Progress in Human Geography 20,1 (1996) pp. 56–84

Increasing the integrity of cognitive mapping research: appraising conceptual schemata of environment-behaviour interaction

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This article examines the development of conceptual schemata of environment-behaviour interaction since behavioural geography's inception in the late 1960s. Although these schemata have developed since then, they have remained naive and in many cases conceptually weak, lacking psychological 'depth'. It is argued that this is one of the prime reasons why behavioural geography failed to achieve academic 'take-off'. Ways to increase the integrity of cognitive mapping research are examined by developing and implementing an integrative conceptual schema. This schema draws together five contemporary theories concerning cognitive map knowledge's content, structure and form, the learning strategies used to acquire such knowledge and the processes of spatial thought, and interweaves them with basic transactional theory to produce a more detailed schema of spatial thought and behaviour. It is argued that this schema, by combining contemporary theories into a more complete whole, advances transactionalism by explicitly detailing the mental processes that are used in environment-behaviour interaction. This provides a theory which is framed in cognition *and* human agency, and which is reactive to environmental, societal and cultural contexts. As such, it provides a new theoretical framework for future cognitive mapping research, raising new questions and providing testable hypotheses. In addition, the schema explicitly illustrates how geographical and psychological theory and practice can be combined to provide an integrative framework for cognitive mapping research.

I Introduction

One of the fundamental human needs is the need to know about the surrounding world. Consequently, every individual possesses a unique comprehension of the geographic world and the cognitive mapping abilities to organize and interpret his or her knowledge (Kitchin, 1994). Cognitive mapping concerns the study of this knowledge and abilities, and how we consciously and, more commonly, subconsciously, acquire, learn, develop, think about and store data relating to our everyday geographic environment (Downs and Stea, 1973a).

Cognitive mapping researchers, by using controlled experiments, aim to understand an individual's cognitive map knowledge. For example, geographers traditionally try to discover the constituent components of an individual's cognitive map knowledge, the amount of information known and the factors that affect how an environment, or a representation of an environment (e.g., a map), is learnt and remembered. Psychologists traditionally study the processes used in thinking about geographical or spatial tasks, how knowledge is stored (structure) and the form of that storage (e.g., images or words). Kitchin (1994) reports that there are persuasive reasons for undertaking cognitive mapping research, not least the need to understand how and why we behave in space as we do. Other applications relate to the planning and creating of environments that are easy to remember, and to educational issues concerning the improvement of wayfinding, orientation skills and general geographic skills, such as map reading. Knowledge of how we think about space can also be used to enhance geographic material, such as maps, so they are more easily understood. A number of techniques can be employed to try to gain information concerning cognitive map knowledge. For example, respondents may be asked to draw a sketch map of an area (Blades, 1990), locate points on a base map (Kitchin, 1992), estimate the distance (Day, 1976) or direction (Kirasic *et al.*, 1984) to a series of other locations, recognize aerial photographs (Matthews, 1984), find their way along a route (Passini and Proulx, 1988), verbally describe a route or an area (Vanetti and Allen, 1988) or build a model that represents an area (Hart, 1979). In addition, qualitative talk-aloud protocols are increasingly being used to elicit cognitive map knowledge within geography (Kitchin, 1995), psychology (Ungar *et al.*, 1995) and planning (Gerber and Kwan, 1994).

Currently, cognitive mapping research suffers from a number of theoretical, practical and conceptual validity problems which weakens the integrity of conclusions which can be drawn from such research (Downs and Siegel, 1981; Allen, 1985; Newcombe, 1985; Liben, 1988). Theoretical validity problems concern the integrity of the theoretical constructs and ideas that support and provide the foundations for empirical research. Practical validity problems concern the soundness of the research strategies used in empirical investigation and the integrity of the conclusions that can be drawn from a study. Conceptual validity problems relate to the correct marriage of theory and methodology, so that research becomes philosophically sound and adopts appropriate methodologies of data collection and analysis (Downs, 1970). Often, conceptual validity relates to whether research and its underlying theory has been grounded in a conceptual schema, or a guiding base of ideas and linked hypotheses. Such conceptual schema provide a diagrammatic conceptualization of a theory or a model explicitly demonstrating processes, concepts and relationships. They provide the theoretical framework for empirical research and are, in effect, large multicausal models. Developing a conceptual schema consists of two major practices: integrating or developing a theory and adopting a research strategy (Downs, 1970). The resulting schema should be characterized in terms of three orthogonal dimensions: domain (generalizability), coherency (internal consistency) and complexity (formalization) (Turk, 1990).

In the next section it is argued that research from geography and psychology needs to be integrated in order to strengthen the conceptual validity of cognitive mapping research. Issues relating to the integration of theories from behavioural geography and environmental psychology are explored. In the third section the conceptual schemata of environment-behaviour interaction, developed in the early 1970s, and their transactional successors, developed in the 1980s, are critically appraised. In the fourth section, a new conceptual schema is detailed in combination with a research strategy.

II Providing a theoretical base for cognitive mapping

> . . . we operate on two levels, both as model builders concerned with a particular aspect of our subject and as students of our entire subject. For some, there is but one level: their intellectual curiosity has shrunk to the size of a speciality. Many though are still concerned about this unsettling distinction and about the ways in which different points of view may be composed into a more comprehensive kind of understanding (Papageorgiou, 1982: 346).

Golledge *et al.* (1985) argued that cognitive mapping theories represented general positions rather than formal models, and that empirical studies were often not explicitly tied to a formal model. Such a position leaves cognitive mapping open to criticism concerning conceptual validity. Cognitive mapping research therefore needs its theoretical underpinnings strengthened. Indeed, Allen (1985) has noted the problem, arguing that while there has been no shortage of empirical studies, these have been motivated by hypotheses that are too limited to be of general applicability or too general to have been meaningful hypotheses in the first place. He blamed these problems on the lack of theoretical constructs to provide the conceptual link between theories and testable hypotheses. Similarly, Lloyd (1982) noted that geographical research concerning cognitive mapping has been seriously hampered by the lack of theoretical structures within which meaningful research could be based and empirical findings judged.

It is argued that, currently, theories suffer as they are often too specific (e.g., structure, form, learning strategy) to relate to cognitive mapping in general, or too vague (environment-behaviour interaction schemata) to give rise to testable hypotheses. If cognitive mapping research is to gain acceptance as a worthwhile subject, a sound theoretical framework must exist that unites the multidisciplinary base. This means that cognitive mapping researchers need to adopt an integrative approach to study (Gärling *et al.*, 1991b). Evans and Gärling (1991) hypothesized that the integration of ideas and theories from environmental psychology and behavioural geography may be a fruitful venture because it forces a more synthetic analysis that may reveal points of convergence and divergence among topics of scholarly inquiry. Such an integration, they contend, might help to illuminate useful models and hypotheses, and to shed constraining or unhelpful 'paradigmatic' restrictions.

Hanson (1983: 35) argued that

> . . . only through the process of communication among divergent points of view, will any semblance of convergence ever be achieved or maintained; through discourse the bits and pieces can be fitted into larger structures, and some degree of order emerges from the mess . . . At the heart of this process of change is communication.

However, Hart and Conn (1991) believed that researchers fear such an integration because it cannot be sought easily using the traditional tenets of good theory-building through experimental research design. Nevertheless, Russ and Schenkman (1980) have argued that such integrations form the basis of advancing scientific progress; scientific advancement is dependent upon quick, untested exchanges of ideas and hypotheses, which can later be formalized and tested. Thus, over the past 30 years cognitive mapping research has developed and research now needs to be extensively formalized. The conceptual schema and research strategy proposed in this article is an attempt at such formalization.

In order to provide an integrative framework that will strengthen the conceptual validity of cognitive mapping, it is necessary to investigate how ideas and theories from the two main relevant fields, environmental psychology and behavioural geography, can be integrated, and to note the problems associated with such a merger. Both environmental psychology and behavioural geography are products of the intellectual currents of the 1960s (Gold, 1980) and consequently share a number of characteristics. Both deal with the environment defined and ordered through human actions and, as such, they both include people as an integral part of every problem. In addition, both are multidisciplinary in outlook (Gold, 1980). Furthermore, Spencer and Blades (1986) noted that researchers in the two fields share interests in a whole range of issues, although joint research remains rare. In addition, the disciplines share research techniques and are attempting to apply their research to the same types of applications. For example, work can be found in both disciplines relating to environmental cognition, environmental assessment and environmental behaviour (Gärling and Evans, 1991; Gärling and Golledge, 1993a). A key difference, on the other hand, between the two disciplines lies in their relationships to their parent disciplines. Behavioural geography represented a challenge to the 'peopleless' geographies of spatial science and the excesses of the quantitative revolution, with the main impetus being the dissatisfaction with the stereotyped, mechanistic and deterministic nature of many of the quantitative models being developed, and a realization that not everyone behaved in a spatially rational manner. Environmental psychology, in contrast, was a self-conscious attempt to apply psychology to new contexts and as such sought to study behavioural processes in real-world settings (Gold, 1980). As a result, while environmental psychology has been assimilated into mainstream psychology, behavioural geography has still not achieved such assimilation despite many pieces of research adopting behavioural approaches and characteristics (Sell, 1994).

The most notable difference between geography and psychology is the scale of analysis. Psychologists tend to take a comparative and developmental approach, using individual data, and are concerned with the underlying processes of cognition of the environment and its phenomena (Spencer and Blades, 1986). Geographers, on the other hand, are more spatially based, dealing with groups of individuals at the macroenvironment scale. Rather than asking the 'how' questions often asked by psychologists, geographers are more interested in 'what', 'where' and 'why' questions, and the reasons for the resultant patterns, especially in real-world situations. However, in recent years geographers have become more interested in these 'how' questions. As a result, geographers have shifted the emphasis of their research to tackle these questions and are much more willing to undertake and integrate psychological approaches into their work. Psychologists, until recently, have remained fairly impervious to the geographic literature outside that published in psychology journals. A glance at the bibliographies of articles in psychology journals reveals few references to geographic work. In the past there have been joint publications (Downs and Stea, 1973a; Moore and Golledge, 1976; Golledge and Rayner, 1983) but often both sets of contributors wrote separately about their research, rather than reporting collaborative work. Recently, there have been emerging arguments concerning co-operation, with calls to bring the disciplines closer together (Gärling and Evans, 1991; Gärling and Golledge, 1993b; Kitchin, 1993). It is hoped that this move towards integration will continue with increasing collaboration between researchers in each field.

Downs *et al.*'s (1988) and Downs and Liben's (1991) work are good examples of collaborative research examining how cognitive development can be applied to geographic education. Problems, such as the misuse of terms, ideas and methodologies from psychology by geographers, have generally ceased as attempts have been made to identify and eradicate this practice (see Kitchin, 1994).

On the basis of reviews of both disciplines (see Gold, 1980; Golledge, 1981; Saarinen *et al.*, 1984; Aitken *et al.*, 1989, for behavioural geography; see Craik, 1970; Proshansky and O'Hanlon, 1977; Stokols and Altman, 1987, for environmental psychology), there seems to be little problem with integrating the two subject areas (Kitchin, 1993), especially if a multidata collection, multianalysis approach is adopted which incorporates research techniques preferred by both subjects. The philosophical underpinnings of environmental psychology and behavioural geography generally seem compatible, and many of the ideas and research techniques that exist in both subject areas overlap. Certainly there are differences in the research approaches, but there is a trend towards convergence and this is likely to continue. For example, many psychologists now use real-world naturalistic tests (Evans *et al.*, 1984; Gärling *et al.*, 1991b; Spencer *et al.*, 1992), allowing the work of both sets of researchers to be compared. With careful thought an integrative cognitive-mapping research field therefore seems plausible, with Gärling and Golledge (1993b: 1) stating: 'We . . . hope this book is instrumental in tearing down existing communication barriers [between geography and psychology]. The other barriers we leave to others to remove'. This article is an attempt to investigate and remove such barriers by combining theories from both subjects with research from other disciplines, such as planning and anthropology, to provide a truly multidisciplinary conceptual schema of cognitive mapping.

III Appraising the conceptual schema of environment-behaviour interaction

One of the first schema of environment and behaviour interaction was developed by Kirk (1963) (Figure 1). His schema attempted to introduce gestalt theory into a geographical

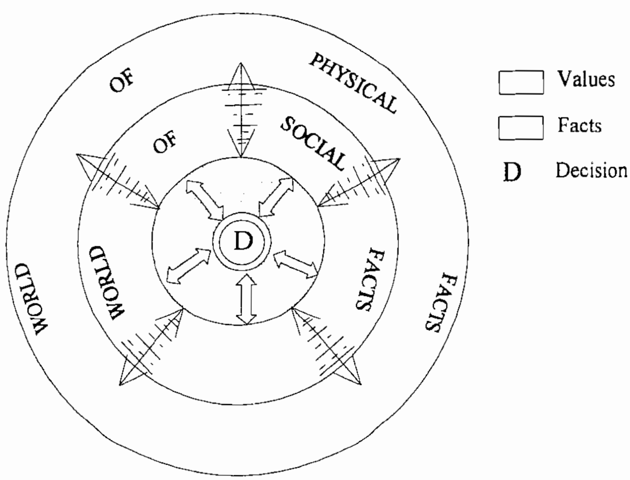

Figure 1 Kirk's (1963) schema of the behavioural environment of the decision-maker
Source: Gold, 1980

context and, in keeping with gestalt theory, he made a distinction between the objective and behavioural environments (Gold, 1980). The objective environment consisted of the physical world around us, and the behavioural environment was the '. . . psycho-physical field in which phenomenal facts are arranged into patterns or structures and acquire values in cultural contexts' (Kirk, 1963: 366). Kirk believed that the behavioural environment was the basis for rational human behaviour and, as such, he combined two traditional beliefs: that of rational decision-making in geography and perceptual principles of gestalt psychology (Gold, 1980). The schema was, however, constrained because of this belief that decision-making is based upon a rational appraisal of a total situation, therefore allowing no individual idiosyncrasies (Gold, 1980). The individual was thus a behavioural equivalent of the rational individual of neoclassical economics.

Kirk's schema was rejected early on by behavioural geographers as researchers sought to replace the 'peopleless' models of positivism with theories that took account of human agency (Gold, 1980). The first main conceptual schema after Kirk's (1963) was that proposed by Downs (1970). Downs regarded the individual as a passive receiver and processor of information. Subsequent behaviour is thus a function of the real world and the decision-making process is dynamic, constantly changing with the receipt of new information. However, no a priori assumptions are made about the perception or cognition processes used in interacting with the environment (Walmsley and Lewis, 1993), Downs (1970) describing the interface between environment and behaviour as a 'black box'. The conceptual schemata he formulated replaced this black box with a 'white box' in which the variable nature of humanity is recognized as being of fundamental importance. The rational individual is thus replaced by a more complex individual capable of independent decision-making within the confines of information received.

In Downs' (1970) schema (Figure 2) the boxes represent concepts and the directional arrows the link between these concepts. Downs recognized the schema as being over-simplified and nonoperational in the sense that it did not lead directly to testable hypotheses. It did, however, make explicit the relationships which had been discussed in earlier work. Downs explained that the starting point for the schema is taken as the real world, which is the source of information. This information is filtered through a system of perceptual receptors which are essentially the five main senses. Meaning is given to the information through an interaction between the individual's value system and his or her stored 'image' or cognitive map knowledge of the real world. The remaining filtered information is then used to update the cognitive map knowledge and to formulate a behaviour decision. This decision leads to either a reiteration of the whole process,

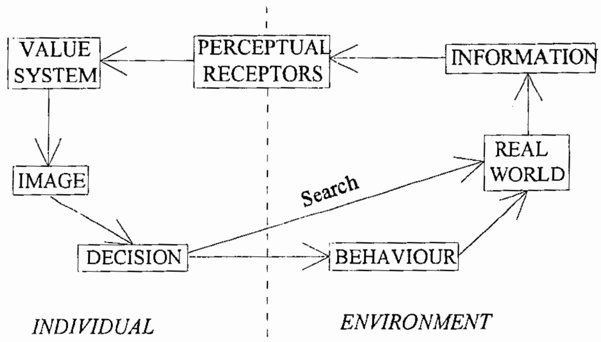

Figure 2 Downs' (1970) conceptual schema of cognitive mapping

creating another search for information from the real world until sufficient information has been acquired or some time/cost limitation acts to constrain the search, or to overt behaviour. As a result of the latter, the real world undergoes a change, fresh information becomes available and the whole process begins again.

Pocock's (1973) conceptual schema was an elaboration upon Downs' original. It was divided into three main sections, each consisting of inter-related components (Figure 3). The first section was the objective environment and comprised three sets of stimuli: previous information, present context and the actual environment. In combination these influence the information reaching the second perceiver stage. The perceiver stage comprised four sets of factors: basic physiological make-up, basic psychological organization, cultural characteristics and the current state of the individual. These factors, in combination, were seen to act as filters, selecting which information received is processed

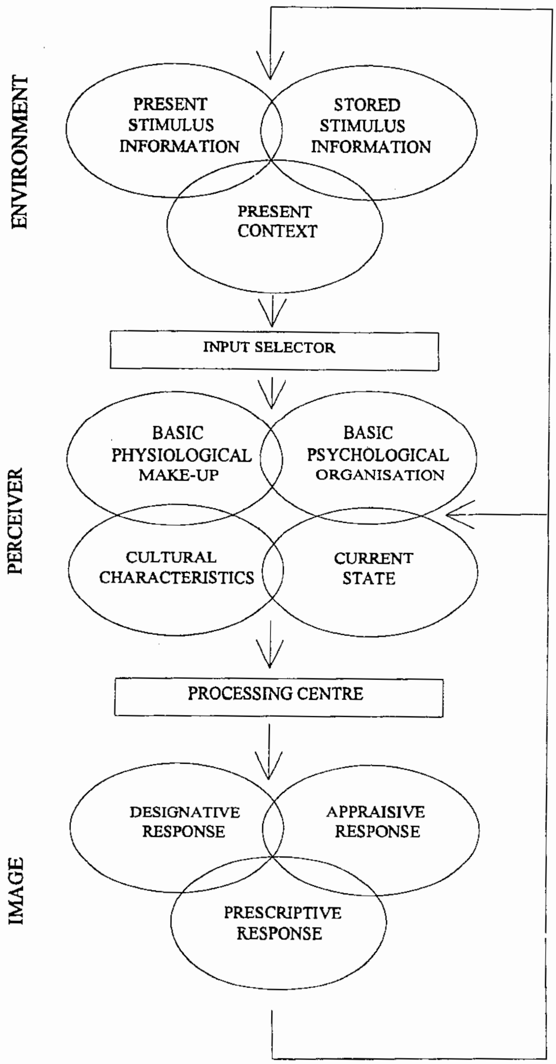

Figure 3 Pocock's (1973) conceptual schema of cognitive mapping

and used. As such this represented a considerable improvement upon Downs' original schema as the individual was no longer seen as a passive receiver but took a more active role in selecting and processing information. The third section was the 'image' and represented the output from the processing centre. These were three inter-related types of response: designative response, concerned with description and classification; the appraisive emotional aspect, concerned with feeling, value and meaning; and the prescriptive aspect, relating to predictions and inferences which give the image meaning beyond that justified by the experience of a particular scene alone. Feedback was distributed back from the image to the environment and perceiver in a cyclical system.

Lloyd (1976) and Pacione (1978) also added to Downs' original schema. Like Pocock they recognized that individuals can be selective in the information they use but they made little progress beyond this point. Lloyd's complex schema emphasized the role of preferences in affecting individual behaviour within the environment (Figure 4). Pacione added two stages to Downs' original schema (Figure 5), suggesting that the perceptual filters interact with the incoming stimuli through physiological, social and cultural factors. He also explicitly incorporated the time and cost constraints imposed by internal and external factors upon choice. Nonetheless, it seems that by this time conceptual develop-

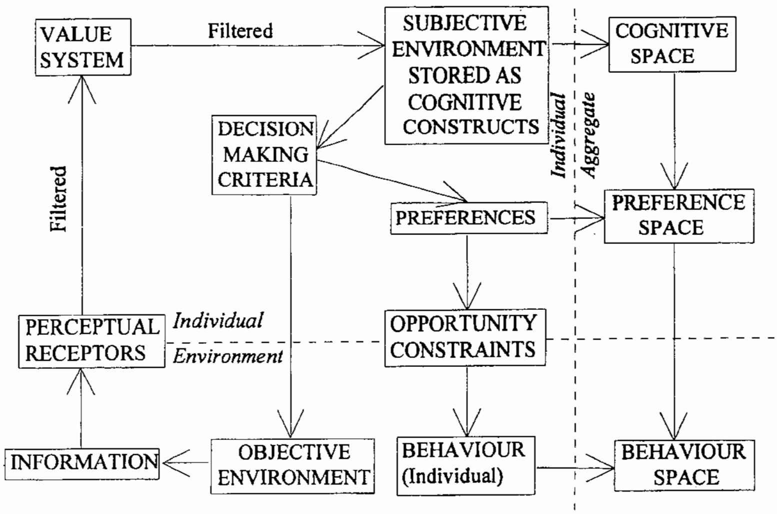

Figure 4 Lloyd's (1976) conceptual schema of cognitive mapping

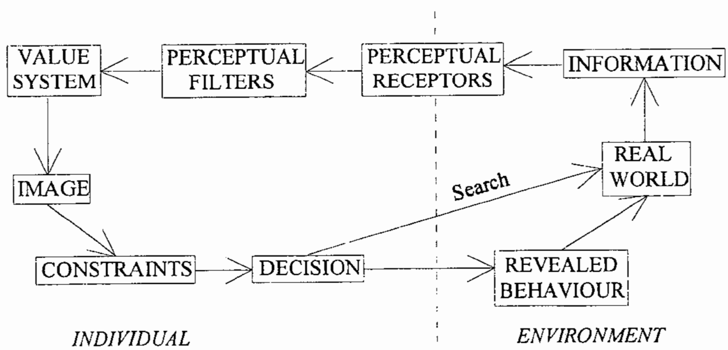

Figure 5 Pacione's (1978) conceptual schema of cognitive mapping

ment had stagnated in behavioural geography. The schemata suggested that the pattern of human phenomena on the earth's surface was best understood by examining the thoughts, knowledge and decisions which influence those phenomena, rather than studying the phenomena themselves (Golledge and Rushton, 1984), but at the same time, cross-fertilization of ideas to help us understand these influences became less common as psychologists were concerned with establishing environmental psychology as a sub-discipline in its own right. All four conceptual schemata consequently came to be seen as uncritically universal and reductionist, psychologically naive, oversimplistic and not providing testable hypotheses or establishing a firm basis for novel research. In addition, the schemata were criticized as being dehumanizing and ignorant of the broader social and cultural context in which decision-makers operate (Ley, 1981). As a result, behavioural geography was severely criticized (see Bunting and Guelke, 1979) and, despite spirited responses by Downs (1979), Rushton (1979), Saarinen (1979) and Golledge (1981), started to fade from mainstream human geography.

Nevertheless, there was conceptual progress in some quarters. Gold (1980) produced a more complex conceptual schema which was further refined by Golledge and Stimson (1987) (Figure 6). Like Kirk (1963), they postulated that an individual is simultaneously part of both objective and behavioural environments, receiving locational and attributive information from the latter and making decisions based upon this information which may affect both environments. Unfortunately, this elaboration did not do enough to revive

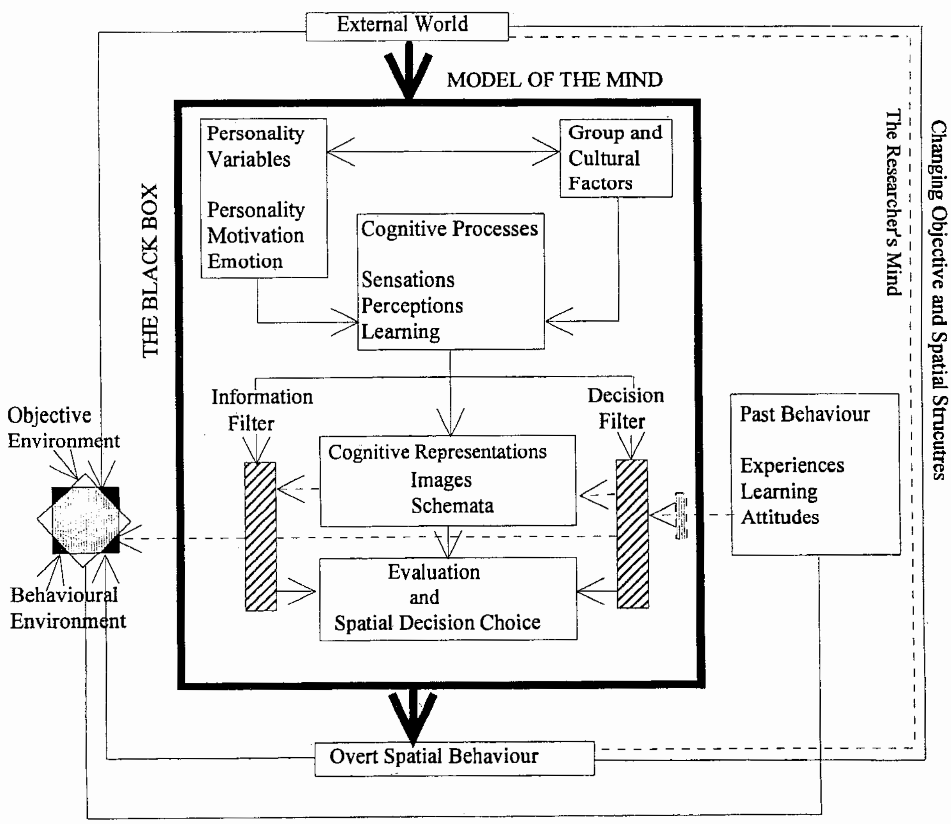

Figure 6 Gold's (1980) conceptual schema of cognitive mapping

behavioural research and, like previous schemata, failed to give rise to *specific* testable hypotheses or provide a firm basis for empirical research.

Further afield, the mid-1970s' cognitive psychologists, such as Neisser (1976), were challenging these successive, information-processing schemata beloved by behavioural geographers. He suggested that an individual actively and selectively searches the environment to gain information (Figure 7). Unlike the successive schemata developed within behavioural geography, Neisser argued that the elements within a conceptual schema are embedded and that relationships parallel the real objects with which they deal. He suggested that individuals use an anticipatory schema, which structures which information is acquired, based upon the required action. This anticipatory schema is rooted in past experiences and present beliefs, and is constantly changing with both increasing experience and the required behaviour. He described a schema as an active, information-seeking structure which directs action, with the cognitive map schema just one of a number of schema which may be active at any one time. The example he used was that of a room and a lamp: just as a room has a cognitive map schema, the lamp also has a schema. Both are simultaneously active, with the latter embedded in the former. Neisser (1976: 113) explained that

> . . . each is a phase of a cyclic interaction with the environment; both interactions occur continuously. They cannot comfortably be separated. I could view the lamp without a surrounding room, but my perception will always be guided by some general cognitive map as well as a specific perceptual schema . . . [Thus] actions are hierarchically embedded in more extensive actions and motivated by anticipated consequences at various levels of schematic organization.

Individuals are therefore discriminatory and active selectors of only that information which

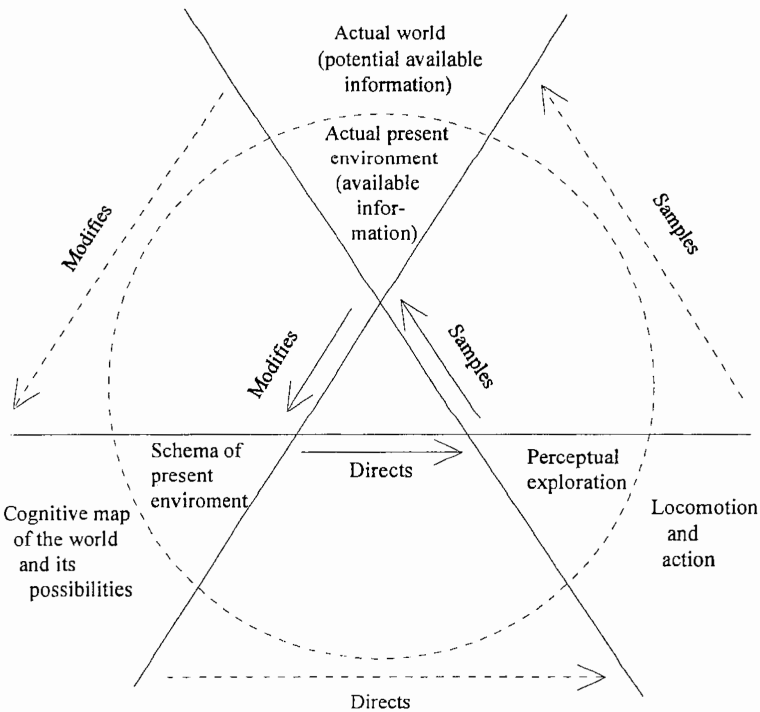

Figure 7 Neisser's (1976) conceptual schema of cognitive mapping

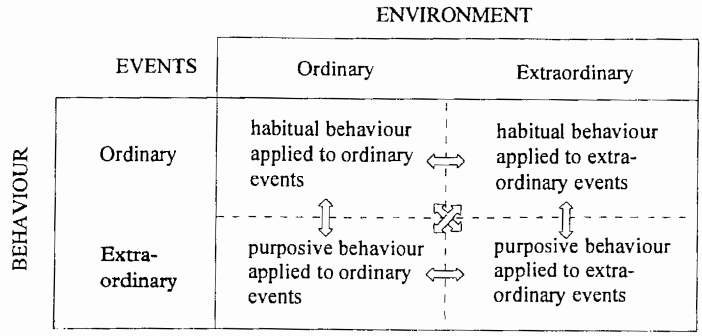

Figure 8 Aitken and Bjorklund's (1988) modes of behaviour/environment transaction and transformation

is relevant to their present needs. Neisser's conceptual schema represents 'transactionalism' or the view that an understanding of person-in-environment contexts must take on board an appreciation of ongoing transactions between the person and the environment, based upon both past events and future expectations (Aitken and Bjorklund, 1988). The previous information-processing schemata allowed no account of future events and only minimum selective perception. Transactionalism has increasingly been adopted in the study of environment-behaviour interaction, both within geography (Sell *et al.*, 1984; Aitken and Bjorklund, 1988; Aitken, 1991; 1992) and in psychology (Wapner, 1981; Altman and Rogoff, 1987).

Aitken and Bjorklund (1988) developed two related transactional conceptual schemata. The first concerned the different modes of person/environment transformation (Figure 8). They argued that environments are dynamic and variable systems and that we seek to maintain an acceptable level of homeostasis within them. To do this we constantly change our behaviour, restructuring ourselves relative to an event. This change can be habitual or purposive. Figure 8 identifies four modes of possible person/environment relations. Aitken and Bjorklund suggested that the categories are not mutually exclusive, nor exhaustive, and no assumptions were made about the relative frequency or sequence of the modes. They argued that individuals changed modes and their ability to process information and correspondingly cope with situations under different degrees of environmental and contextual stress. The key to these behavioural transformations was human agency, as individuals seek to make sense of their surroundings. As such, individuals were seen as being goal directed, given to anticipating events and to constructing a mental reality which organizes an environment and endows it with meaning (Aitken and Bjorklund, 1988).

Aitken and Bjorklund's (1988) second schema details human behaviour as it mediates change (Figure 9). In the schema, change prompts an individual to search for and to select information, and to try to anticipate and evaluate behaviour in a new context. Once again, the intention is to maintain equilibrium and to reduce stress, using either negative feedback (seeks stability) or positive feedback (seeks change and adoption of new equilibrium level). Both feedbacks are analogous to purposive behaviour. Aitken and Bjorklund did not, however, describe the mental processes used to process such information beyond the use of schemata.

Transactionalism has the potential to provide the basis for a rejuvenation of behavioural approaches and ideas, leading to the productions of geographies of everyday life, by acknowledging the changing contexts within which individuals operate. This allows

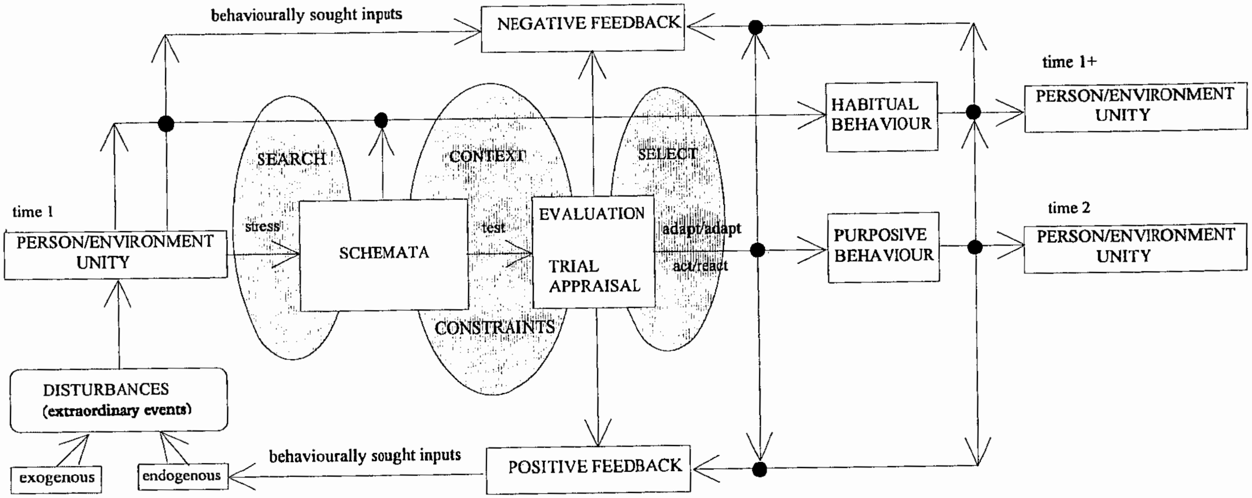

Figure 9 Aitken and Bjorklund's (1988) conceptual schema of human behaviour at the person/environment interface

behavioural approaches to incorporate broader aspects of culture and society. Indeed, Aitken (1992: 557) has stated that 'transactional and transformational theories are likely to have a strong influence on future directions in social science as researchers become increasingly aware of the limitations of relying exclusively on static, decontextualized models'. However, Altman and Rogoff (1987: 37) concluded their review of transactionalism with a cautionary note:

> The lure of the transactional approach is simultaneously coupled with a sense of uncertainty. How does one build a theory of holistic, changing phenomena? What methods can we use to study phenomena at a holistic level? How do we incorporate change and temporal factors as part of psychological phenomena?

Stokols (1987) argued that these questions pose an ambitious but promising agenda for future research and the schema outlined in the next section is an attempt to build such a transactional schema which details how we think about and interact with geographic space, incorporating a description and explanation of the mental processes missing from Aitken and Bjorklund's (1988) work.

In contrast to the 'universal' schemata described above, there have been several theories concerning cognitive map development, such as those of Piaget and Inhelder (1956), Werner (1957), Hart and Moore (1973) and Siegel and White (1975), which have generated testable hypotheses and many empirical studies. In addition, theories exist concerning learning strategies (e.g., landmark based (Golledge, 1978), route based (Allen, 1981)); constituent components (Golledge, 1993); knowledge structures (Liben, 1981; Thorndyke, 1983); the structure of cognitive map knowledge (e.g., networks (Kaplan, 1973), hierarchical (McNamara, 1986), partial hierarchical (Stevens and Coupe, 1978)); and the form of cognitive map knowledge (e.g., images (Kosslyn and Pomerantz, 1977), propositions (Anderson and Bower, 1973), dual coding (Paivio, 1979), genetic coding (Fishbein, 1976)). These theories have been successful in generating attendant research because they all focus upon very specific features of a larger whole and explicitly lead to testable hypotheses by detailing the actual processes involved. However, the theories tend to exist as separate subareas of study and have not, as yet, been interwoven to create a conceptual schema which provides an adequate account of cognitive mapping as a whole. The conceptual schema outlined below combines five of these theories into one integrative theory in an attempt to provide such a basis for future research.

IV A proposed conceptual schema of environment-behaviour interaction

It is apparent from the previous discussion that a new integrative conceptual schema is needed to provide the theoretical basis for future cognitive mapping and behavioural research. Currently, conceptual schemata are oversimplified and do not explicitly detail the relationships and the processes of communication between elements. In addition, contemporary cognitive mapping research is fragmented (Portugali and Haken, 1992) and focuses on specific aspects of environment-behaviour research. There is a need to draw these disparate theories together to form a more coherent whole in order to gain insights into the whole process of spatial thought and behaviour. Hence, the conceptual schema outlined here is an attempt to provide a consistent theoretical and integrative framework for empirical research, drawing upon theories from both geography and psychology. It was developed to form the theoretical basis and provide testable hypotheses for a large-scale study of 170 undergraduates' configurational knowledge of relationships and associations between places in the Swansea area (Kitchin, 1995).

The schema rests on four premisses. First, an individual is a decision-maker, actively making conscious decisions, setting goals and performing tasks which he or she then uses to respond to and guide behaviour in the environment to achieve those goals. The goals are constantly changing based upon the information which is continuously acquired. Secondly, behaviour is a function of both the real and subjective worlds. Consequently, sometimes individual reactions are deterministic, in that one's options become limited and constrained. Such limitations can be imposed by the environment (for example, there may be only one safe route down a mountain); economic factors, such as the cost of travel; social factors, such as employment; or by other constraints, such as the built environment or time. However, although these constraints are recognized, for the majority of the time individuals have the capacity to use and process the information received from the environment in order to construct self-made decisions. Thirdly, an individual is an active perceiver. He or she is a discriminating and active selector of real-world information, using past experiences and present beliefs to filter out the information required. An individual does not just passively receive information and react to this, but selects what is thought to be important and processes information in the light of previous encounters and future expectations. Fourthly, the whole system is dynamic and embedded. Information is constantly recycled and reprocessed, with many problems and scenarios being simultaneously processed in parallel. The whole cycle linking thought and behaviour is thus in a constant state of flux.

Five main theories are drawn upon to form the basis of the conceptual schema. The first theory to be incorporated into the conceptual schema is Golledge's (1993) 'cognitive counterparts theory', where he hypothesized that the constituent elements of physical reality will have cognitive counterparts. His theory details a comprehensive mental database which consists of seven components whose complexity and spatial structure differ. Golledge's first component concerns the individual occurrences of phenomena. In physical reality, phenomena such as buildings and landmarks exist as unique occurrences. These are characterized by *identity*, which is a name or label that can be attached to a phenomenon. Such identity can be made place specific, signified by a unique location, or class specific, signified by a generic label. Each phenomenon also has a *location*. In physical reality these locations remain fixed but in cognitive space frames of reference may become altered so that they are stored egocentrically, allocentrically, topologically or even multidimensionally, rather than within strict co-ordinate systems. The *magnitude* of a phenomenon will also vary so that, just as phenomena in physical reality vary in size and volume and are categorized as such, phenomena within cognitive map knowledge will also differ. Lastly, each phenomenon also exists in *time* as well as space (Golledge, 1993).

Places in reality are often connected together by routes or pathways and it is likely that such connections exist in cognitive map knowledge as well (Couclelis *et al.*, 1987). Spatial linkage and connectivity therefore form linear elements, which are thought to be the second basic component of cognitive map knowledge after individual phenomena. A higher level of organization in physical reality is a spatial distribution, which occurs when phenomena are grouped through common identity, magnitude, temporal or functional characteristics in order to expose a pattern or arrangement. Properties of spatial distributions include density, arrangement and the spatial variance of a set of phenomena (Golledge, 1993). Such a process is also likely to occur in cognitive maps, where people may store in memory distributions of selected phenomena for specific uses (Couclelis *et al.*, 1987).

Spatial contiguity relates to the spatial separation and connectedness between phenomena. Distance between locations is important because it is the concept that links places in both cognitive and physical space (Golledge, 1993). Places in physical reality and cognitive maps can be described as being proximal, clustered or separated. Places close to each other are likely to have some spatial association, that is, some common link that makes them more alike. Distances in the cognitive map may differ from physical reality with symbolic, topological, projective spatial relations existing rather than Euclidean relations (Cadwallader, 1979; Tversky, 1981).

When we classify a set of common phenomena, it is usual to stratify the data into classes in a hierarchical ordering. An example from physical reality would be that cities are larger than towns, which are larger than villages which are larger than hamlets (Golledge, 1993). The reason for this stratification is to try to impose an order on reality to help understand the geographic world. It is possible that cognitive map knowledge performs the same kind of categorization, but might be based on both subjective judgements and physical facts (Stevens and Coupe, 1978; Hart and Berzok, 1983). Physical reality is a complex structure of phenomena, involving many spatial components, and it is likely that very few people actually possess a comprehensive cognitive spatial structure which contains all the information about locations, distributions, densities, dispersions, patterns, connections and hierarchies (Golledge, 1993).

The second theory to be incorporated into the conceptual schema is that knowledge is stored within a partial hierarchical structure. Partial hierarchical theories allow relations to be encoded between information in different branches of the hierarchy. It is argued that such a strategy increases the speed and accuracy with which certain estimates could be made (McNamara, 1986). Most evidence for the presence of such hierarchies comes from the analysis of errors that people make when completing cognitive mapping exercises.

Downs (1970) was the first to propose a hierarchical structure to cognitive map knowledge, and argued that the use of each hierarchy varies according to intended space use. Cox and Zannaras (1973) suggested that these 'superordinate' structures could influence people's spatial and nonspatial cognitive estimates, and Stevens and Coupe (1978) found specific evidence of this. In the latter study, respondents were asked to indicate from memory the direction to one USA city from another. They discovered that some interesting systematic errors were occurring. One of these concerned the direction from San Diego in California to Reno in Nevada where most people thought, incorrectly, that Reno was east of San Diego. Stevens and Coupe argued that this result occurred because cognitive map knowledge is stored using a hierarchical system. In this system, we store the relative location of the states, and then store cities by the states that contain them. When asked to make direction judgements between cities, we do not compute them directly but rather infer them from the relative positions of the states they are in (Tversky, 1992). Because California is generally west of Nevada, the inference is that all cities in California are west of Nevada cities, which is of course incorrect.

A second piece of evidence for a hierarchical system comes from reaction times used in making estimates. Wilton (1979) found that respondents took longer to verify truth statements, such as 'Edinburgh is north of Sussex', when places were in the same category or branch than when they were in separate branches. Maki (1981) found the same results in judging directions to cities in different USA states. It seems that because the places are in different categories, and therefore different branches, it is easier to infer the direction: Edinburgh is in Scotland, Sussex in England, Scotland north of England, Edinburgh north of England. Places in different branches have to be thought about.

Howard and Kerst (1981), McNamara (1986) and McNamara *et al.* (1989) have all shown evidence of hierarchical structuring by identifying clusters in respondents' spatial products. Hirtle and Jonides (1985) discovered evidence of subjective cluster membership, with across-cluster distances overestimated and within-cluster distances underestimated. Allen (1981) found evidence that route knowledge was segmented and that across-segment distances were consistently judged longer than identical within-segment distances. This suggests that each segment contained independent information, but that this information existed within a framework, that is, a hierarchical structure. Chase and Chi (1981) reported that normalizing errors by respondents differed between learnt hierarchically grid-based maps and nonhierarchical maps, and McNamara and LeSueur (1989) found that respondents created their own spatial hierarchies when no physical or perceptual boundaries existed. In addition, they found that targets preceded by close primes (high-order nodes within the hierarchy) were recognized faster (McNamara and LeSueur, 1989). Similarly, Hirtle and Mascolo (1986) have found evidence of clustering where no spatial boundaries existed, so that respondents remembered semantically related locations as being closer together than unrelated locations. Just and Carpenter (1985) noted that it is difficult to imagine a whole map in detail and they suggested the way we cope with this is to create a 'window' on the composite area we are interested in. They contended that we have embedded systems, so that we move up and down through a hierarchical system to deal with situational demands. They suggested that this occurs because of the limited capacity of working memory. McNamara *et al.* (1989) argued that this hierarchy reflects the store and not the recall strategy, as different patterns of distortion would have arisen from hierarchical structures only imposed during the recall task (McDonald and Pellegrino, 1993).

Further evidence of a hierarchical system comes from work examining differences in spatial ability and the effects of barriers on distance estimation. Distance estimation to locations separated by a barrier are generally higher than if the barrier was removed. Such evidence suggests that the barriers may have been acting as the boundary between regions and, as such, branches in the hierarchy. Evidence for this effect can be found in many studies using both metric distance estimates and distances derived from ranking. For example, Kosslyn *et al.* (1974), Cohen *et al.* (1978) and Newcombe and Liben (1982) found that barriers increased the distance estimates between places.

The third theory to be incorporated into the conceptual schema is Golledge's (1978) 'anchor-point theory'. Golledge (1978) proposed that, in addition to storing data in a hierarchical manner, we used such a strategy to learn new information. He suggested that different places have different salience to different individuals, so that as we gather information we 'attach' it to other previously stored information. Golledge *et al.* (1985) identified four main levels of cues, upon which other data are attached. Primary nodes act as spatial primers and are the anchors upon which other information is 'hung'. They act as spatial mnemonics, increasing the probability of recognizing or knowing the position of an associated target cue. Other landmarks have lower levels of use and recognizability (Golledge *et al.*, 1987), acting as minor anchors for the levels below. Secondary nodes identify places of decision-making, recreation and entertainment, such as major junctions, parks and cinemas. Tertiary nodes are usually places of minor decision-making, such as little-used junctions or other known landmarks. Minor-order nodes are places that are specifically known but which do not act as decision-making points. Often these are unique to the individual. Couclelis *et al.* (1987) expanded upon Golledge's work, suggesting that nodes within the hierarchy may not necessarily represent landmarks but may include any feature that acts as a cognitive map cue or anchor. For example, a stretch of main road may act as a cue. Similarly, Gärling *et al.* (1986) suggested that it might be better to consider reference points not as points but as areal extents, so that they become topical areas. These areas then act as the anchors for the rest of the cognitive map knowledge.

The fourth theory to be incorporated is 'dual coding', which suggests that cognitive map knowledge consists of both images and propositions. Paivio (1979) postulated two interconnected memory systems, verbal and visual, that operate in parallel. Concrete pictures and words are stored in both visual and verbal memory but abstract material is only represented in the verbal system (Lloyd, 1982). Kosslyn *et al.* (1977) suggested that these memories work in a parallel-processing 'race' fashion, whereby one retrieves and processes visual imagery and conceptual-proposition information at the same time. The process that runs to completion first will provide the information needed. MacEachren (1992) found evidence of this, when a group who learnt routes but who were unable mentally to rotate their knowledge responded more quickly in their estimates of distance than a group who could mentally rotate their knowledge. He concluded from this that the first group were able to retrieve distance information by some nonanalog process that did not take increasing time with distance. He argued that nonrotators had difficulty with visualizing the learnt map and so coded their maps in a nonanalog fashion, thus the faster reaction times owing to less processing.

Similar types of findings have been found elsewhere. Hintzman *et al.* (1981) argued that direct learning through interaction or learning from multiple perspectives leads to proposition memory, whereas single orientation, such as map learning, leads to analog memory. McNamara *et al.* (1984; 1992) concluded from their spatial-priming experiments that spatial and nonspatial information may be integrated into the same memory representation used to solve cognitive mapping problems, which suggests a dual-coding strategy. Morrow and Ratcliff (1988) reported that patients with neglect problems of long-term memory displayed dual-coding characteristics. When tested using imaginal and nonimaginal strategies, these patients gave different responses depending upon which of the two abilities they had neglect of. In contrast, respondents without neglect problems did each task equally well. Farah (1988), likewise, came to the conclusion, based upon patients' lack of topographic orientation, that cognitive maps did not just consist of mental images. Lastly, Eddy and Glass (1981) also concluded that information is stored using a dual-coding strategy. Using imagery and no-imagery sentence tests they found that respondents relied on imagery to verify sentences that required imagery to answer (e.g., is a grapefruit larger than an apple) but did not on nonimagery questions (e.g., salt is used less often than pepper).

The fifth theory to be incorporated into the conceptual schema involves the idea that mental schemata are used to access knowledge. Such schemata represent both how knowledge may be structured and how we think about the everyday geographic environment. They are seen as a useful concept because they define memory in ways that approximate to how the world is organized (Zimring and Gross, 1991). Essentially, they are structured abstract formats for representing different kinds of knowledge, reflecting our limited abilities to process the perceptual world, and thus act as an automated way of processing everyday data. They are able to do this by acting as a framework or outline of essential information necessary to be able to act or define a place or concept (Medyckyj-Scott and Blades, 1992). Individuals construct schemata of everyday situations and use them when they encounter those situations. These schemata influence what we expect to see, what we look for and how we respond (Mark, 1989).

Brewer and Treyens (1981) have suggested that there are a number of ways in which schemata could influence memory performance, including the memory for places. The schemata could determine which pieces of information are viewed and encoded; they may serve as a framework for the selective retention of material and could aid in the integration of new and old knowledge; and they may be used to guide the search for information in memory and may influence the subset of information selected for answering a query, giving instructions or any other form of external expression. Cox and Zannaras (1973) and Axia *et al.* (1988; 1991) proposed that place schemata have an embedded hierarchical structure, which is likely to be based upon areal units. For example, we have schemata concerning the structure of hamlets, villages, towns and cities. Tuan (1975) suggested that some global schemata may be passed on genetically, but that other global and all local schemata are learnt through experience.

The existence of schemata would certainly suggest how individuals can operate within an unfamiliar city by applying their knowledge about the structure of other cities. In general, it provides a useful theory as to how knowledge is used to guide spatial behaviour. It can also be hypothesized that schemata could be the way in which individuals think about cognitive mapping data, allowing updating and retrieval. However, it does not explain the choice of an appropriate route from two unknown routes where the destination cannot be seen. Instead it concentrates on how to handle such a situation.

The overall schema proposed here (Figure 10) is divided into three sections, all of which are intricately linked and entwined. Like Neisser's (1976) schema, these sections are seen as being embedded rather than successive. There is no start and end point and, although portrayed as stages in a successive order, subunits can be running in parallel to each other rather than waiting for information from another section. For example, the working memory continually operates, rather than sending a request to the long-term memory and waiting for a response.

The first section is the 'real world' and represents the environment individuals are interacting with. Unlike Kirk's (1963) or Gold's (1980) proposals, a behavioural environment is not portrayed in the schema, although it is suggested that such an environment is constructed within the working memory, based upon the 'real world', and information from the long-term memory, and this aids in the formulation of overt behaviour. The 'real world' has been divided into two sources of information: primary or environmental interaction and secondary or social interaction. These represent the factors that individuals interact with that influence cognitive map knowledge and provide information upon which to base decisions (Table 1). In the proposed schema the environmental and social interaction parts are portrayed as two different entities but there is interaction between the two, represented by the broken arrows. Table 1, although not comprehensive, lists the factors that researchers have found to be significant in influencing cognitive map knowledge in the last 30 years.

The primary or environmental interaction sources can be further divided into three parts. P1 represents environmental sources that are generally unalterable by individuals. These include the macrotopography of an area or the physical straight-line distances between places. P2 factors are environmental sources that are alterable by humans in the sense that they are human-made structures which are often changing with time. Examples include the number of turns along a route, types of landmarks encountered, place-size and structure. The third group, P3, are environmental interaction sources such as direction travelled, mode of travel and functional distance. These change dependent upon the route choice. The secondary or social interaction sources are a collective of everyday social sources of information and circumstances that people interact with. Examples include

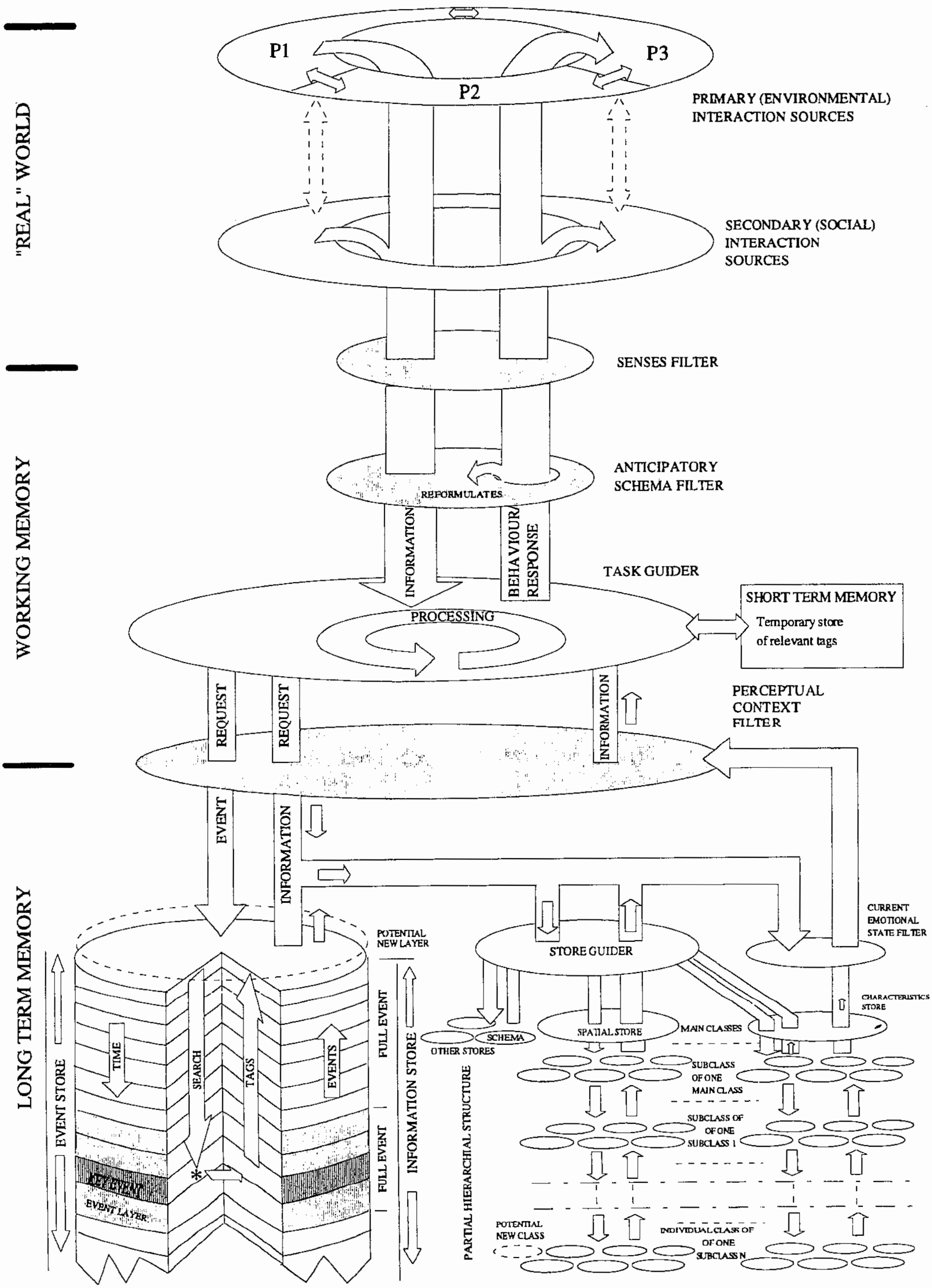

Figure 10 A proposed conceptual schema of cognitive mapping

Table 1 'Real world' factors that affect cognitive mapping research

Sources			Examples
Primary (environmental) interaction sources	Unalterable environmental sources	Physical topography	Canter (1977); Cohen *et al.* (1978)
			Cadwallader (1973);
		Physical distance	MacEachren (1980)
	Alterable environmental sources	Number of turns	Golledge *et al.* (1969); Staplin and Sadalla (1981)
		Number of intersections	Sadalla and Staplin (1980)
		Place size	Lynch (1960); Briggs (1973a)
		Place structure	Antes *et al.* (1988)
		Number of landmarks	Golledge *et al.* (1985)
	Environmental interaction sources	Direction travelled	Briggs (1973b)
		State of traffic flow	Saisa *et al.* (1986)
		Mode of travel	Golledge (1992)
		Functional distance	Day (1976); Montello (1991)
		Travel time	MacEachren (1980); Coshall (1985)
Secondary (social) interaction sources		Social mediation	Gärling *et al.* (1985)
		Verbal mediation	Hart (1981); Blades (1991)
		Media sources	Golledge (1976); MacEachren (1991)
		Map use	Thorndyke and Hayes-Roth (1982); Lloyd (1989)
		Education	Saarinen *et al.* (1988)

social events, such as social and verbal mediation, the media and education, and tasks, such as formal map reading.

The second section, which is divided into six parts, is the working memory and this illustrates the process of thinking (both conscious and unconscious). First there is the senses filter, which represents all five main senses and secondary senses such as balance and co-ordination. Each sense differs in its capacity to measure and report a current situation and, consequently, the information reaching the brain will differ depending on the particular scenario. Secondly, there is the anticipatory schema. This was proposed by Neisser (1976) as having the role of actively selecting the information received and directing behaviour to influence the information gathered. It is through this mechanism that an individual stops being a passive recipient of information and instead becomes active and discriminatory. The anticipatory schema is constantly being reformulated as new situations arise and goals are altered. Thirdly, the task guider is responsible for making decisions based upon the information received from both the 'real world' and long-term memory. It essentially directs the thought process and controls the responses, and is equivalent to Charness's (1985) problem space. Fourthly, there is the short-term memory store, which acts as a temporary storage of information just processed that is deemed relevant for the current or forthcoming situation. Relevant information itself is not stored but a relevant memory tag is retained, avoiding the subsequent search of long-term memory by providing an exact address. The fifth part of the working memory is the perceptual context filter. This is essentially the anticipatory schema between working and long-term memory. It uses the present context or situation to influence the requests from, and information received by, the task guider. The final part of working memory is the current emotional state filter, which works in partnership with the perceptual context. This represents the effect of the personality and character upon the decision-making process. It includes factors such as beliefs, needs, emotions, values and personality, preferences and desires, all of which influence the decisions made.

The third section of the proposed schema is the long-term memory and illustrates how we store and access our knowledge. It is divided into two main parts, the first being an event store containing records of situations within a time framework. Each layer represents a situation and is placed within the context of a series of related situations with certain layers relating to key situations. As new situations arise they are added to the event store. The second part of the long-term memory is an information store, which is partially hierarchical in structure and is controlled by the store guider. The store guider divides the requests into their constituent parts and directs them to the information they are seeking. If a piece of information is new then it is added to the information store.

The entire conceptual schema is based upon the assumption that memory consists of a system of pointers linking a set of partially hierarchical network stores. These stores are accessed using schemata. The store guider and event store provide quick access to the information store by interpreting the tags and directing the requests to the relevant information: in effect, the relationship of an index to a book. Each piece of knowledge is tagged with a memory tag and a set of pointers to relevant information (Figure 11). For example, in the spatial store, information concerning landmarks may be given the memory tag A, monuments Aa, statues Aaa and an individual statue Aaa1. Each individual statue is complimented with a set of pointer tags which tell the store guider where information concerning this individual class is located within the event or location store. The store classes are pointed to consist of all the information relevant to that individual class and can include distances or relative position concepts such as near/far.

As stated earlier, there is no start and end point for the schema, but in order to describe the process it is easiest to start with the input of new data from the 'real world'. Such information was gathered using instructions from the task guider on the basis of the previous situation. The information from the 'real world' first passes through the senses filter and the anticipatory schema before reaching the task guider. Before processing the

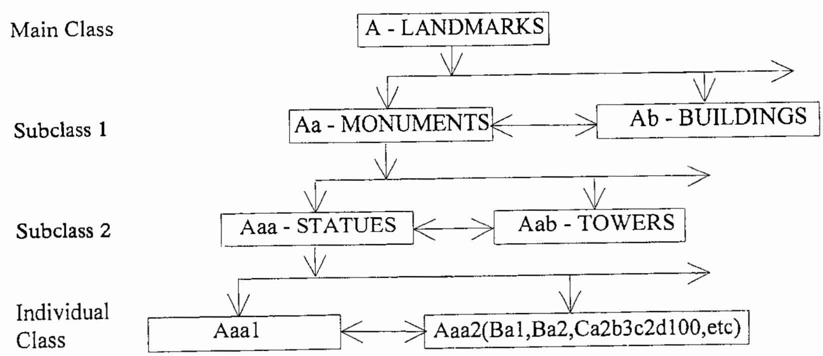

Figure 11 Partial hierarchical model showing the memory tagging with associated pointers
Main class: Bs are roads; Cs are districts. *Subclasses:* a are A-roads; a is continent; b is country; c is county/state; d is town; a is good feelings. *Individual tags:* 1 is Gower Road; 2 is County Road; 2 is Europe; 3 is Wales; 2 is West Glamorgan; 100 is Swansea; 1 is happiness

data, the task guider needs to determine what the information consists of, and to assess the situation. In order to do this, it simultaneously passes a request to the event and information store. Because the information is new it has not yet been tagged and both the event store and the information stores are capable of giving the information its first tags. The event store is a situation schema that is time-indexed and tries to find a similar scenario that will provide memory tags of information connected with that scenario which will aid the decision-making process. As described, schemata are based on the notion that we have limited abilities to process the perceptual world and act as automated ways of processing everyday data. Lloyd (1994) described them as prototypes, which act as skeleton keys to unlock or identify similar objects or information.

In the information store, the store guider passes any untagged information to the schema store to determine its general nature. The store guider then uses the tags from the event store and the schema store to investigate the information store to which the tag corresponds. If the tag and, hence, the information, is new and unique, then the store guide creates a new class, thereby producing a new schema class. If at any time in the future this schema is again encountered, and there is additional information to supplement the schema and the information it points to, the memory tags are updated and transferred to an appropriate store. Every situation is added to the event store with significant events tagged as key events. After a time, other event layers fade and in effect become 'forgotten'.

The information from the stores is then passed back to the task guider through the current emotional and perceptual context filters. The task guider can then either further investigate the pointers associated with a tag, search for more information or make a decision based upon the information so far retrieved. Any tags that are deemed to be relevant for the current situation can be placed in short-term memory for immediate or future use. By further processing of the tags it is possible to anticipate future outcomes by using the gained knowledge to construct scenarios. The task guider uses the information returned from the long-term memory store to construct either analog (images) or propositional constructs. Once the task guider has processed enough information, a decision can be taken which affects the behaviour or response to the situation. This response also updates the anticipatory schema. It is possible, though, just to think about a scenario without interacting with the 'real' world, with all parts in the working and long-term memory operating in isolation. In this case, the task guider sets, and then investigates, a scenario without input from or output to the 'real world' (the ability to think, imagine and daydream). It is important to remember that the whole system is dynamic and embedded so that the task guider is constantly dealing with information and situations. It does not receive a piece of information and pass this on to the long-term memory and wait for a response; rather, it is constantly receiving information from the 'real world' and the long-term memory so that many operations are being processed simultaneously.

Because the proposed schema brings together a range of theories to produce a more coherent whole, it raises a number of questions concerning the relationships between the findings within the different areas of research. These questions need to become the focus of future research, if a more complete picture of spatial thought and behaviour is to be formed. For example, the schema hypothesizes a partial hierarchical structure, but we are still unsure as to how temporal aspects are encoded within this structure, how different knowledge structures fit within this hierarchy, how imagery and propositions are stored within the hierarchy, and how aspatial attributive information is stored. Cognitive mapping researchers have over the last 30 years devoted much time to developing each subarea (e.g., learning, form and structure) but the links between these subareas are still relatively underdeveloped and we still remain unsure as to the processes that link thought with behaviour and their relationship in different contexts. In addition, how relevant are some of these theories to populations such as people who are blind or mentally retarded? How does development throughout childhood relate to this schema? In this regard the conceptual schema poses a number of questions and testable hypotheses. For these types of questions to be answered an effective research strategy which adopts elements from both geography and psychology needs to be adopted.

Self *et al.* (1992) suggested that cognitive mapping researchers should adopt a research strategy which involves the coupling of passive laboratory exercises with active field exercises to form a multidata collection, multianalysis approach. Such an approach is important because the convergent validation of current methodologies is weak (Cadwallader, 1979; Bryant, 1984; Montello, 1991). Methodologies need to be more fully understood and explored if we are to draw valid conclusions concerning cognitive mapping (Kitchin, 1995). It is only through using a host of exercises and analyses that a more complete 'picture' can be drawn of how cognitive map knowledge is learnt and used (Goodchild, 1974). The fact that tests which are meant to be measuring the same knowledge are producing differing results cannot be brushed aside (Newcombe, 1985). Through the combination of psychology and geography research practices and techniques, the 'how', 'what', 'where' and 'why' questions can be investigated within an integrative framework to form a coherent research field. Indeed, hypotheses generated by the outlined conceptual schema were tested in the Swansea study (Kitchin, 1995) using such a research strategy, combining quantitatively based exercises with qualitative interviews. The results from this study did confirm some of the assumptions underpinning the schema, with evidence of both a partial hierarchical structure and dual coding.

V Conclusions

It has been argued that, at present, cognitive mapping research is conceptually weak, with environment-behaviour interaction conceptual schemata being oversimplistic and psychologically naive. These schemata have led to few testable hypotheses, despite the shift from an interactional to a transactional approach during the 1980s. It is suggested that a fruitful route to future research is through the integration of theory and practice from the parent disciplines of geography and psychology. A conceptual schema has been developed which aims to advance transactionalism through the inclusion of the underlying mental processes that govern spatial thought and behaviour. The schema combined five contemporary cognitive mapping theories from both geography and psychology. It is argued that this schema can provide a sound theoretical framework for future research by providing a more holistic and complete account of environment-behaviour interaction, linking cognition and human agency and being reactive to environmental, societal and cultural contexts. In addition, it raises a series of new questions concerning how we acquire, learn, think about and store data relating to the everyday geographic environment, providing testable hypotheses to drive future research. The schema illustrates that geographic and psychological theory can be successfully integrated and it is suggested that the best method to test the questions raised is through a multidata collection, multianalysis strategy. Such a strategy, combining quantitative exercises and qualitative interviews, has been effectively used to test aspects of the new conceptual schema. Since the early 1970s collaborative research between geographers and psychologists has remained relatively rare despite books which detail work from both disciplines (Gärling and Evans, 1991; Gärling and Golledge, 1993a). Yet, if cognitive mapping research is to progress and develop, then an integrative framework needs to be adopted, with collaborative research essential to this process. This article represents a move towards such a future.

Acknowledgements

I would like to thank Mark Blades, Paul Boyle, Reg Golledge, Keith Halfacree, Phil Hubbard and Dan Montello for comments on an earlier draft of this article, and the two anonymous reviewers for helpful and sound advice.

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