in scale, rotation of perspective and a two-stage operation of abstraction and symbolisation, all of which result in a representation of relative space.

[...]

Thus, we should be interested in developing theoretical statements about the cognitive signatures that are employed in dealing with information from the spatial environment. [...] The only differences between Lynch's (1960) 'images' and city maps of cartographers lie in the degree of abstraction employed and the types of symbols chosen to depict information. [...] We should be concerned with the nature or signature of relative space as it is construed and constructed by the individual. Only if we do this can we ask how relative and absolute spaces

compare and differ. [...] Some aspects of our composite cognitive maps may resemble a cartographic map; others will depend upon linguistic signatures (in which scale and rotation operations are irrelevant), and still others upon visual imagery signatures derived from eye-level viewpoints (in which the scale transformation may be disjointed or convoluted). [...]

Before considering the nature and functions of cognitive maps in more detail, we must discuss some basic definitions and attempt to clarify a few misconceptions which currently prevail.

The concepts of perception, cognition, attitude and preference

Perception and cognition: distinctions

Unfortunately, perception and cognition have been employed in a confusing variety of contexts by psychologists and other social scientists. [...] It is difficult to determine whether the process of perceiving is being discussed or [...] the product of the perception process. [...] Perception has been used in a variety of ways: to experimental psychologists it involves the awareness of stimuli through the physiological excitation of sensory receptors; to some social psychologists it implies both the recognition of social objects present in ones immediate sensory field and the impressions formed of persons or groups experienced at an earlier time. To many geographers perception is an all-encompassing term for the sum total of perceptions, memories, attitudes, preferences and other psychological factors which contribute to the formation of what might better be called environmental cognition. [...]

Given the varied uses of the terms it is difficult to distinguish between perception and cognition. [...] We reserve the term perception for the process that occurs because of the presence of an object, and that results in the immediate apprehension of that object by one or more of the senses. Temporally it is closely connected with events in the immediate surroundings and (in general) linked with immediate behaviour. [...] Cognition need not be linked with immediate behaviour and, therefore, need not be directly related to anything occurring in the proximate environment. [...]

However this distinction falls short of establishing a clear dichotomy [...]. Both refer to inferred processes responsible for the organisation and interpretation of information [...]. Cognition is the more general term and includes perception as well as thinking, problem solving and the organisation of information and ideas. A more useful definition from a spatial point of view is

offered by Stea (1969). He suggests that cognition occurs in a spatial context when the spaces of interest are so extensive that they cannot be perceived or apprehended at once [...]. This scale dependent distinction [...] also suggests that we are concerned with the nature and formation of environmental cognitions rather than with briefer spatial perceptions.

Attitudes, predictions, preferences and cognitive maps

[...] The parallels between the concepts of cognitive map and attitude are marked. [...] Fishbein (1967) replaces the holistic concept of an attitude with a formation containing three components: cognitions or beliefs, affect or attitude and conations or behavioural intentions. Fishbein claims that the fact that affect, cognition and action are not always highly correlated necessitates this more complex typology. [...] Fishbein points out that attitudes, beliefs and expressed behavioural intentions are frequently brought into line with actual behaviour. [...] In other words, if the behaviour can be specified an attitude can usually be postdicted.

Finally, we must distinguish among attitudes, preferences and traits. [...] Preferences are usually considered to be: less global [...]; and less enduring over time. [...] When a given attitude pervades a wide variety of objects over a considerable period, it becomes a personality trait. [...]

Hypothetically, one could construct a scale from preference through attitude to trait, increasing in both inclusiveness and duration of the cognitive, connotative and effective components. [...]

The nature and function of cognitive maps

What do people need to know?

[...] There are two basic and complementary types of information that we must have for survival and everyday spatial behaviour: the locations and attributes of phenomena. Cognitive maps consist of a mixture of both. [...] We must also know what an object is.

Locational information is designed to answer the question, 'where are these phenomena?' and leads to a subjective geometry of space. There are two major components of this geometry, distance and direction. Distance can be measured in a variety of ways and we are surprisingly sensitive to distance in our everyday behaviour. [...] Knowledge of distance [...] is essential for planning any strategy of spatial behaviour. [...] Direction is no less important in the

geometry of space, although we are less conscious of directional information. [...]

By combining distance and direction we can arrive at locational information about phenomena, but not necessarily the same as that provided by Cartesian co-ordinates of cartographic map. [...] Thus, locational information is not as simple as it might appear. We must store many bits of distance and direction data to operate efficiently in a spatial environment, a process involving relatively accurate encoding, storage and decoding. Use of locational information [...], however, requires a second type of information: that concerning the attributes of phenomena.

Attributive information tells us what kinds of phenomena are out there and is complementary to locational information. [...] An attribute is derived from a characteristic pattern of stimulation regularly associated with a particular phenomenon, which, in combination with other attributes, signals the presence of the phenomenon. [...]

We can divide attributes of phenomena into two major classes: descriptive, quasi-objective or denotative; and evaluative or connotative. [...] Here we are separating attributes which are affectively neutral (descriptive) from those that are affectively charged (evaluative).

[...] An object is identified and defined by a set of attributes and bits of locational information. However, what is an object at one spatial scale can become an attribute at another [...]. The scale of analysis of the problem at hand defines what is an object and what is attributive and locational information.

What do people know?

If we compare a cognitive map with a base map of the real world [...] we find that cognitive mapping does not lead to a duplicative photographic process [...], nor does it give an elaborately filed series of conventional cartographic maps at varying spatial scale. Instead cognitive maps are complex, highly selective, abstract, generalised representations in various forms. [...] We can characterise cognitive maps as incomplete, distorted, schematised and augmented, and we find that both group similarities and idiosyncratic individual differences exist.

The incompleteness of cognitive maps

The physical space of the real world is a continuous surface which we have come to understand through a classic geometrical framework: that of Euclid. [...] There are no gaps or bottomless voids. [...] Yet all cognitive maps are discontinuous surfaces. Seemingly some areas of the earth's surface do not exist when their

existence is defined by the presence of phenomena in the subject's cognitive representation. [...] [However] we must be careful in interpreting the absence of phenomena from cognitive maps as reflecting discontinuity of space.

Distortion and schematisation

By the distortion of cognitive maps we mean the cognitive transformations of both distance and direction, such that an individual's subjective geometry deviates from the Euclidian view of the real world. Such deviations can have major effects on the patterns of spatial use of the environment. [...] If people are sensitive to distance, consequent spatial behaviour patterns will be dependent on such distance distortions.

Far more significant and as yet little understood are the results of schematisation (the use of cognitive categories into which we code environmental information). We are, as Carr (1970: 518) suggests, victims of conventionality. This conventionality can be expressed in two ways. The first involves the use of those spatial symbols to which we all subscribe and which we use both as denotative and connotative shorthand ways of coping with the spatial environment. [...] However, there are other symbols dealing with geographic entities [...] which owe their cogency and importance to their mere existence. [...] Such entities have been termed the invisible landscape. As images these elements are perhaps the most purely symbolic. [...] A second aspect of schematisation or conventionality involves the very limited set of cognitive categories or concepts that we have developed in order to cope with information derived from the spatial environment. [...] Our understanding of the semantics of cognitive maps is remarkably limited.

The controversy over linguistic relativity suggests that there are cross-cultural differences in the ways in which spatial information is coded. Such differences are not only cross-cultural. [...] Downs (1970) assumed that a neighbourhood shopping centre would be clearly defined and commonly agreed upon spatial unit, with the edge of the commercial area defining the shopping centre boundary. However, residents of the area recognised four distinct subcentres.

Augmentation

[...] There is some indication that cognitive maps have non-existent phenomena added as embroidery. [...] Such distortions may be highly significant, but we know little about their causes, and nothing about their eradication.

Inter-group and individual differences in cognitive maps and mapping

[...] Underlying group perspectives are the result of three factors. Firstly, the spatial environment contains many regular and recurrent features. Secondly, people share common information processing capabilities and strategies [...]. Thirdly, spatial behaviour patterns display similar origins, destinations and frequencies. These factors in combination yield inter-group differences in cognitive maps.

The individual differences among cognitive maps emerge primarily from subtle variations in spatial activity patterns. [...] Such idiosyncrasies are particularly notable in verbal descriptions of cognitive maps – the choice of visual details shows tremendous variation from subject to subject.

In answer, therefore, to the question, ‘What do we know?’, we can conclude that we see the world in the way that we do because it pays us to see it in that way. [...] People behave in a world ‘as they see it’ – whatever the flaws and imperfections of cognitive maps, they are the basis for spatial behaviour.

How do people get their knowledge?

We have postulated a set of basic characteristics that our knowledge of the spatial environment should possess, and we have indicated the characteristics that our knowledge (or cognitive map) actually possesses. Some of the differences [...] can be attributed to the ways we acquire spatial information.

Sensory modalities

In our studies of cognitive maps we have overlooked the range and number of sensory modalities through which spatial information is acquired, and have ignored the imaginative nature of cognitive processes [...]. The visual, tactile, olfactory and kinaesthetic sense modalities combine to give an integrated representation of any spatial environment. The modalities are complementary despite our intuitive belief [...] that visual information is predominant. [...] The quality of distinctiveness or memorableness is not solely the result of the way the environment looks. [...]

Direct and vicarious sources of information

Sources have a different degree of validity, reliability, utility and flexibility. Direct sources involve face-to-face contact between the individual and, for example, a city and information literally floods the person from all his sensory modes. He must be selective in what he attends

to. [...] Reinforcement and checking are continuous: erroneous beliefs about locational and attribute information are rapidly corrected by feedback from spatial behaviour.

Vicarious information about the city is by definition second-hand. [...] This is true of a verbal description, a cartographic street map, a TV film, a written description, a colour photograph or a painting. In the mapping context these modes of representation, though similar in function, are different in form because they display different signatures. [...] The result of this filtering is a complete representation, which varies with both the individual and his group membership [...]. We may not be able to translate from the signature of the street map back to the spatial environment. [...] Both active and passive information processing are tied to the spatial environment, and result from symbolic elaboration, embroidery and augmentation. [...]

Thus we have three sorts of information available to us at any point in time. Each has distinct characteristics, validity and utility.

A terminology for change

To this point our whole discussion of cognitive mapping has been static – concepts of learning time and change have been omitted. [...] We acquire the ability to know things about our environment through a process of development. [...] Development clearly includes change; taking place over a considerable period, such change is assumed to be irreversible and [...] is also regarded as progressive. Development encompasses both growth [...] and maturation. [...] What effects or learned changes can spatial information induce? Boulding (1956) suggest three possibilities: no effect, simple accretion and complete reorganisation. The no effect case is the most frequent in the normal adult: the information simply confirms what he already knows [...]. Most of the spatial information that we receive, although essential for the successful use of the environment of any point in time, has no effect on the stored knowledge or cognitive map.

A typology of change: accretion, diminution, reorganization

The simple accretion case relates to minor changes to the cognitive map. [...] Both locational and attribute information are added to the cognitive map: a simple additive change has occurred through learning. [...] Diminution develops directly from deletion. There is no need to assume that cognitive maps undergo only progressive

change [...] Either through the passage of time or through maturation we forget – the amount of information available through the cognitive mapping diminishes. [...] All stored knowledge is subject to this time decay: we need to repeat a spatial experience in order to remember the route in the future. [...] Diminution may also be an adaptive process. [...] Given our limited capacity to store and handle information, diminution maybe [...] ensuring that excess information is lost but important information retained. [...]

The most dramatic changes in cognitive maps are the result of total reorganisation. Boulding (1956) suggests that images are relatively resistant to change in their overall nature. It requires an accumulation of contrary evidence before complete reorganisation can occur. [...] The most frequent spatial example of such a complete reorganisation is to be found in long-distance human migration and subsequent residential site selection. [...]

We have examined some aspects of our cognitive maps and how they came to be. We know they are modes of structuring the physical environment [...]. Much of the support in contentions concerning their existence is behavioural, stemming from introspection and anecdotal evidence, but the harder experimental data are beginning to emerge. [...] Thus, the face of cognitive mapping is growing clearer – only the features have yet to be fully filled in.

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Further reading

- Blaut, J.M., Stea, D., Spencer, C. and Blades, M. (2003) Mapping as a cultural and cognitive universal. *Annals of the Association of American Geographers*, **93** (1), 165–185. [A comprehensive meta study reviewing the cross cultural evidence for cognitive mapping as a common human trait.]
- Fabrikant, S.I. and Lobben, A. (2009) Cognitive issues in geographic information visualization. *Cartographica*, **44** (3). [This themed issue includes a number of useful articles focusing upon the application of cognitive approaches to geovisualisation some forty years after the Downs and Stea book.]
- Kitchin, R. (1994) Cognitive maps: what they are and why study them. *Journal of Environmental Psychology*, **14**, 1–19. [A tightly focused and critical introduction to the nature of cognitive mapping.]
- Kitchin, R. and Freundschuh, S. (2000) *Cognitive Mapping: Past, Present and Future*, Routledge, London. [An edited research monograph reviewing research progress thirty years after the heyday of behavioural geography.]
- Liben, L.S. (2009) The road to understanding maps. *Current Directions in Psychological Science*, **18**, 310–315. [Reviews different psychological approaches to map understanding, with a rich emphasis upon contextual differences and their impact on environmental cognition.]

See also

- Chapter 1.3: On Maps and Mapping
- Chapter 1.6: Cartographic Communication
- Chapter 1.11: Exploratory Cartographic Visualisation: Advancing the Agenda
- Chapter 3.3: Cartography as a Visual Technique
- Chapter 3.6: The Roles of Maps
- Chapter 4.9: Understanding and Learning Maps
- Chapter 4.11: Usability Evaluation of Web Mapping Sites

Cognitive maps, alternatively referred to as mental maps or environmental images, refer to people's cognitive representations of the spatial environment. Cognitive mapping has referred to the process of acquisition, amalgamation, and storage of these cognitive representations (Downs & Stea, 1973). As mentioned earlier, the seminal work in this area was conducted by Lynch (1960), who collected cognitive maps of Boston, Jersey City, and Los Angeles. Downs, R. M., & Stea, D. Cognitive maps and spatial behavior: Process and products. In R. M. Downs & D. Stea (Eds.), *Image and environment*. Chicago: Aldine, 1973. Google Scholar. Recent papers in Wayfinding, cognitive maps, spatial orientation. *Papers. People. The Art of Cognition. Infravisual Image Language and the Case of Aboriginal Designs. Cognitive Science with its re-evaluation of schematic imagery, the role of metaphorical cognition and its new understanding of the centrality of embodied categorial structure allows for a fresh, enlightening look at aboriginal more.* This study focusses on understanding the importance of wayfinding behaviours of people in an outdoor environment. The study area is an archaeological heritage site in the city of Delhi, India. Three navigational exercises were conducted to study the wayfinding behaviours among the users. Findings from each of the exercises are compared and evaluated. In contrast to cognitive maps and cognitive collages, these have been termed spatial mental models. Unlike cognitive maps, they may not preserve metric information. Unlike cognitive collages, they do preserve coarse spatial relations coherently. Remembering one spatial location with respect to another leads to direction distortions as well. Two nearly-aligned locations tend to be grouped, in a Gestalt sense, in memory, and then remembered as more closely aligned than they actually were [41]. Students were given two maps of the Americas, one a correct map, and the other, a map in which South America was moved westward with respect to North America, so that the two Americas were more closely aligned.