SPATIAL CONFIGURATION, SPATIAL COGNITION AND SPATIAL BEHAVIOUR:
The Role of Architectural Intelligibility in Shaping Spatial Experience

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ABSTRACT

This thesis investigates the role of spatial configuration in shaping resident's experience of their neighbourhood. Studies to date have found that spatial configuration affects spatial behaviour and movement patterns (e.g., Hillier et al, 1993), however there has been little investigation of the cognitive processes that might underlie this relationship. Other research into cognition of the urban environment suggests that local spatial factors may play a role in cognitive processes (e.g., Hart & Moor, 1973), however these studies have not addressed global spatial configuration in quantitative terms. No studies to date have sought to integrate cognitive, behavioural and configurational factors within a single framework. Using Hillier's (1996) definition of intelligibility as the relationship between local and global configurational factors, this thesis investigates the relationship between resident's cognition, observed patterns of movement and the spatial configuration of an area.

Two adjacent areas in Hampstead Garden Suburb in North London were investigated in detail. One area is relatively intelligible, the other less so. Structured interview surveys were carried out with local residents to elicit aspects of their cognition of the local area and detailed observations were made of movement patterns in the two neighbourhoods. Analysis of the spatial characteristics of the two areas using 'space syntax' methods provided a common basis for analyses of these data.

The findings confirm that spatial configuration, spatial cognition and space use patterns are all related to one another. The main finding is that the degree of intelligibility of the area is the most significant intervening variable in relations between the three variables. The more intelligible area showed more powerful correlations between spatial configuration and patterns of movement, as well as giving rise to perceptions of greater legibility and increased neighbourhood size by local residents. Strong correlations were also identified between residents' cognitive maps and observed patterns of movement in the area. The correlations were again found to be stronger in the intelligible area than the unintelligible area.

These findings suggest that spatial configuration may play an important role in determining people's daily spatial experience by increasing or reducing their sense of autonomy. By reducing the ability to predict either one's precise location within his/her global context, or the likely behaviour of others in space, unintelligible urban configurations may result in perceptions of a lesser sense of personal control over one's own actions in the environment. The thesis concludes that 'architectural intelligibility' may be a basic aspect in achieving human spatial needs.

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INTRODUCTION

1.1 Aims and motives

Understanding the relationship between human beings and the built environment raises the question of the impact of the built environment on human beings and the characteristics of the interaction between them. More precisely, human spatial experience appears to be shaped by spatial cognition and behaviour, interacting with the physical built environment. To date, however, the role of spatial configuration has not been properly incorporated into this research framework. The basic question of this thesis is thus raised. How is spatial experience affected by spatial configuration, and how do three domains - spatial configuration, spatial cognition and spatial behaviour - interact with each other. This thesis addresses these issues according to a series of specific questions. (1) What is the relationship between spatial configuration and spatial cognition? (2) How far are the patterns of space usage characterised by spatial configuration? (3) What are the underlying regularities in the relationship between spatial cognition and space usage patterns? (4) What is the interaction among these three domains? In each answer of these questions, how each relationship is affected by morphological 'intelligibility'[1] is also examined.

This thesis thus attempts to bring spatial, psychological and behavioural dimensions into a single methodological framework. This framework is based on acquiring data on residents' cognition in cognition and movement patterns of behaviour , coupled with syntactic variables of spatial configuration by computer modeling.

This chapter addresses the basic arguments of this thesis, including how this research relates to existing knowledge, and simultaneously how it differs from it. The first two

[1] The intelligibility of an area (Hillier et al., 1987) is the degree of correlation between its local and global properties of spatial configuration. Section 1.5 and 2.3.4 address it in detail.

sections identify two main problems in carrying out this research. One is the lack of understanding of spatial configuration in cognitive research (e.g., Downs and Stea, 1973). These studies explain spatial experience as being mediated by perception and cognition. The other is the lack of understanding of spatial cognition in studies examining the impact of spatial configuration on spatial behaviour (e.g., Hillier et al, 1993). After this, the latent possibility of morphological intelligibility is discussed as a suggestive factor for shaping spatial experience. Considering these problem definitions, an integrated approach is proposed, which benefits from the two fields: the syntactic description of spatial configuration and knowledge accumulated by research on spatial cognition. Finally, the overall structure of the remainder of the thesis is presented.

1.2 The lack of understanding of spatial configuration in cognitive studies

Spatial-temporal reasoning is a basic function in people's daily life. People employ it almost constantly to infer information about their environment and about their changing location in space. Our knowledge of the spatial environment and the way in which we visualise and symbolise it, is a consequence of our experience in it and with it.

A few studies has identified the salient role of spatial configuration in human spatial experience (e.g., Garling et al, 1986). Many researchers address the importance of cognitive representation in spatial experience. For example, Zimring (1981) reviews relevant research and contends that environmental forms that encourage acquisition of accurate cognitive representations reduce stress. At a more empirical level O'Neill (1991) suggests that higher levels of configurational understanding are generally associated with more efficient wayfinding performance.

The process of cognitive mapping and the map itself has been used as a research tool to measure how people perceive and recognise their built environment and how people act in it. These studies are valuable in providing data on differences in the ways in which individuals, and perhaps groups, recognise their environment.

However concern in this area has focused on individual or group differences in cognitive mapping ability in laboratory settings or in fieldwork, which restricts the parameters available for analysis. In addition, conventional analysis of cognitive maps has concentrated on the disaggregation of represented elements (e.g., Lynch, 1960). Cognitive studies provide us, therefore, with a useful method, but not with a theoretical starting point for an inquiry into the human being and built environment relationship. This appears to be primarily caused by the absence of a methodological tool to describe both objective configurations in reality and subjective ones in cognitive representations. There thus have been gaps in understanding and describing configuration as a total field of the interrelation of elements, patterns and sequences.

Hart and Moore (1973) argue that, even though psychologists and geographers alike converge in treating the understanding of spatial configuration as the ultimate stage of spatial cognition, configuration is perhaps the most difficult aspect of the environment to describe in an objective and analytical manner. Methods that have been used to date in analysing cognitive maps thus seem to have failed to describe the internal representation of spatial configuration systematically. The absence of a proper method for studying cognitive representation appears to constrain exploration of the information that is contained in it. Thus the cognitive approach reveals gaps in our knowledge of human spatial experience without relating the likely effect of spatial configuration on that experience.

In order to describe and analyse the role of spatial configuration in the cognitive representation, a more flexible and analytic method may be needed. If this were available then we would be able to understand cognition of the built environment in association with spatial configuration, since it may encourage and/or impede its cognitive representation.

1.3 The implication of cognitive studies for the syntactic approach

Hillier and Hanson (1984) contend that the social implication of building plans and settlement layout should be seen not only as something imprinted in human subjectivity, but also as something constituted in space. They define conventional studies investigating the man-environment relation as those in which the physical environment has no social content and society has no spatial content. Hillier (1996) reiterates this man-environment relation as not a direct physical relation of cause and effect, but as an indirect relation, mediated by spatial configuration. He further proposes a theory in which we find pattern effects from space to people and from people to space.

From this theoretical background, Hillier and his colleagues developed a descriptive theory of space, Space Syntax[2]. Space syntax not only suggests an effective conceptual framework for investigating the man and built environment relation, but also a method for describing spatial configuration as collections of local elements and as an interrelated whole.

Syntactic analysis of spatial configuration coupled with extensive empirical observation of people's space use patterns, has explained how complex buildings and urban areas work. Thus it provides information on spatial configuration and its possible consequences on the surrounding area, in terms of space use and movement. This enables further analysis using a computer model to predict how a new design will affect existing spatial patterns both globally and locally. The syntactic approach thus seems to offer better solutions to overcoming problems in conceptualising relations between spatial form and social life, and in describing such relations in spatial terms.

This work has a substantial relevance to the present work, but does not provide the starting point for this dissertation, since there is a fundamental difference in how the problem is conceptualised in research investigating the human being and built environment relation. Most work to date using the syntactic approach has attempted to show how buildings and settlements help to constitute society through the way in which configurations organise space. However, they have not claimed an impact of spatial configuration on cognitive representation, which might play a key role in the

[2] Space syntax is a set of concepts and quantitative measures for representing the topological properties in spatial layout. Basic concepts and procedures are described in section 3.2.

relation. Despite many conjectures on the effect of spatial configuration on the human mind, this cognitive aspect has been largely neglected within syntactic studies. Also, the syntactic approach to the understanding of spatial behaviour has focused on the relationship between configuration and its consequent behaviour, without claiming a role for spatial configuration in cognition.

In this context the cognitive approach is valuable to this syntactic approach. Downs and Stea's (1973) contention that the 'cognitive map' is a pre-requisite both for human survival and for every day behaviour is noteworthy, since behaviour is dependent on the individual's 'cognitive map'. This is understood as the basis for deciding upon and implementing any strategy of spatial behaviour. O'Neill (1991) also contends that configurational knowledge, which plays a decisive role in wayfinding, may be assessed by the ability to draw accurate sketch maps. These works show clearly the need for an inquiry into spatial cognition for an in-depth understanding of the relationship between configuration and the behaviour.

The problems described in section 1.2 and in this section can be summarised as that there has been little proper attempts to understand the impact of spatial configuration in cognitive representation quantitatively in spite of its likely significance at the psychological level. The importance of an individual's subjective internal representation of the spatial configuration has hitherto remained unexplored in both cognitive studies and syntactic approaches.

1.4 Intelligibility and its possible role in shaping spatial experience

Kevin Lynch (1984) contends that space suggests action as well as constraining it. Earlier, Lynch (1960) defines 'legibility' as the ease with which a system's parts can be recognised and can be organised into a coherent pattern. He states that if a city is legible it can be visually grasped as a related pattern of recognisable symbols, so a legible city would be one whose districts or landmarks or pathways are easily identifiable and are easily grouped into an over-all pattern. He further argues that in the process of wayfinding, the strategic link is the environmental image, a generalised mental picture of the exterior physical world which benefits from architectural legibility as experienced by an individual. He defines this characteristic as 'imageability'. Based on this conjecture, he suggests that legibility may play a decisive role in acquiring a sense of spatial control.

In supporting Lynch's argument, Kaplan and Kaplan (1983) contend that legibility is one of the most salient aspects essential to an individual's effective functioning, since it allows one to explore extensively without becoming lost. In a similar vein Garling et al (1986) proposes a model of preferable spatial forms that may affect spatial orientation and navigation through perception and cognition. Garling's study is unique in that the concern for legibility is shifted to a systematic description of spatial configuration that is not conceivable by Lynchian methodologies. These three examples of studies have a common approach that emphasises more abstract and affective qualities of spatial form rather than an objective and analytic description of it.

Hillier seems to have a similar theoretical stance regarding the role of the built environment. However, his approach is quite different to the studies defined above. Hillier et al (1987) propose a syntactic definition of intelligibility to describe this qualitative aspect of spatial form analytically and quantitatively. It is his contention, although there are few direct empirical findings, that intelligibility is related to the capacity of a space to give clues to the understanding of the whole system. Hillier develops a metric for intelligibility by correlating a local measure of spatial configuration with a global measure. He defines intelligibility as the relationship between these two such that where you are locally in a system may provide you with sufficient clues as to where you are globally in the whole system. Thus it may be possible to predict the spatial structure of a whole settlement, if it has high intelligibility, from spatial relations held in local parts. Hillier (1996) argues that urban design problems are exactly this part-whole problem.

He develops these ideas and suggests that intelligibility is a 'generic function' that permits a spatial complex to be adapted for human occupation and movement. He proposes that intelligibility supports this generic function of spatial structure.

Anticipating Hillier's conjecture of intelligibility, Steadman (1983) argues that morphological intelligibility might be an important factor promoting or restricting architectural possibility. Hanson (1991) conjectures that the sociological potential of intelligibility is that it might lead to a stronger movement interface between inhabitants and strangers.

Supporting these hypotheses, Penn and Dalton (1994) suggest that the human mind may in effect be a correlation detector searching for perceptual information from the local spatial configuration in order to predict global location. They thus conjecture that if the mind has a problem with making sense of these data, it is because the correlation has broken down. They suggest that the unconscious process of recalling a 'map' in the human mind is essentially the search for correlations between factors as people move through space.

All these conjectures regarding the role of intelligibility require empirical investigation at the psychological level, which is not yet available. Such findings would allow the incorporation of this extended notion of intelligibility into a research framework investigating the relationship between man and the built environment.

1.5 Two conjectures: the need to expand theories of the built environment and behaviour

Cognition and spatial behaviour may be linked to the spatial configuration of individual areas and to the way that spatial properties of each area interact with surrounding areas. This conjecture is intended to explain the interrelationship between and among spatial configuration, cognitive representation and patterns of space use.

It is hypothesised that spatial configuration may affect cognition, which contains configurational knowledge. The acquisition of this knowledge may also be affected by variations in spatial configuration. Then this knowledge in turn may cause differences in spatial behaviour in daily life. If an association exists between them, account must be taken of the role of the salient aspect of spatial configuration - intelligibility. The hypotheses regarding intelligibility are; i) it may be the intervening variable, which influences interaction within the framework; ii) it may facilitate a clear image of spatial layout, thus people who live in an intelligible area may have better legibility of spatial layout than those in an unintelligible area. At the same time, they may have a more intelligible cognitive map of the whole area.

The same hypothesis applies to the relationship between configurational properties and patterns of space use, and between cognitive representation and patterns of space use. The former emphasises whether intelligibility leads to a stronger association. The latter aims to build a theoretical bridge to the association between spatial cognition and spatial behaviour.

Considering this series of hypotheses, intelligibility may affect and characterise the interactive process of the interface between man and the built environment. Figure 1.1 illustrates the general conceptual hypothesis regarding the role of intelligibility in the present study.

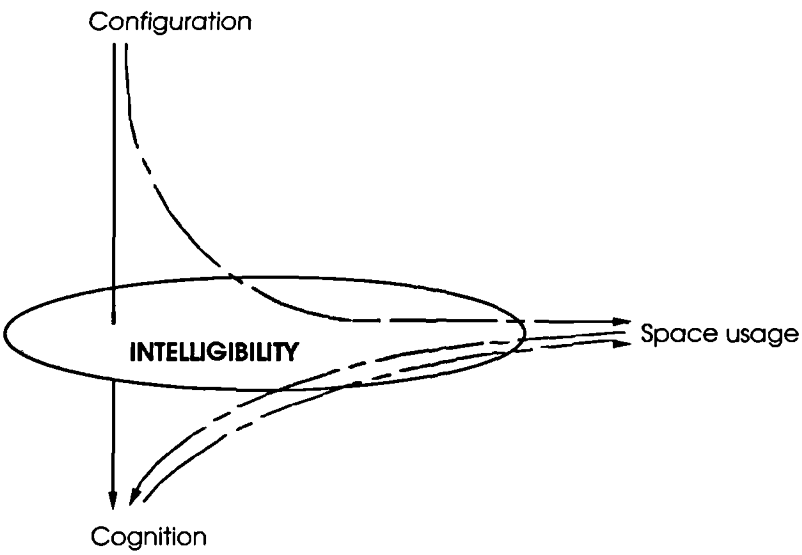


Figure 1.1 The intelligibility and spatial experience interface

If configurational factors are found to be influential in these interactions, different types of spatial configuration may lead to a totally different spatial experience. This would provide empirical grounds to assert that, for architectural practice, one should incorporate knowledge of spatial configuration and its implications into design rationales. This research attempts to clarify some of these intricate issues which are part of the dialogue between form and function in architecture.

1.6 The need for an integrated approach to spatial configuration, spatial cognition and spatial behaviour

Some attempts have been made to understand these three domains from an integrated perspective. They provide us with a useful conceptual framework for investigating their relationship (e.g., Evans and Garling, 1991; Garling, 1995). Nevertheless, the salient role of spatial configuration has not been incorporated in that research agenda.

Both aspects of spatial configuration - in the real world and in cognitive representation - seem to be required for any adequate theoretical understanding. These aspects might receive their proper recognition if they are understood in terms of an interactive process composed of the three 'moments' of configuration, cognition and behaviour. As far as the behavioural phenomenon is concerned, this process does not seem to be thought of as occurring discretely. Individual spatial behaviour is likely simultaneously to recognise spatial configuration as an objective reality and to represent and activate it as a cognitive map for action in the environment. Behavioural consequences and each part of them seem continuously to communicate in these three moments. Therefore any analysis in terms of only one or two of them may fall short.

This thesis adopts three methodologies. First, in order to analyse and understand spatial configuration in reality and in cognitive representations, Space Syntax was utilised. Second, an interview survey was conducted to gather data about cognition, along with sketch mapping. Third, an intensive observation of overt spatial behaviour was carried out to acquire information on space usage patterns. The latter two methods aim to acquire data on both 'stated' and 'revealed' aspects of spatial cognition.

Thus, syntactic descriptions of spatial configuration coupled with both interview survey and observation, permit an investigation into the way the three domains interact within the overall research framework. The findings provide us with information on human spatial experience, along with the possible role of spatial configuration within the framework. These relationships are summarised in Figure 1.2.

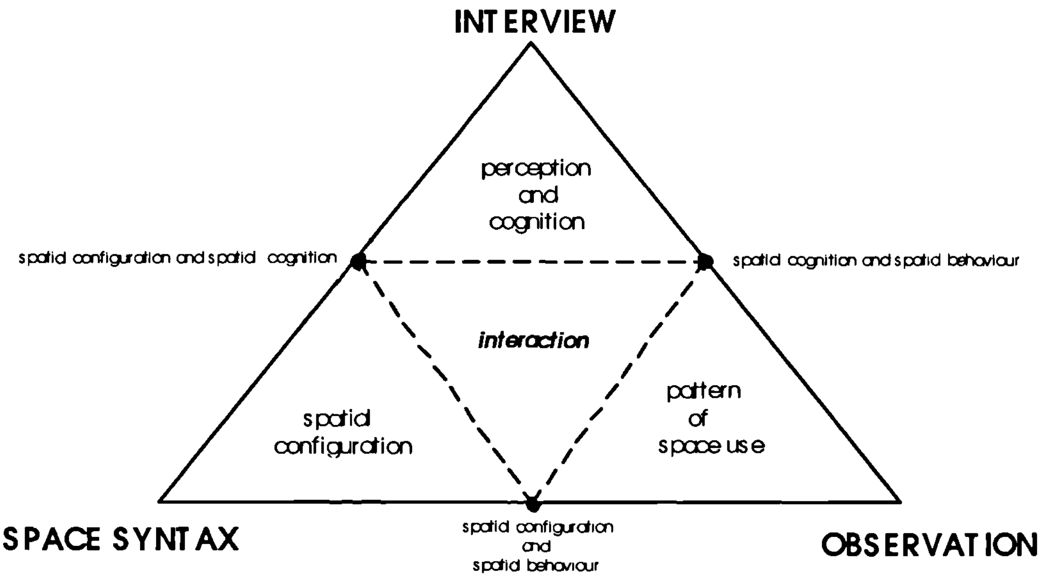


Figure 1.2 The research framework

1.7 Outline of the dissertation

In Chapter two, literature on relevant theoretical positions and research frameworks about human spatial experience is introduced. The interface between spatial configuration and spatial behaviour is set out, beginning with a discussion of notions such as 'legibility' and 'internalising spatial configuration'. Next, studies regarding spatial configuration and its consequences for space usage are addressed. The acquisition and the nature of spatial knowledge are then reviewed, since this constitutes the most important factor in spatial cognition. A review of the literature on cognitive mapping and its end product of the 'cognitive map' are also covered. Considering these findings, the use of cognitive maps as a research tool is proposed, along with the possibility of their syntactic analysis. Thus the possible use of sketch maps in measuring configurational knowledge is identified, and theoretical grounds for applying syntactic description directly to these representations are provided.

This review goes on to consider links between cognitive maps and spatial behaviour, through the investigation of the relationship between sketch maps and space use patterns. The next section discusses a conceptual framework, which synthesises the three fields that have operated largely in isolation from one another to date. The argument of chapter two concludes by going back to the problem of intelligibility and its incorporation into this research framework.

Chapter three begins by describing three methodologies employed; 'Space syntax' for spatial analysis, interview survey for measuring residents' perception and cognition, and gate observations for gathering information on space usage patterns. These methods eventually enable an integrated investigation of relations among design parameters, the image of a place in the cognitive dimension and patterns of space usage in the behavioural sphere.

These sections are followed by an overall view of the organisation of data, and its processing procedures and an outline of the statistical tests employed. Next, a new way for analysing configurational knowledge in sketch maps is presented. This is followed by the neighbourhood definition applied in this study. Finally, the study area is introduced.

Chapter four aims to understand the spatial morphology of Hampstead Garden Suburb as a whole system of spaces and buildings constituting a pattern, using syntactic descriptions. The chapter starts by introducing the historical development and design concepts of the Suburb. Coupled with a general morphological overview of the area, the spatial layout of the Suburb is described in-depth and its spatial realisation in terms of its degree of intelligibility is investigated. Thus, the suburb is subjected to a thorough investigation, first focusing on the pattern of its spatial layout within its global context, and then, on the area itself without its surroundings. These two ways of looking at the spatial structure, one as an interwoven part of the whole, and the other as a distinct structure, allow a discussion about the spatial experience produced by its spatial configuration. Two halves of the Suburb are identified by these analyses. One is a relatively intelligible area and the other is less so.

Chapter five presents interview data on residents' perception and cognition of the Suburb: firstly, the characteristics of spatial configuration in sketch maps; secondly the boundaries of the perceived neighbourhood; and thirdly, general findings about the perception and cognition of the Suburb. These findings are systematically compared between samples from the two halves of the Suburb to investigate likely effect of the intelligibility of the area in which they reside. These findings feed back into the discussion of the role of intelligibility and the extension of its current definition, and provide preliminary grounds for the incorporation of it into the conceptual framework, developed in chapter two.

The findings of chapters four and five, coupled with the observed movement patterns provide information that allows extensive scrutiny between and among the three domains of cognition, behaviour and space. The following three chapters are therefore on the relationships between: spatial configuration and spatial cognition; spatial configuration and spatial behaviour; and spatial cognition and spatial behaviour.

In Chapter six, an investigation is made of the relationship between configurational characteristics of the spatial layout and the spatial cognition of residents as revealed in chapter five. The intention here is to isolate significant regularities in this relationship. The issues covered are: first, the relationship between respondents' cognition of the area and the syntactic attributes of their residential location; second, the syntactic characteristics of their internalised configurations; third, the association between the internalised configuration in sketch maps and the configuration in reality; and fourth, a comparison of spatial configurations in reality and in sketch maps.

The findings provide strong empirical support for hypothesised psychological effects of spatial configuration. These revealed regularities enable a discussion about the systematic effects of spatial configuration on spatial cognition. They initiate the theoretical debate between objective 'intelligibility' and subjective 'imageability'. In other words, this brings two dimensions - objective configuration and its subjective cognition - to the main argument of the thesis.

Chapter seven investigates the relationship between spatial configuration and spatial behaviour. There is a body of research on this topic that shows a positive relationship between them. This chapter thus is not intended to reconfirm these findings, rather it is more focused on how intelligibility affects this association in this purely residential area. In this context, an attempt has been made to ascertain whether there is a contrast in space use patterns between the intelligible and the unintelligible parts of the Suburb. This chapter thus raises theoretical questions as to how the psychological aspects of intelligibility affect the relationship between spatial cognition and space use patterns. This relationship seems to be unexplainable with reference only to spatial variables and movement patterns alone. This issue is addressed in chapter eight, which tackles the association of spatial behaviour with cognitive variables in sketch maps.

Chapter eight attempts to incorporate a cognitive dimension into the behavioural domain by investigating the relationship between cognitive representations of the spatial configuration and the pattern of space use. Then it extends the discussion to the role of intelligibility in this association. Based on perception and cognition in Chapter five and the observed movement patterns in chapter seven, systematic exploration of the likely interdependence between the two variables is carried out.

Chapter nine attempts to investigate the interaction among three variables, which has been examined at the individual level or only partially synthesised in the previous analysis chapters. This chapter is focused on understanding how configuration influences cognition and behaviour, and how spatial cognition interacts with space use patterns. In this context, the chapter aims not only to integrate our understanding of these three domains but also to interpret each one within the perspective of the whole framework. This is attempted, firstly by describing the interaction between and among three domains, focusing on the ways in which configuration, spatial cognition and spatial behaviour co-vary within the system. Secondly, a conceptual framework interfacing spatial configuraiton-spatial experience relation is proposed through the identified interaction between and among these three domains.

This chapter identifies intelligibility as an intervening factor promoting the process in the proposed 'spatial configuration-spatial experience interface'. It proposes that intelligibility influences the interaction between spatial cognition and spatial behaviour including the feedback process of spatial behaviour to spatial cognition. Finally, an extended concept of intelligibility is discussed.

The dissertation ends with a discussion of findings and their implications in Chapter ten. The empirical results of this study are subjected to a synoptic review and interpretation, with reference to the questions and hypotheses posed earlier in this thesis. This leads to a discussion of intelligibility and the incorporation of its extended conception into design rationales. An attempt is then made to discuss the proposed framework in architectural theories. The thesis finishes by proposing the notion of 'architectural intelligibility', which may be a basic human need for securing a sense of autonomy in spatial experience.

Chapter Two

INCORPORATION OF SPATIAL CONFIGURATION INTO HUMAN-ENVIRONMENT RESEARCH FRAMEWORK

2.1 Introduction

This thesis aims to investigate the interaction between and among spatial configuration, spatial cognition and spatial behaviour. The reviews of literature in this chapter reflect this goal. Its purpose is to clarify the extent to which previous studies have contributed to an understanding of the interaction between man and the built environment and to identify any approaches and methodology that seem to be relevant to this thesis. The literature about spatial cognition and their associated spatial behaviours are all important to an understanding of the man/ built environment relation, however they are reviewed selectively, since the current research is more focused on the incorporation of the role of spatial configuration into man/built environment studies.

The review is in three parts. The first three sections 2.2 - 2.4 attempt to identify the general understanding of spatial cognition, cognitive maps, and the relationship between cognitive maps and spatial behaviour. The studies are examined from the perspective of the way the impact of spatial configuration is understood in these areas. This issue is deeply related to the question of how to incorporate the notion of spatial configuration into the man-built environment research framework.

While the first part outlined above raises mostly questions of how spatial configuration is examined in cognitive approaches in explaining spatial behaviour, the second part focuses on notion of cognitive maps. These play a salient role in every day spatial behaviour, and are considered as a contributing factor in syntactic studies. This approach places spatial configuration as the most salient mediating factor in the man-environment interface. Sections 2.5-2.7, therefore, review theories and studies of how a syntactic approach explains spatial behaviour, including its implications for understanding human spatial experience.

The final part reviews integrative research linking the first two approaches. It is in three sections. First, section 2.8 asks how previous research and theory have attempted to interpret interaction among configuration, cognition and behaviour. This review is of particular importance in structuring the framework for this thesis by identifying how cognitive and syntactic approaches can be combined to contribute for better understanding of man-built environment interaction. Sections 2.9 and 2.10 review the way spatial configuration has been incorporated into the man-built environment research framework. It proposes that the notion of 'intelligibility', as defined by Hillier et al (1987) could contribute an intermediate factor in the relationship between human beings and their environment. The structure of this literature review is illustrated in Figure 2.1.

PART ONE:
SPATIAL COGNITION, COGNITIVE MAPS, AND SPATIAL BEHAVIOUR

2.2 Acquiring spatial knowledge

2.2.1 Process of spatial learning

Human beings relate to the physical built environment through the psychological processes of perception and cognition. Burnett (1976) asserts, in examining the relationship between human beings and their environment, that perception and cognition are recognised as intervening psychological processes, a filtering mechanism in human action in the environment. Perception is the act of apprehending through the mind and senses, of observing, of being aware. It is closely connected with events in the immediate surroundings and is linked with immediate behaviour.

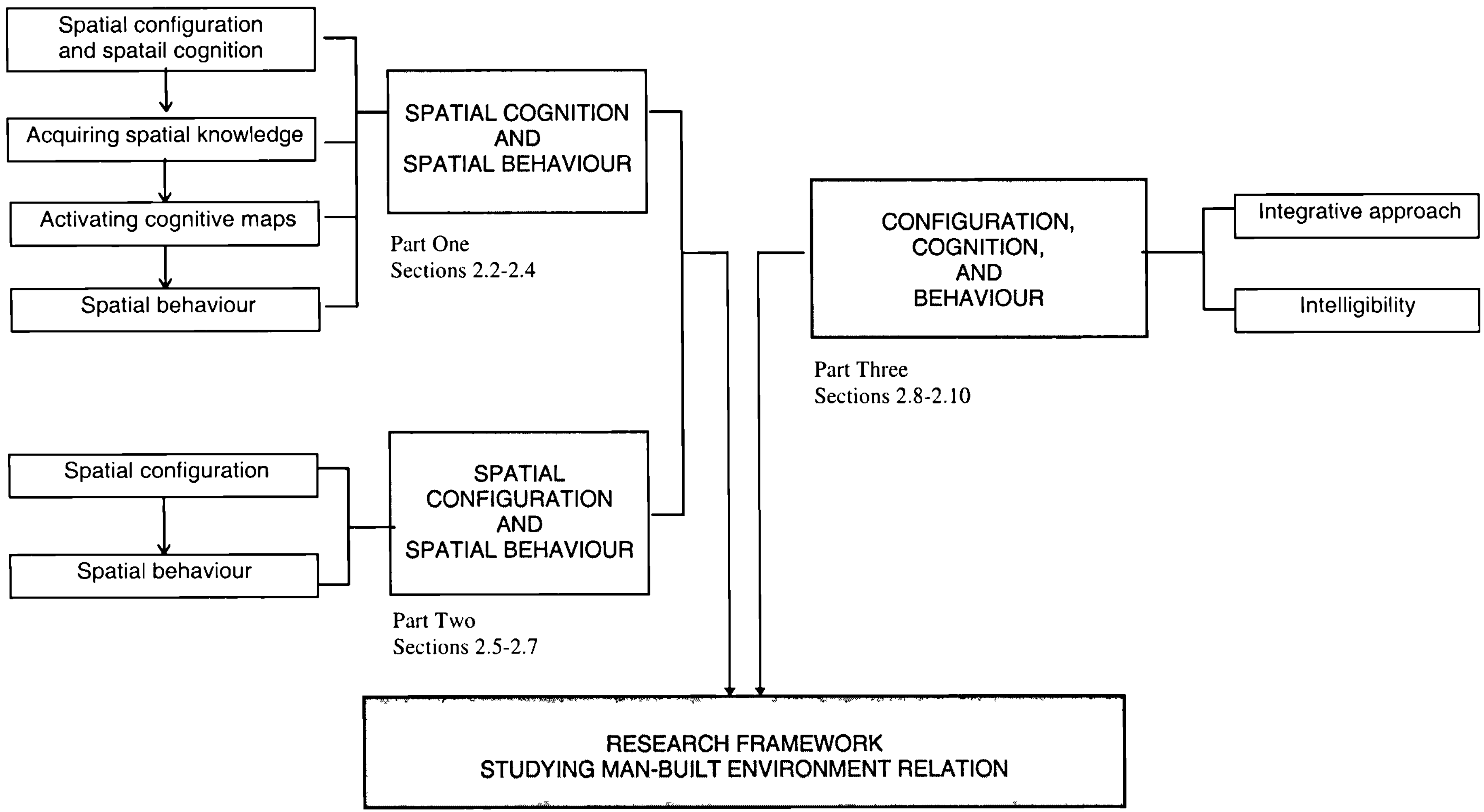


Figure 2.1 Structure of literature review

Psychologists have tended to treat perception as a sub-set or function of cognition, which is the act or faculty of knowing, of consciously gaining and storing new information in the memory. Figure 2.2 illustrates that spatial information as filtered through a psychological filter, which results in images and behaviour.

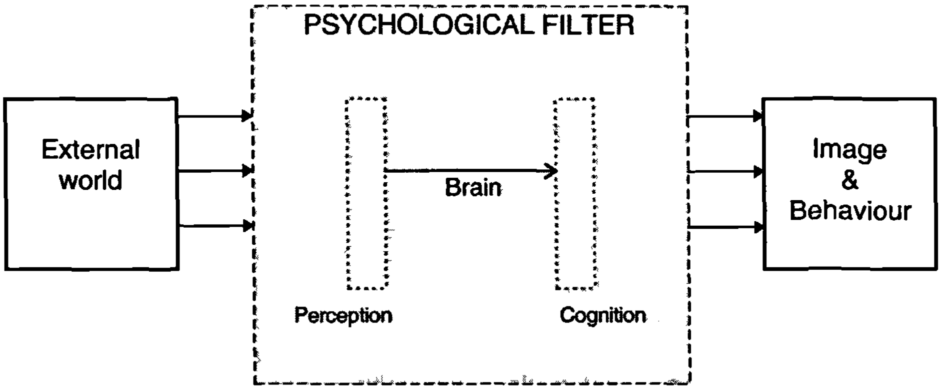


Figure 2.2 The formation of images and behaviour in psychological studies

In a similar vein, Golledge and Stimson (1997) identify the work of psychological processes as an interface between the environment and human behaviour. They note that:

> "We may perceive the street where we live by physically being there, but knowing the route depends on cognitive organisation of a set of perceptions experienced through frequent travel" (p190).

Such processes involve a mixture of attitudes towards the environment, perception and cognition, and learning. This approach suggests that the understanding of spatial structure in the built environment is a cognitive process based on sets of perceived information.

2.2.2 Development of spatial knowledge

In the development of qualitative spatial learning, Piaget and Inhelder (1975) contend that children's spatial learning develops from an understanding of topological relations to projective, and ultimately to Euclidean concepts.

On the other hand, Siegel and White (1975) describe the sequence of spatial learning from an ability to identify landmarks, to an integration of knowledge about the routes linking individual landmarks, and finally to an understanding of abstract spatial relations in a survey representation. They define route knowledge as the knowledge of how to go from one location to another, without definitive knowledge of the relative positions of locations. In other words, it is characterised by the knowledge of sequential locations without the knowledge of general interrelationships. The most developed spatial knowledge is 'configuration or survey knowledge', that is, a 'cognitive map', which is knowledge of the relative locations of objects in the environment. From the cognitive map, landmark and route information can be derived, even for routes never before travelled. Configurational knowledge is thus affected by the ability to generalise beyond learned routes and locate objects within a general frame of reference. However, configurational knowledge is relatively less clearly defined and generally refers to the individual's ability to traverse complicated configurations of paths and nodes within some external frame of reference, including an ability to find new routes between nodes without getting lost.

On the development of configurational knowledge in cognitive maps, Golledge (1975) proposed an anchorpoint theory in which a hierarchical ordering of locations, paths, and areas within the general spatial environment is based on the relative significance of each to the individual. He continues that both node and path knowledge are organised hierarchically with primary, secondary, tertiary, and lower order nodes and paths forming a skeletal structure upon which additional node, path, and aerial information are grafted. Thus neighbourhoods surrounding the primary node set become known first, and continued interactions along developing node-path networks strengthen the image of segments of the environment for each individual at the same time as they formalise the content and order the basic common knowledge structure.

The relative development of spatial knowledge may vary both with the particular spatial environment and individual ability. Heft and Wohlwill (1985) have reiterated the importance of invariant cues in the environment that provide direct information about the identity and spatial position of objects as well as their functional purpose or meaning. They contend that even when individuals have similar levels of exposure to a place, their internal cognitive representations and their qualitative reasoning about the place will differ. Thus not only the type of orientation cues used by individuals but also their subsequent spatial behaviour may depend both on the existing spatial configuration of the setting as well as on the needs, experiences, and goals of the individual.

Given current knowledge and the set of assumptions described above, it is possible to hypothesise that an individual's spatial knowledge acquired through spatial learning may be categorised as simple quantitative and complex qualitative knowledge. The former refers to the amount of information without organisation of each element, and the latter to how this information is interrelated to create an understanding of the built environment. Both spatial knowledge and reasoning about spatial layout are related to the degree of complexity or cohesion of the configuration of spatial elements.

2.2.3 Measuring spatial knowledge

The dimension of spatial knowledge includes: information on recalling and representing layouts; connecting locations; wayfinding in real-world environments; landmark cognition; orientation; sketch mapping and many others. Generally, spatial knowledge has been tested by such means as wayfinding ability, direction estimates, distance estimates, sketch maps[1].

Wayfinding refers to a person's cognitive and behavioural abilities to determine the path between a specified origin and destination and to successfully negotiate the path. For successful travel, information must be obtained about the reference

[1] Sketch maps are explained in detail in sections 2.3-2.5.

point used to identify start, end, and current location, cues that signal when changes of direction are required, recognition of the appropriate turn angle that links consecutive segments, and a mechanism for determining where one is at any particular point in time with respect to the origin.

Spatial orientation refers to the ability to imagine how configurations of elements would appear from different perspectives. This involves a person's ability to relate personal location to environmental frames of reference. These frames of reference might be local and relational as with respect to landmarks or street systems, or they might be related to a global and widely accepted frame of reference such as traditional geographic latitude and longitude correlated systems and the cardinal compass directions. Thus spatial orientation is seen to be an important component of the larger process of spatial knowledge. It is also important in wayfinding and navigation.

Riser et al (1982) suggest that the major components of spatial orientation include:

i) Knowledge of spatial layout of destinations and landmarks along the way.

ii) The ability to keep track of where they are and in which direction they are leading.

iii) Comprehension of the organising structural principles embedded in a given environment.

Cognitive distance describes the relative spatial separation of objects in a cognitive map. It is accepted that generally cognitive distances may be asymmetric and that, in some cases, the distances may be interpreted in a functional, proximity, or similarity context rather than in a geometrical one. For example, Baird et al (1982) have suggested that, given the asymmetric nature of cognitive distance, its representation may be impossible in any known geometric space.

Montello (1991) suggests that we should be aware of the following four difficulties associated with cognitive distance studies:

i) The ratio calculation problem. Substantial differences may exist among individuals in their ability to determine the ratio between the length of a standard distance and the length of a test distance.

ii) The scale translation problem. This might occur when the standard distance in an environment is represented by an arbitrarily scaled length of line to make the appropriate estimate; a subject must be able to perform the scale translation between the given standard and the real-world standard before a legitimate result can be achieved.

iii) The problem of bias. Giving a standard distance with certain lengths provides no guarantee that all subjects will internally represent the standard as being of equivalent length.

iv) The orientation problem. This may occur when the standard line is given in an orientation different to that normally experienced with respect to the usual frames of reference used in the environment. Vertical lines often appear longer than horizontal lines (i.e., vertical illusion). Aligning standards with real-world occurrences helps to reduce this type problem.

In addition to the measurements of spatial knowledge outlined above, landmark knowledge is usually assessed by asking observers to recognise or recall the landmarks that they have seen along a route.

2.3 Cognitive mapping in spatial cognition

2.3.1 Spatial cognition and cognitive maps

Hart and Moore (1971) define spatial cognition as the knowing of, and internal or cognitive representation of the structure, entities, and relations of space; in other words, the internalised reflection and reconstruction of space in thought. Concurring with this view, Downs and Stea (1973) note that this is the process by which the individual acquires, codes, stores, recalls and decodes information about the relative location and attributes of phenomena in the every day spatial environment. Thus, the process of cognitive mapping is a means of structuring, interpreting, and coping with complex sets of information that exist in different environments. These environments include not only observable physical environments, but also memories of environments experienced in the past, and the many and varied social, cultural, political, economic, and other environments that have impinged both on those past memories and on our current experiences.

The end product of the cognitive mapping process is a cognitive map. Over the past three decades, scientists and psychologists in a variety of fields have examined questions relating to the nature of cognitive maps; to the psychological process of acquiring and forming them; to the representation of such knowledge acquisition; and to their role in every day spatial activity. The cognitive map is our individual model of the world in which we live. For example, Garling et al (1979) note that it is long-term stored information about the relative location of objects and phenomena in the everyday physical environment. Thus it represents information either known to exist or imagined; it may be incomplete, pictorial, or distorted, and may contain features hypothesised from experience in everyday life. Sometimes it may be a map of the imaginary world. It is unlikely that there will be any simple match between features in external reality and elements depicted in the cognitive map.

Cognitive mapping's definitions are varied basically due to its multi-displinary nature. Kitchen (1994) noted that cognitive mapping has no one strong subject base and is essentially a research topic with inputs from most of the social sciences. This confusion concerning the meaning and context of the term has also led to the use of alternative terms, such as cognitive configurations (Golledge, 1977), cognitive representations (Downs & Stea, 1973), topological representations (Shemyakin, 1962), and environmental images (Lynch, 1960). In this perspective, Kitchen (ibid, pp3-4) has described four main viewpoints that can be adopted in explaining the use of the term 'map' that have caused confusion and misuse in the past. To summarise Kitchen's viewpoint:

i) *Is it the case that the cognitive map is a cartographic map (Explicit statement)?:* A cognitive map is a map (O'Keefe and Nadel, 1978; Arbib, 1982).

ii) *Is it the case that the cognitive map is like a cartographic map? (Analogy)*: A cognitive map is like a map (Downs and Stea, 1973; Kaplan, 1973; Goodchaild, 1974; Garling et al., 1985).

iii) Is it the case that a cognitive map is used as if it were a cartographic map (Metaphor)?: A cognitive map works as if it were a map (Kaplan, 1973; Spencer et al., 1989; Kupiers, 1983).

iv) Is it the case that the cognitive map has no real connections with what we understand to be a map, i.e. a cartographic map, and is neither an explicit statement, analogy or a metaphor but rather an unfortunate choice of phrase: 'a cognitive function?' (Sigel, 1981). In effect just a hypothetical construct (Moore & Golledge, 1976; Tversky, 1981).

O'Keefe and Nadel (1978) hold that the hippocampus should be called a cognitive mapping system, and the term cognitive map reserved for the products of that system. The cognitive map interpreted as analogue to a cartographic map generally relies on the argument that both have Euclidean spatial properties. Although there has been substantial empirical evidence that cognitive configurations constructed in two-dimensional Euclidean spaces correlate highly with Euclidean representations of objective reality (e.g., Golledge et al, 1975; Garling et al, 1985), there is also much evidence that, for the most part, cognitive maps can violate some if not all of the basic Euclidean axioms (e.g., Gale et al., 1985). The cognitive map as a hypothetical construct or cognitive function implies that the use of the term map provides no literal meaning. Moore and Golledge (1976) suggest that "as a hypothetical construct the term cognitive map and its approximate synonyms refer to covert, non-observed processes and organisations of elements of knowledge."

2.3.2 Methods for eliciting cognitive maps

Since cognitive maps are internal representations of the physical environment (Hart and Moore, 1971, Golledge et al., 1976), their configuration can be inferred from verbal communications, drawings, or relational judgements.

Verbal description of cognitive maps is the easiest way to elicit information about cognitive maps. The form of perceived space and the location of significant elements within it are of importance. The use of this technique requires images to be communicated in a more abstract form than the symbolic notation used in free-recall map drawing, or in the identification of neighbourhoods from base maps or photographs. Procedures include requesting subjects to imagine scenes from different perspectives, or to list the best recognised or most frequently visited places. The unstructured verbal technique places considerable reliance upon respondents' conceptual abilities. Brunner (1966) addresses this reliance noting that image communication is highly likely to be difficult task for certain social and ethnic groups[2].

The problem of bias-free recording of descriptions of spatial images, together with that of extracting information with regard to their form, extent, and composition appears acute, although these difficulties are seldom discussed. Notetaking, supplemented by tape-recording, is essential, but unless descriptions are detailed, considerable subjectivity is involved if the physical dimensions of subjective neighbourhoods are to be assessed. Spencer (1973) asserts that in order to obtain sufficiently detailed descriptions, which would permit analysis, responses can be structured by the introduction of specific questions designed to elicit the required information.

Graphical representation is widely used for representation of cognitive maps, which can be derived by two methods: *sketch mapping* and *boundary delimitation*. *Sketch mapping* has long appeared to be a useful instrument for recovering information about the environment.

[2] He argues that relatively deprived social groups may exhibit incomplete development of their cognitive mapping abilities to comprehend symbolic modes of representation.

In order to draw an image from memory on a blank sheet of paper, respondents must possess considerable conceptual abilities, since this technique is more abstracted from reality. Pictorial representation, which is the prevalent form of response, may be due to the fact that respondents who lack cartographic skills find map drawing a difficult task. Spence (1973) contends with empirical evidence saying that there is also the possibility that whenever the construction of a sketch map is difficult, respondents concentrate on drawing whatever they can, and may thereby become oblivious to the request to sketch their neighbourhoods or home areas. As for analysing sketch maps, Goodey et al (1971) report that although the process of preparation of composite maps appears simple, it in fact involves many problems, especially those associated with the abstraction of data from individual image maps. Table 2.1 shows a selection of the main published image studies using sketch map technique. Sketch mapping is further explained in section 2.3.3-1.3.5.

Another strategy for eliciting cognitive maps is *boundary delimitation.* This technique involves asking respondents to mark the boundaries of perceived neighbourhoods or local areas by outlining areas on a base map. For successful completion of this task, Spencer (1973) argues that it is dependent on knowledge of the area, and map reading ability.

Empirical studies, using boundary delimitation, reveal the differences in the perceived size of neighbourhood among respondents. Spencer (1973) found that heterogeneous neighbourhoods in terms of the house: shop ratio and house: amenity building ratio cause difficulties in representing their image exactly. They continue that as difficulties in cognitive mapping increase, the size of delimited neighbourhoods decreases. In similar research, Downs and Stea (1973) say that this could be caused by (a) differences in physical environment and (b) differences in the people themselves. They claim that differences in neighbourhood size were not related in any way to the part of the city in which the subject lived. They continue that the average area of neighbourhoods in outer middle class suburbs and high density slums was much the same. From a design perspective, the criterion of "perceived wholeness" may not be the only one for deciding how large a neighbourhood should be, there may be economic or educational or traffic considerations especially if we are to include in the values we seek the idea of "a sense of community."

Multidimensional scaling is a set of mathematical techniques that enables a researcher to uncover the "hidden structure" in data about the differences among a set of elements, and to represent that structure spatially. Kruskal & Wish (1978) say that:

> "It refers to a class of techniques. The techniques use proximity among any kind of objects as input. A proximity is a number which indicates how similar or how different two objects are, or are perceived to be, or any measure of this kind. Each point in the map produced corresponds to one of the objects. This configuration of data reflects hidden structure in the data and, often makes much easier to comprehend. By reflecting the data structure we mean that the larger the dissimilarity between the two objects, as shown by their proximity value, the further apart they should be in the spatial map" (p7).

Multidimensional scaling outputs are, as Dancer (1990) noted, considered to provide a more metric cognitive representation whereas sketch maps are considered to be primarily non-metric cognitive configurations.

In order to investigate subjects' spatial knowledge, Golledge and Rushton (1972) introduce the idea of using metric and non-metric multidimensional scaling (MDS) to recover the latent spatial structure underlying people's preferences and evaluations of proximity or similarity, constructing from these the first examples of cognitive configurations - that is a map-like externalisation of implied or latent spatial knowledge from MDS output. Increased sophistication in specifying the design of experiments for recovering cognitive information, and the use of MDS, has given researchers a great deal of confidence in their ability

Table 2.1 A selection of the main published image studies using sketch maps

Author	Study area	Investigation method	Response
Lynch (1960)	Boston Jersey City Los Angeles	Interview and sketch mapping on a blank paper	30 residents in Boston 15 residents in Jersey City 15 residents in Los Angeles
De Jonge (1962)	Amsterdam Rotterdam The Hague	Sketch mapping of central areas	20 staff members in Department of Architecture, Technical University of Delft
Kansas City Planning Dept. (1967)	Kansas	Sketch mapping of a renewal area	63 residents
Henry and Cox (1969)	"The Murray" East Kilbride	Delimitation of neighbourhood boundaries on base map	73 residents
Appleyard (1970)	Ciudad Guayana	Sketch mapping	75 residents
Ladd (1970)	Boston	Verbal description of neighbourhoods and sketch mapping on blank paper by residents	60 residents
Hall and Shelley (1971)	Cardiff (city-wide)	Neighbourhoods drawn by respondents on blank paper	125 maps obtained (males and females)
Goodey et al (1971)	Birmingham	Sketch mapping of central area through advertisement on the Birmingham Post	167 residents

Author	Study area	Investigation method	Response
Karan et al (1980)	Central area of Panta in India	Interviews of perception and sketch maps	79 residents from lower socio-economic group
Walsh et al (1981)	Westlake and Long Beach neighbourhoods in Los Angeles	Sketch map and laboratory experiment	101 elderly residents from neighbourhoods for sketch maps
Passini (1984)	A commercial centre in Montreal	Sketch mapping of layout of the building	over 100 residents
Moser (1988)	Health Science Centre,	Sketch mapping of spatial layout of a hospital on a blank paper	20 student nurses from the hospital
Rovine and Weisman (1989)	Downtown Bellefonte in Pennsylvania	Sketch mapping after guided tour of the study area on a blank paper	45 students from psychology department
Blades (1990)	Sheffield	Sketch mapping of a route from the department to a railway station	109 students from a psychology course
Gale et al (1990)	A residential neighbourhood in Goleta, California	Sketch mapping of a route on a paper with the relative positions of the start and finish of the route marked	16 children
Aginsky et al (1997)	A route learned in a driving simulator	Sketch mapping of a learned route	16 MIT undergraduate students

to recover useful spatial information from what appears to be a non-spatial knowledge structure.

2.3.3 Cognitive maps for externally representing the image of the built environment

Lynch (1960) identifies the close links between "image" and the objective patterns of the environment. He developed a sketch map technique to assess residents' representations of Boston, Jersey City and Los Angeles in three studies of a total of 60 individuals. Based on the analysis of respondents' sketch maps, he argues that the image of a built environment is enhanced by the legibility of the system considered in terms of five components: paths, nodes, districts, landmarks, and edges. With the findings of this study he proposed that a city with appropriate physical elements will produce accurate mental representations, and that such a city will encourage effective wayfinding. Lynch defines legibility as "*the ease with which cities' parts can be recognised and can be organised into a coherent pattern*" (p3). Legibility, he contends, not only offers security but also heightens the potential depth and intensity of human experience. He continues that a clear image enables one to move about easily and quickly. He thus defines this characteristic of legibility as 'imageability', which is the quality in a physical object that gives it a high probability of evoking a strong image in any given observer. In order to be 'imagable', he suggests that an area needs to be apprehended as a pattern of high continuity, with a number of distinctive but interconnected parts.

Central to Lynch's analysis of the images of cities is an interest in discovering the relative imageability or legibility of different environments. His study not only serves to focus attention on the perceptual and cognitive qualities of urban environments, it also provides a conceptual framework for the discussion of the structural components of city images that still occupies a primary place in the literature on city structure.

Although he produced a useful typology and provided a valuable conceptual tool, he seems to fall foul of the problems involved in aggregating and disaggregating elements. The attributes of built environments are decomposed into and identified as five components, but this leaves open the important question of how they can be re-assembled. Even though any city can be decomposed into its component parts, detailed analysis of the parts raises questions of how they can possibly be reassembled. Later, Gale et al (1985) point out that the separate decomposed elements of sketch maps cannot be reassembled into a whole using conventional geometric or cartographic methods, since higher order geometric properties are ignored in favour of the basic components of spatial configuration. This is a critical methodological problem for Lynch since continuity and interconnectedness appear to be central to the concept of imageability.

Some studies have identified path systems as a salient aspect in building a strong and precise image. De Jonge (1962) assessed the effect of configuration on the formation of a map image. He investigated relations between urban form' and city image using interviews and sketch map techniques. In the first phase of the inquiry some 20 staff members of his University were interviewed to see what their images were of the central areas of Amsterdam, Rotterdam, The Hague, Utrecht, Leyden, and Delft. He then extended his investigation to about one hundred people in urban residential neighbourhoods in South Holland. From a comparison of sketch maps of three cities: Amsterdam, Rotterdam, and The Hague, he found that the formation of a sketch map image is easiest where there is a street plan with a regular pattern, and a single dominant path, characteristic nodes, and unique landmarks. Where the general pattern is not clear, a greater amount of attention is given to isolated landmarks, individual paths, and visual details. The investigation also found that orientation in sketch maps was often incorrect in areas with an irregular street pattern, consisting of paths with curves that are not clearly connected with each other in a readable configuration. He concluded that people's perceptions of the main pattern of the built environment tend to follow the same 'laws' Gestalt psychologists have found in their laboratory experiments[3].

[3] Their approach emphasised the holistic nature of human reactions to sensation. For example, according to Werthemier (quoted in Ellis, 1955, p5), "There are wholes, the behaviour of which

Tzamir (1975) manipulated a scale model to vary the similarity of path distances and the angle of path intersections. His work with simulations established the importance of the path system. Confirming Lynch's findings, he found that regular street system produced sketch maps with fewer distortions than irregular models. Therefore, he argued that it is essential to understand the effects of path networks on imageability. Holahan and Sorensen (1989) also demonstrated a positive effect of path networks using measures of accuracy and speed of recognition of schematic maps which subjects were asked to study. However, these studies were laboratory based rather than field-based, and clearly, studying a map for a limited period of time is different from learning about a city through actually living in it.

In conclusion, the findings in this section suggest that metrics for measuring 'continuity' are essential to describe spatial configuration and its impact on image.

2.3.4 Errors and distortions in cognitive maps

As with cognitive maps generally, sketches are incomplete, distorted, mixed-metric, or nonmetric modes of representation; they are schematised and are often full of blank spaces and nonconnected networks. Much research on cognitive maps has involved recovering locational patterns of well-known places in different environments, and, then comparing the recovered pattern to the real pattern.

Sadalla and Magel (1980) investigated the effect of the number of turns in a path on the perception of its length. Using two different path sets which have same length but different turns, 7 and 2 turns, respectively, they found that paths with seven turns were estimated and drawn as being longer than those with two turns. They conclude that the number of turns in a path makes the perception of its length longer. Similarly, intersections along a route have also been found to

is not determined by that of their individual elements, but where the part processes are themselves determined by the intrinsic nature of the whole."

influence the estimated length of that route. Sadalla and Staplin (1980) examined the effect of intersections on the recognised length of a route. Subjects reported that the paths contained varying numbers of intersection with an increase in the recognised length of a route.

The prominence of the grid configuration in cognitive schemata of the physical environment is also suggested by several studies showing systematic distortions of non-grid structures. Casey (1978) found that his subjects tended to simplify the environment in their representations by straightening curved lines. Evans (1980) also found that common distortions include the straightening of gradual curves, the squaring of non-perpendicular intersections, and the aligning of non-parallel streets.

Tversky (1981) investigated the perception of intersections in sketch maps with his forty-seven subjects. Subjects were asked to make sketches of the Palo Alto area, including nine major roads or highways. According to his findings people tend to draw sketch maps with intersecting streets as closer to 90 degrees and make parallel familiar streets that in fact are far from parallel.

With respect to errors and distortion in cognitive maps, Couclelis et al (1987) propose three general types. First, elements within regions in cognitive maps defined by 'anchorpoints' are better co-ordinated spatially than are elements in different regions[4]. Second, areas around anchorpoints are magnified because they are well known. Third, like a magnet, anchorpoints attract other spatial elements with a 'force' which decays over distance.

[4] Golledge's (1975, 1978) 'anchorpoint' theory proposes that a hierarchical ordering of locations, paths, and areas within the general spatial environment is based on the relative significance of each to the individual. Initial locations that are critical in the interaction process - such as home, work, and shopping places - anchor the set of spatial information developed by an individual and condition the search for paths through segments of space capable of connecting the primary nodes or 'anchorpoints'. Both node and path knowledge is organised hierarchically with primary, secondary, tertiary, and lower-order nodes and paths forming a skeletal structure upon which additional node, path, and areal information is grafted.

Sketch mapping is often used to elicit the image of the built environment. However, sketches are generally incomplete, distorted, mixed metric, or nonmetric modes of representation, and there are also varying forms of represented elements on sketches by different people. Sketch maps are schematised and are sometimes full of blank spaces. If more information is to be inferred from sketch maps then a more structured form of graphic response is necessary so that variations in the possible meaning of responses are reduced. Otherwise, an unstructured response leaves difficulty in analysing the information. The next section reviews this issue.

2.3.5 Sketch maps for investigating the image of spatial configuration

Although sketch maps usually contains distortions of reality, they can provide data, such as the number of features, the mix of point, line, and area features, and the topological relations of elements including the sequences of cues along routes or the sequence of segments and turns along routes. Additional information can be obtained from the system constructed as the basis for the sketch, particularly the regularity or irregularity of frameworks such as street systems by using analytical tools to quantify their characteristics. Sketches, therefore, provide information that comes readily to mind when one is given a task of representing local knowledge within specified time constraints, and the evidence suggests that if the environment is known the sketches produced are reliable.

Blades (1990) has provided evidence to show that the sketch mapping procedure is quite consistent over time. This implies that when used in a multiple trial-task situation, confidence can be placed in the sketch mapping procedure. O'Neill (1991) notes, by examining sketch maps, that people rely on the information stored in the cognitive map to guide them through the environment. He goes on to assert that configurational knowledge can be assessed by the ability to draw accurate sketch maps. Gollege and Stimson (1997) also argue the validity of sketch mapping task, saying that sketches can indicate the quantity of information that comes readily to mind when one is given a task of representing local knowledge within specified time constraints, and if the environment is known, the sketches produced are reliable - that is, they are consistent over time.

Sketch maps have been analysed mainly into two ways hitherto. First, by reviewing studies of sketch maps, Pipkin (1981) notes that the contents of images are usually treated as dependent variables in relation to factors such as socio-economic status, length of residence, mobility characteristics, and the activity patterns of people (e.g., Appleyard, 1970). Second, frequency that counts of the appearance of different features in sketch maps has been investigated to develop a composite map on which those places known best by the largest number of people are located (e.g., Lynch, 1960).

2.4 Spatial cognition and spatial behaviour

2.4.1 Cognitive maps and spatial behaviour

Movement and locomotion are basic human actions in the environment. Gibson (1966, 1979) proposes that our perceptual systems, therefore, are tuned to directly perceiving the permanent spatial layout of the environment, consisting of surfaces and their 'affordance' for locomotion. Another movement-related function of spatial cognition is to facilitate spatial orientation and navigation or wayfinding. The ability to navigate has been assumed to rely on the availability of acquired mental models, or cognitive maps, of the environment. This contention supports Boulding's earlier argument (1956) that in order to understand people's behaviour it is essential to understand the image they form of their physical and non-physical environment. The image guides behaviour and enables us to interpret the information we receive from our surroundings. This highlights the importance of our subjective interpretation of our experiences in determining behaviour.

At the individual level, moving through space is an integral part of our existence. Downs and Stea (1973) contend that normal everyday behaviour such as a journey to work, a trip to a recreation area, or giving directions to a lost stranger would all be impossible without some form of cognitive map. They interpret the cognitive map as a basic component in human spatial behaviour, and a pre-requisite both for human survival and for everyday environmental behaviour. In choosing whether one has to travel or not to achieve a goal the cognitive map helps decide where to go, which route to take, and what travel mode to take to get there. It is a coping mechanism through which the individual answers two basic questions quickly and efficiently: (1) where certain valued things are; (2) how to get to where s/he wishes to be from wherever s/he is. They thus postulate the cognitive map as the basis for deciding upon and implementing any strategy of spatial behaviour. Neisser (1976) offers the view that a cognitive map is first and foremost an orienting schema. He suggests that configurational representations of spatial information are specialised knowledge structures whose purpose is to direct perceptual exploration of the environment. Garling et al (1984) concur with this view, proposing that movement in an environment is usually goal directed, and thus the purpose of a cognitive map is to aid in planning movement.

Pipkin (1981) claims that there is a fundamental discontinuity between the cognitive approach seeking psychological transformations in predictive variables with respect to trips, and the goals originally formulated for cognitive behavioural geography. A distinctive feature of a cognitive paradigm is the emphasis it places on the structuring of behaviour, not by observable, spatial, or topological properties of the environment but by inferred motives and intentions. Behavioural needs are seen from the viewpoint of the primacy of inferred cognitive structures, as represented through cognitive maps.

As behavioural geography developed, an interest was aroused in using cognitive mapping as an explanation of movement patterns. Zannaras's (1973) empirical study in Ohio is still unique in terms of its incorporation of the cognitive paradigm into an explanation of movement patterns. It investigates the role of cognitive representations of the spatial structure of cities and their effects on movements to the city centre. She found that changes in the physical structure of land use significantly influence image building and consequent wayfinding behaviour from the periphery to the city centre.

Zannaras results show that the city structure may be a significant factor in explaining variations in the mean importance assigned to environmental cues used for wayfinding. City structure also significantly explains variation in the mean accuracy of responses associated with her slide and field trip experiments. She argues that viewing the city as structured in terms of wedges and sectors leads to a better understanding of the spatial relationship between urban features and variations in personal characteristics in determining what features would be chosen for wayfinding, the accuracy of locating and sequencing such features, and the accuracy of using such features in wayfinding tasks from the periphery to the centre. The main finding of this study is that the structure of the actual urban environment is of considerable importance in determining how the city is imagined and how behaviour takes place within it. Overall the physical structure or layout of a city significantly explains variations in the accuracy of location tasks and of wayfinding tasks. While previous work on urban images has focused on deconstructing the city into its component imaged parts, this study is unique in that it attempts to relate organisational characteristics of elements in the urban image to generalised models of the arrangement of city elements suggested in the geographic and planning literature.

At the neighbourhood scale, Walsh et al (1981) uncover a linkage between elderly urban residents' knowledge of their neighbourhoods and their patterns of neighbourhood facility use. The frequent underuse of local services and resources is associated with poor cognitive maps. The level of detail and specific, systematic distortions of path systems can be partially explained by spatial configuration. This suggests that predominant usage of place may correct as well as frame a cognitive mapping.

At the building scale, there has been little empirical research concerned with the direct relationship between cognitive representations and spatial behaviour.

Weisman's study (1981) suggests a tentative understanding of this link[5]. He rated the legibility of simplified floorplans which are classified from abstracted two-dimensional diagrams of real buildings into "high" and "low" groupings, and found these values to be a good predictor of the building users' self-reported incidence of 'being lost'. Users become disoriented in buildings where the overall circulation pattern is confusing and hard to imagine.

Other empirical studies have investigated the role of cognitive maps, in consumer behaviour (Coshall, 1985; Timmermans, 1979), in movement patterns both in migration and a mobility context (Johnston, 1972; Briggs, 1973), and in movement associated with recreational and leisure choice (Pigram, 1993; Golledge & Timmermans, 1990). The use of cognitive maps in many different environmental situations varies from establishing preferences for shops, shopping centres, apartments, and modes of transportation, to the planning of specific residential environments. They are in common use when one is examining the learning of unfamiliar layouts, at scales varying from the neighbourhood to global geography.

2.4.2 Simulating and modelling of spatial behaviour

Research on the interaction between cognitive representation and spatial behaviour has benefited from the use of computer simulation. This technique is being used both in artificial intelligence and cognitive psychology to model internal information structures and their processing (e.g., Smith et. al., 1982).

In cognitively based computer models for wayfinding, Kuipers (1978) describes a computer simulation of a cognitive map and investigates how it might be used for different purposes such as spatial orientation and navigation. He represents an individual's cognition of the environment, how it is acquired, and how it is used to choose routes. However, this work is not based on empirical research on people's cognitive maps, their spatial behaviour patterns, or how they actually go about wayfinding. It essentially only proposes a model for how they might do

[5] His study is reviewed in detail in section 2.8.2.

these things. Several other cognitively based computer models, such as TRAVELLER (Leiser and Zibershatz, 1989), SPAM (McDermott and Davis, 1984), and ELMER (McCalla et al., 1982), simulate learning and problem solving in spatial networks. In NAVIGATOR (Gopal et al., 1989), two views of an environment, objective (i.e., spatial elements) and subjective (i.e., cognitive maps), are complemented by cognitive processing relating to spatial learning and navigation. The cognitive map is modelled through a hierarchical network consisting of nodes, links, subnodes and sublinks. The focus of these computer models lies primarily in the creation and exploration of possible representations of the cognitive map, but, difficulty has been experienced in incorporating configurational aspects of the real-world into these representations. Little insight has been pointed so far into the ways in which the characteristics of spatial configurations relate to human understanding and use of space by means of these models.

Doran and Gilbert (1994) argue that computer simulation is an appropriate methodology whenever a social phenomenon is not directly accessible, either because it no longer exists or because its structure or the effects of its structure, i.e. its behaviour, are so complex that the observer cannot directly attain a clear picture of what is going on. Simulation is based on a model which is more readily observable than the target phenomenon itself. Previous research into the simulation and modelling of patterns of movement has explored a number of different computational paradigms. One field relevant to this thesis is focused on understanding human spatial experience and its interaction with the built environment by means of *multi-agent* simulation[6] (e.g., Drogoul et al, 1991). It is based on the idea that programs exhibit behaviours that can not be entirely explained by their internal mechanisms, namely the program instructions. By relating an individual to a program, it is possible to simulate an artificial world populated with interacting processes. For example, Resnik and his colleagues (1994) have developed agent based simulations of flocking and shoaling

[6] Multi-agent simulations are used primarily to represent situations in which there are many individuals, each with complex and different behaviours, and to analyse the global structures that emerge as a result of the individuals' interactions.

behaviours, with models where individuals respond to the movement of others in their immediate neighbourhood. Similar methods have been developed for traffic simulation (e.g., PARAMICS and TRANSIMS) with local behaviours in terms of conservation of car to car distance or relative speed. However, in these simulations the road network is represented directly in the system, and no mechanism for cognition of the environment is incorporated. Generally, in these multi-agent based models, agents interact with other agents or their local environment, thus they have no global understanding of their environment.

At the micro scale, to account for individuals' spatial behaviour, work has been done in modelling movement in the evacuation of buildings in emergencies (e.g., SIMULEX (Thompson, 1995), EXODUS (Owen & Galea, 1996)) which explains the different individual characteristics of a sample such as walking speed, proneness to panic and other factors affecting mobility. These simulations are based on models of cognition, and generally assume that agents have 'perfect' knowledge of the configuration of the system and of how to navigate in it to achieve a least cost path.

The newly emerging field of 'Virtual Environments' (VE) provides another means of simulating real world places by indirectly experiencing the place. A Virtual Environment (VE) is a computer-generated simulated space within which an individual moves and interacts. VEs may convey information about real world places effectively because they attempt to preserve the spatial-temporal aspects and natural modes of interaction characteristic of real world environments.

By comparing actual and simulated navigation experience Thorndyke and Goldin (1982) note that simulated navigation can be used as a substitute for actual navigation under some circumstances. Held and Durlach (1992) have suggested that VEs, by eliciting a strong sense of "being there", or presence, may enhance learning and performance of some tasks. Presence is defined by Witmer & Singer (1994) as the subjective experience of being in one place when one is physically in another. Witmer et al (1996) investigated route learning ability using a VE model of a building. The participants were able to transfer this knowledge when it was tested in the real building, although their performance was poorer than people trained in the real building. They conclude that VEs that adequately represent real world complexity can be effective training media for learning complex routes in buildings. This work is significant since it suggests that the purely visual information contained in the VE constitutes the main input to the creation of the cognitive map.

Tlauka and Wilson (1996) report navigation in computer-simulated space and real space lead to similar kinds of spatial knowledge. Subjects either explored a simulated 3D environment by navigating through it, or were presented with a map-like single orientation plan view of the same environment. When asked to indicate the direction of test objects that were no longer directly visible within the simulation, response latencies suggested that the navigation group has an orientation-free representation while the map group has an orientation-specific representation.

Ruddle et al. (1997) demonstrate that people who navigate large-scale virtual buildings ultimately develop route-finding abilities and some survey-type spatial knowledge, which are as accurate as those abilities and spatial knowledge developed by people who work in real buildings. They found that participants' ability to judge directions and relative distance was similar to that found in the real building. Also, experiments showed that participants were more accurate in their route finding when memorable objects (3-D models of everyday objects) were used as landmarks. In a similar context, Ruddle et al (1998) investigate components of participants' spatial knowledge when they navigate large-scale "virtual buildings" using "desk-top" virtual environments. Their experiments showed that participants could estimate directions with reasonable accuracy when they travelled along paths that contained one or two turns (change of direction), but participants' estimates are significantly less accurate when the paths contain three turns. They thus propose that people have difficulty remembering the direction they have come from if they follow complex paths in

VEs, even if these paths contain no places at which people must decide in which direction to travel.

Although there are factors which may affect the results of experiments using virtual environments, (such as people's lack of knowledge of their position, their orientation and a VE's structure, and a general lack of familiarity with using VEs), this approach seems promising for research on the relationship between spatial configuration and spatial behaviour.

2.4.3 The need for an analytic tool for understanding relationships between configuration, cognition and behaviour

Spatial cognition and behaviour in the built environment cannot depend wholly upon direct or indirect perception of local properties but also requires a more global understanding of the way in which local parts are interrelated in a whole system. Especially, the investigation of the relationship between global characteristics of spatial configuration in cognitive maps and movement patterns remains unexplored. In order to gain an understanding of this two things appear to be needed; one is an analytic tool for analysing the pattern of street segments in cognitive maps, and the other is to gather empirical data on space use patterns. It should then be possible to explore the relationship between the characteristics of path segments in cognitive maps and patterns of movement in those selected segments.

The literature in this chapter suggests that cognitive maps consist of both direct information from spatial configuration, such as visibility in a certain point, and indirect information, which can only be acquired from the exploration of places. Almost all studies of sketch maps, however, appear to have failed to explain how the whole configuration, not just simple local characteristics of configuration such as angle or number of intersections, number of turns or distance, affect its image as represented in sketch maps. In addition, cognition of spatial configuration is interpreted as "clarity or legibility", "imageability", "highly differentiated", "complexity and coherence", "complex layout versus simple layout" and "visible accessibility" (e.g., Lynch; 1960; Lawton, 1975; Kaplan and

Kaplan, 1983; Garling et al, 1986). Thus these studies seem to fail in describing global characteristics of spatial configuration quantitatively, rather than simply by local measurements such as number of turns in a path or the angle of intersection. This lack of quantification means that these studies have also failed to establish the impact of spatial configuration on cognitive maps and movement patterns. Empirical evidence on which global characteristics of spatial configuration influence cognitive representations and spatial behaviour is still lacking. This appears to be mainly due to the lack of an analytical methodology and theory for describing the configurational information represented in sketch maps.

PART TWO:
SPATIAL CONFIGURATION AND SPATIAL BEHAVIOUR

2.5 Spatial configuration and space use patterns

The connection between spatial configuration and patterns of pedestrian's space use has received only scant attention, since until recently there have been no appropriate methods to describe spatial configuration as a whole. Thus, the effect of configurational factors on movement did not receive much attention until the 1980's. More recently studies using a syntactic approach to the representation and measurement of configuration have uncovered a linkage between configuration and movement. They have tested the structure of public open space networks, quantified by the analysis of axial maps, against the occupancy of public spaces within cities[7]. During a series of studies carried out by Hillier and his colleagues during the late 1980s (Hillier et al, 1993) a good correlation between the two has been found in most circumstances, and this has been confirmed by others (e.g., Peponis et al, 1989, Read, 1998; Penn et al, 1998).

[7] An axial map is a map of the least set of the fewest and longest straight lines of sight and access that pass through all convex spaces and make all rings. See section 3.3 for detailed explanation.

Peponis et al (1989) investigated the relationship between the morphology of Greek towns and their patterns of pedestrian movement using space syntax. They show that the degree of integration of a space is strongly associated with, and seems to determine, the distribution of pedestrian movement[8]. They also argue that a descriptive theory of urban space is more powerful if it can provide not only an accurate and sensitive model of the differences between one type of urban layout and another but also relate the description of morphological properties to some empirically observable consequences for space usage

Based on empirical evidence, Hillier et al (1993) introduced the concept of 'natural movement' defined as that proportion of urban pedestrian movement determined by the grid configuration itself. They argue that the urban grid seems to be structured in order to create, by the generation and channelling of movement, a kind of probabilistic field of encounter and avoidance. A number of empirical studies are reported that show the amount of movement passing down each line is very strongly influenced by its 'integration value'. They propose that natural movement is only secondarily influenced by local spatial properties, such as those that describe the relation of each space to its neighbours, or the architectural quality of a particular space.

Penn and Dalton (1994) investigated the impact of spatial configuration on both vehicular and pedestrian movement patterns. They showed that the measure of global integration overall also gives a good account of the pattern of vehicular movement. The pattern of local integration was found to relate strongly with the patterns of pedestrian movement. More recently, Penn et al (1998) studied both vehicular and pedestrian traffic in London. The research results show that rates of vehicular movement in road segments are to a greater extent than previously realised the direct outcome of the location of those segments in the network configuration as a whole and that this is the case especially in the fine structure of the urban grid.

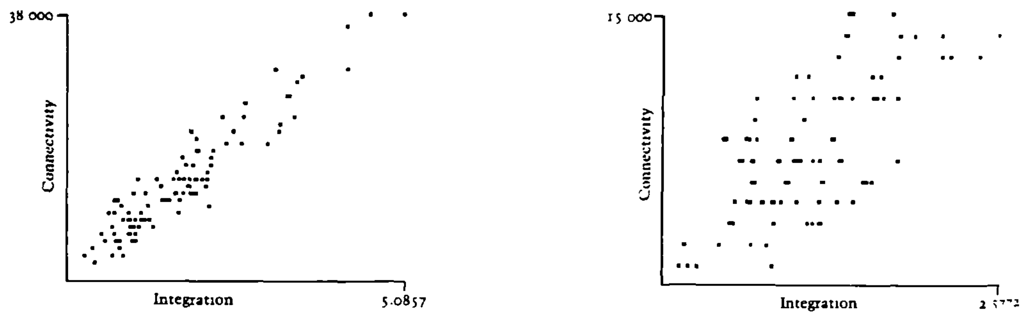
[8] Integration is a syntactic measure of accessibility. It represents the mean number of lines and changes of direction that need to be taken to go from a space to all other spaces in an area. See section 3.2 for more details.

All these empirical studies suggest a possible role of spatial configuration in the social and cultural function of the city. With respect to these configurational characteristics, Hillier et al (1987a) suggest that spatial configuration generates a potential field of probabilistic co-presence and encounter. The field of probabilistic co-presence and encounter generated by the configuration has a definite and describable structure, one that varies greatly with the structuring of space. They suggest that the field of potential encounter be called the 'virtual community'. Virtual communities have a certain density and structure, and are made up of a probabilistic interface between many different types of person: inhabitants and strangers, relative inhabitants and relative strangers, men and women, old and young, adults and children and so on. They suggest that configuration is therefore at the root of a range of social and cultural functions in the city, not merely as a background to social action, but playing an active role in constructing it.

Findings using this syntactic approach to configuration and its correlation with movement patterns have established that the syntactic properties of spatial configuration are related to the expectation of probabilities of encounter, and the pattern of space use. A significant correlation between configuration variables and movement is in itself a justification of the usefulness of describing spatial patterns in terms of the property of syntactic integration (e.g., Hillier et al, 1993). Hence, syntactic modelling of spatial layout yields a prediction of pedestrian movement at the micro level. This suggests that movement patterns are shaped by the opportunities and constraints present in the spatial configuration, not only in the local environment but also by its global context. Thus, configurational factors in spatial layout are assumed to impede and/or facilitate accessibility, and, in turn, to affect patterns of space use.

However, something important is missing between these two factors. To understand the movement pattern in the built environment by investigating the relationship between the syntactic variables of spatial configuration and spatial behaviour, it is necessary to understand perceptual and cognitive processes. The main point here is that the relationship can not be understood precisely without knowing the psychological processes of a subject. In other words, once we have found that the syntactic variables of spatial description are related to patterns of space use, it is natural to conjecture that the syntactic properties and space usage patterns may be associated through this cognitive dimension.

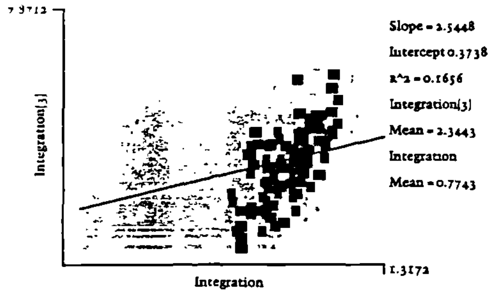
Peponis et al (1990) attempted to incorporate the cognitive dimension into space syntax by investigating the relationship between the syntactic properties of spatial configuration and wayfinding in a hospital. 15 subjects were asked carry out a number of search, wayfinding, and orientation tasks. After the completion of the open search phase, subjects were asked to perform directed searches for specific locations. By examining the relationship between the routes followed and the syntactic description of the study building, they found the search pattern to be strongly associated with the degree of global integration of each space and each choice node of the circulation system within the overall spatial layout. They suggest the idea of a search structure which defines the intelligible properties of layouts and interacts with navigation rules to produce characteristic patterns of exploration.



(a) An intelligible system (b) An unintelligible system

Figure 2.3 Examples of an intelligible and an unintelligible systems. Source: Hillier, 1996

(a) An intelligible spatial layout:
City of London in its global context.



(b) An unintelligible spatial layout:
Housing estates in its global context.

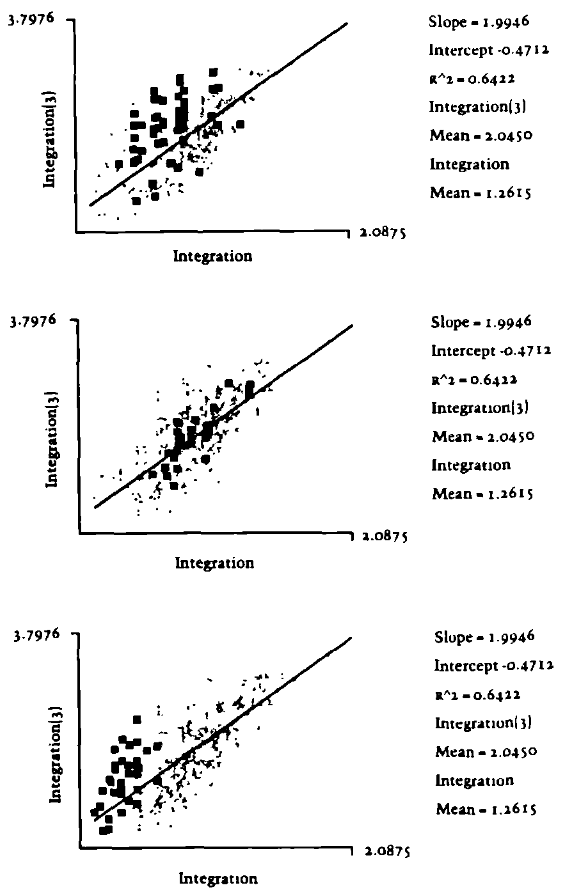


Figure 2.4 Examples of an intelligible and an unintelligible spatial layout. Source: Hillier, 1996

2.6 Syntactic intelligibility and it role in form-function theory

When looking at complex buildings or urban areas, we need to understand the way a part is located within a global structure. Space syntax defines this as intelligibility. This characteristic of intelligibility seems to be pertinent measure, which may differentiate the understanding of local areas in terms of the global structure.

The intelligibility of a form as defined by Hillier et al (1987) can be measured by analysing the relationship between how spatial configuration can be seen from its parts and what it is like as an overall pattern, that is, as a distribution of integration. It is defined as the degree of correlation between the connectivity and integration values of the line in a configuration. Hillier (1996) explains this notion using scattergrams which show the correlation between them. He notes that:

> " We can read the degree of intelligibility by looking at the shape of the scatter. If the points form a straight line rising at 45 degree from bottom left to top right, then it would mean that every time a space was a little more connected, then it would also become a little more integrated - that is to say, there would be a perfect 'correlation' between what you can see and what you can't see. The system would then be perfectly intelligible (pp129-130)."

For example, in figure 2.3(a), the points form a tighter scatter around the regression line, which indicates a strong degree of correlation, and therefore greater intelligibility. Figure 2.3(b) shows that the scatters are diffused and do not form a tight fit about the 'regression line', suggesting that the system is relatively unintelligible.

We then apply this notion to see how the internal structure of an area relates to the larger-scale system in which it is embedded. This investigation may be important in explaining how different types of relation affect one's experience of an urban area. Hillier (1996, p135) defines this notion as the relationship between global and local integration. This is illustrated by highlighting all the lines in an area in scattergrams of the whole system and examining the scatter of local against global integration. Figure 2.4(a) illustrates a series of examples that can be read as intelligible and unintelligible in the whole system. A local area, represented as a cluster of dots, is 'intelligible' if the regression line for that cluster is steeper than that of the whole system, and at the same time, shows a strong correlation between global and local integration. This effect is read as a characteristic steepening of the cluster of points, which represent an area, on the scattergram produced when local integration is plotted against global integration for every other space in the system. On the other hand, if a set of dots in the scattergram is not tight and does not form a linear scatter, it can then be described as a local area that is unintelligible in the global context. For example, figure 2.4(b) shows an unintelligible spatial layout of a typical modern housing estate. It shows a broken relation between the local and global integration of spaces, forming a series of layers, each distributed in a vertical pattern in the scattergrams that means there is a very unclear relation between the local and global structure.

The notion of intelligibility has two fundamental roles in the form - function relationship. First, the pattern of space use is affected by the degree of intelligibility of an area. Hillier (1996) argues that, in a spatial configuration, every local move has its own configurational effect, and it is the laws that govern these local to global effects that govern global configuration. These laws might meditate the relationship of human beings to space. A relation between local parts and the global/whole structure of an urban system can be understood through the analysis of the relation between local and global integration in the axial map. In the case of a poor relation between local and global integration, he suggests that it implies a broken relationship of all interfaces in functional terms.

Recently, supporting empirical evidence that poor prediction of pedestrian flows in areas which are relatively unintelligible in comparison with their context was found in studies of Barbican and the South Bank areas in London (Chang, 1998; Chang & Penn, 1998). They suggest that in these situations people appear to rely to a greater extent on local factors in the immediate environment, such as the visibility of transition spaces, and on the presence of other people, to guide their wayfinding decisions. This work suggests that the degree of predictability of movement flows with axial maps might be associated with the degree of intelligibility. In other words, the ability to predict patterns of pedestrian movement in urban areas decrease as those areas become less ‘intelligible’.

Second, intelligibility reflects the aspect of ‘generic function’ in both buildings and urban areas. Generic function refers to what all buildings must have in common before specific uses are assigned to them. Generic function is the first filter that reduces the vast expanses of theoretical possibility to the field of architectural and urban actuality (Hillier, 1996). In the case of settlements, generic function refers not to the specifications of different cultural, social and economic forms, but to what these forms have in common when seen from a spatial point of view. For example, by creating different degrees and patterns of integration and intelligibility, and different degrees of local and global organisation in the overall form specific social interfaces can be reproduced. This is a product of generic function.

As discussed, morphological intelligibility may have a fundamental role for the understanding of the form-function relationship in architecture. It therefore seems to have a cognitive dimension, in so far as it affects the shaping of spatial experience. This is reviewed in the following section.

2.7 The latent role of intelligibility in shaping spatial experience

A structured grid is one in which integration and intelligibility are arranged in a pattern of some kind. In reality, lines and areas are prioritised for integration and intelligibility to varying degrees in order to create a system of differentiation, which supports functionality and intelligibility. Hillier (1996) asserts these two are the keys to ‘generic function’, which permit a spatial complex to be adapted in principle for human occupation and movement. He says: “... an integrated space for everyday living is one in which generated movement is natural to its function, while a segregated space for use only on special occasions is one where generated movement is not" (ibid, p393). These laws, and their relation to generic function, might therefore be constraints on spatial experience, since these seem to encourage or impede aspects of human activity.

The most salient aspect of generic function reflects the property of 'intelligibility' which Steadman (1983) conjectures is one of the critical factors restricting architectural possibility. He further suggests that fundamental reasons to do with the nature of human cognition and the nature of spatial complexes will bias the selection of spatial forms away from syntactic depth maximising processes and in the direction of the depth minimising processes. Concurring with Steadman's conjectures, Hillier (1996) argues that a depth maximising form is hard to understand, since the information available from its constituent cells is too poor and undifferentiated to give much guidance about the structure of the complex as a whole. Through this objective property of intelligibility - a property of objects rather than a property of minds - he hypothesises that generic function might play a salient role in structuring human spatial experience. In this framework, it can be conjectured that the structures of the 'logical environment' and an individual's spatial experience are related fundamentally by the degrees of acquisition and transformation of structural information for everyday living, which is affected by the degree of inherent intelligibility of the whole structure of objects.

In conclusion, this part of the chapter has reviewed theoretical perspectives concerned with the role of spatial configuration in the relationship between human beings and the built environment. This suggests a definite effect of spatial configuration on spatial behaviour. Nevertheless, most studies in this area have not claimed an impact of spatial configuration on cognitive maps. In other words, the syntactic approach to the understanding of spatial behaviour has mainly focused on the relationship between configuration and consequent behaviours, without claiming a role of spatial configuration in cognitive maps.

In this perspective, further research is needed to investigate the relationships between spatial configuration and its cognitive representation; between spatial configuration and spatial behaviour; between cognitive representation and spatial behaviour; and finally direct links among spatial configuration, cognitive representation, and spatial behaviour.

PART THREE:
AN INCORPORATION OF SPATIAL CONFIGURATION INTO A MAN-BUILT ENVIRONMENT RESEARCH FRAMEWORK

2.8 An integrated approach to spatial configuration, spatial cognition and spatial behaviour

2.8.1 The need for an integrated approach

Knowledge of the relations between environmental assessments and the descriptive attributes of spatial configuration are valuable both for addressing practical questions and for advancing our understanding of the processes involved in spatial behaviour. Craik and Femer (1987) emphasise the importance of prediction for advancing our understanding of environment-behaviour transactions and argues that this understanding in turn provides a basis for improving planning, design, and management of our built environment, by way of establishing dependable predictive relations between descriptive attributes of places and how they are evaluated and used. In this perspective studies relating observed behaviour and the representation of spatial configuration in the mind needs further exploration.

Within cognitive studies, it is however generally assumed that people act on the basis of decisions they make. These decisions are based on appraisals of acquired information. Thus, the relationship of observed actions or spatial behaviour to the environment is mediated by psychological processes. For example, Brand (1984) argued that decisions or intentions can be considered as causes of actions in the same sense as physical phenomena are causally determined.

In a similar vein, it has been asserted that action or decision making is dependent on the mental categories that an individual uses to make sense of a situation and on the theories of action and strategies that an individual uses to cope with the world[9]. Actions due to the impact of the environment in turn affect cognition and modify its impact, feeding back to cognitive representation as well. In this perspective, Evans and Garling (1991) argued that previous research has had a distinctly cognitive bias, emphasising the role of cognition as it influences assessment and action rather than integrating the three areas of scholarship.

It is probably fair to say that interactionism is dominant, implying mutual casual influence over time between behaviour and the environment. A theoretical and empirical curiosity in integrating these domains is inevitable. Attention must be paid to the physical built environment, its cognitive maps and patterns of space use.

2.8.2 Spatial configuration, its cognition and consequent use pattern

In this section we review research into the way people assess and recognise spatial configuration and how they behave based on this assessment. This perspective provides a way to integrate three research agendas: spatial configuration, its cognition and consequent patterns of space use.

Indeed, Lynch (1960) has suggested that "a distinct and legible environment heightens the potential depth and intensity of human experience" (p5). Lawton (1975) again stresses that the clarity or legibility of the physical environment may impact on the "successful adjustment" of elderly residents to communal housing. In their discussion of therapeutic environments, Canter and Canter (1979) elaborate on this stating that in order to comprehend a complex environment and take advantage of it, it is necessary to understand how it is arranged in space.

[9] see Argyris et al., 1985, for a further discussion of action theory.

Other environmental researchers (e.g., Appleyard, 1970; De Jonge, 1962) have pointed out the difficulty of comprehension of complex urban scale settings. Specifically, they have invoked the Gestalt psychology laws of perceptual organisation and "good form" in characterising which spatial relationships are most readily represented in an individual's cognitive map. For example, Canter (1974) has proposed the relevant qualities of "good form" to be symmetry, regularity, and continuity. Alexander and Carey (1968) indicate a strong relationship among patterns which match these criteria: preference, complexity, ease of description, and finally, the ease with which one could memorise such configurations.

More significant empirical research has been done at the building scale. Previous theories about the relation of the physical built environment at the building scale to legibility fail to analyse spatial settings as a whole, just as in urban settings. The notion of spatial pattern as a configuration that defines the relation of all spatial elements has not been incorporated into this research. While Lynch's research is based on a qualitative study of the records completed by subjects interviewed, Weisman (1981) criticises this approach and offers conceptual and empirical foundations for a quantification of qualitative aspects of spatial configuration. He investigates the impact of legibility upon wayfinding using several theoretically derived visual or spatial variables. He found that two aspects of floor plan configuration, which is judged from abstracted two-dimensional diagrams of real buildings into "high" and "low" groupings in terms of complexity of plan configuration, were strong predictors of the reported frequency of disorientation. Weisman proposes that wayfinding in buildings is affected by four design elements: i) perceptual access, which is the degree to which the user can actually see interim or ultimate destinations; ii) visual differentiation which is the visual distinctiveness and personal and community significance of design features, and the congruence between distinctiveness and significance; iii) signs "especially those that define next decisions"; iv) legibility, which is defined as: "geometrical relationships that are more adequately perceived and remembered". This research finding is valuable for the predictive power of judgements of plan configuration diagrams, despite the use of simple paper-and-pencil tests.

However, this case study is limited in the extent to which it can be generalised to different environmental settings. The study is restricted to describing the objective properties of the spatial configuration by subjective self-assessment without a generalisable objective measure of complexity of spatial configuration. Nevertheless, the approach is noteworthy for being concerned from the outset with spatial configuration as a whole rather than with isolating particular spatial features. Thus the focus of research shifts to the problem of objective description of spatial configuration as a whole.

Kaplan and Kaplan (1983) provide an integrated view of the role of spatial configuration in cognition by integrating two basic informational needs - making sense and involvement. They stress that there are four spatial properties: two relating to the immediate environment and two relating to the longer-range future. Coherence and complexity are the first two factors; coherence refers to how easy it is to organise what one sees into relatively few identifiable units, or chunks. Complexity refers to the visual "richness," or diversity, of a scene. However, complexity needs to maintain coherence within this richness if positive evaluation is to be enhanced. They argue that it is easy to have complexity at the expense of coherence. The two environmental factors relating to the longer-range future are mystery and legibility. Mystery refers to inferences about what would be likely to happen if one were to walk some distance into the scene - such as when one is moving along a path and anticipating what will happen next. Legibility is that characteristic of an environment that suggests one could explore it extensively without being lost. They summarise human preferences for configurational aspects of the built environment, as shown in Table 2.2.

Employing a theoretically and empirically based model, several researchers (e.g., Garling, 1986; Kaplan and Kaplan, 1983) have tried to address the general properties of environments that are likely to affect spatial orientation and navigation though the perception and cognition of spatial form. Garling (1986) proposes a model, as shown in Figure 2.5, that identifies factors affecting spatial orientation and navigation in small and medium-scale built environments.

The degree of direct or indirect visual access to destinations in a particular environment is assumed to be one factor that affects spatial orientation and navigation. Visual access is useful if parts of the environment are differentiated so that they can be recognised. Hence the degree of differentiation is a second factor. The complexity of paths becomes a third factor. Visual access and differentiation may reduce the negative effect of a complex path system. However, if the path system is simple, differentiation and good visual access may not further enhance the ability to maintain one's orientation and to find one's way. This contention reiterates several findings from the piecemeal approach to these issues.

To summarise, these studies are in lack of describing spatial configuration objectively in reality or in cognition, and at the same time, understanding its role in man - the built environment relation. Nevertheless, they provide a valuable conceptual tool which enables us now to incorporate configurational aspects into the research frame work.

Table 2.2 Spatial form preference framework. *Source*: Kaplan and Kaplan, 1983.

	Making sense	Involvement
Present or immediate	Coherence	Complexity
Future of promised	Legibility	Mystery

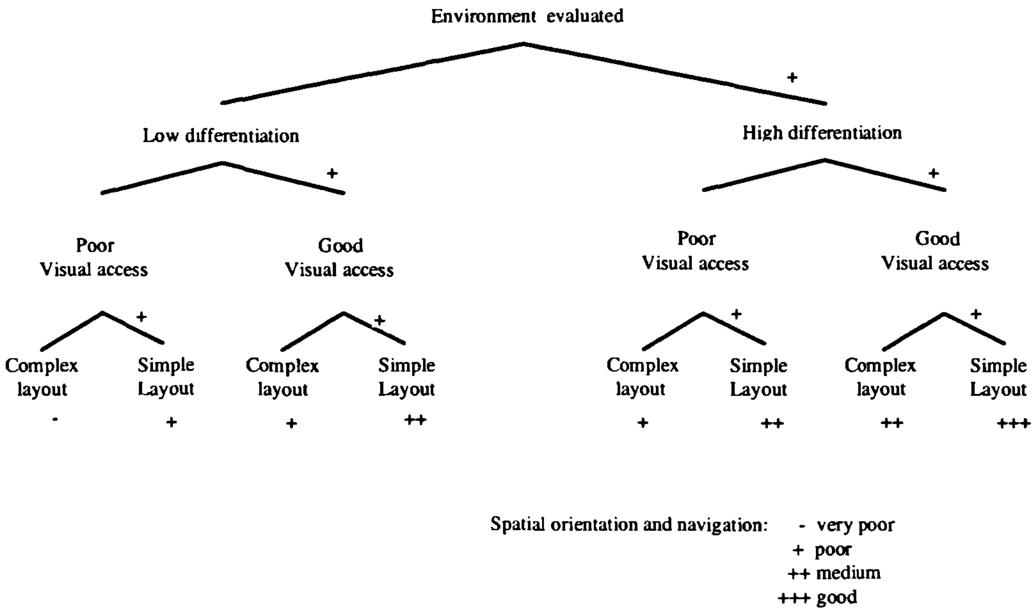


Figure 2.5 The built environment, and spatial orientation and navigation.
Source: Garling et al., 1986

2.9 Incorporation of spatial configuration into the man-environment relation

In research investigating human and environment settings, psychological variables have been the most salient intervening factor. However, Piaget (1968, 1971) argues this relation needs to be understood from the perspective of how far 'knowledge' originates in the subject and how far in its environment. Firstly (1968) he argues that knowledge of an object does not consist of having a static mental copy of the object but of effecting transformations and effecting some understanding of the mechanisms of these transformations. Secondly, logical relationships on which these transformations are based have their origins in physical operations, or more precisely in co-ordinations of operations such as uniting, ordering, introducing correspondences and so on. Thirdly, knowledge is not therefore determined either by the knower or the known, but by exchanges and interactions between them. Piaget (1971) further argues that the fundamental relation is not one of simple association but of assimilation and accommodation. An individual thus assimilates objects to the structures of his actions and to the unforeseen aspects of the reality he encounters. Piaget thus places great emphasis on the subject's own constructive activity, whether he is performing on objects external to him or on internalised symbols and representations.

On the other hand, by taking a contrary point of view to both previous man-environment studies and Piaget's subjectivist alternative, Hillier and Leaman (1973) argue that the problem in these approaches lies in the object of study, which place priority on the human being, and thus these studies cannot account for individual or social knowledge, or for the nature of societies, or even the physical and spatial properties of urban systems. They continue that we exist not in 'spatial space', pure and simple, but in spatial space as it has been constructed in terms of the contents and structures of logical space.

Hillier (1996) regards this man-environment relation not as a direct physical relation of cause and effect, but as an indirect relation, mediated by 'a generic information structure', passed from one generation to the next, and gradually evolving, but not on the time scale of individuals. Hillier (1996) proposes that a 'man-environment paradigm' exists in which, by representing the human subjects as the object of concern at the centre of the research agenda, the appearance is set up of a human science concerned with understanding the effects of the built environment on the social, cognitive and emotional life of people.

From this theoretical background, Hillier and his colleagues developed 'Space Syntax'[10], a conceptual framework and descriptive tool. Space syntax seems to offer better solutions to overcoming problems both in conceptualising relations between spatial form and social life, and in describing such relations in spatial terms. Thus, through conceptualising the social implication of spatial layout as something constituted in the spatial pattern of this layout, space syntax has established a logically implied connection between the two aspects. Both the conceptual framework and formal approach to plan description enable us analyse spatial layouts as social interfacing systems. Hillier and Hanson (1984) argue that space thus works socially by admitting and sustaining different patterns of movement and encounter according to spatial configuration.

Hillier's approach to the investigation of the man-environment framework is distinguishable as being concerned initially with the environment as an object rather than with the human subject, thus the focus of research shifts from the problem of describing the physical environment to its active role within the framework. Of particular interest here is his argument on spatial configuration as an intervening variable within the interface between physical built environment and social behaviour (Hillier and Leaman, 1973). Hillier's general approach is to conceive of the problem as that of first describing how environments acquire their form and order as a result of a social process. This work has substantial relevance to the present work, but does not provide its starting point, since there is a fundamental difference in the way the problem is conceptualised at the interface. His argument appears to be lacking in an

[10] The basic concepts and a procedure for syntactic analysis using Space Syntax are described in section 3.1.

account of the role of the human mind which must be of relevance at some level in this man-environment relation.

2.10 Intelligibility and spatial experience

In order to achieve heightened spatial experience, many studies have pointed out the salience of factors, such as, imageability, complexity, cohesion and hierarchy in spatial configuration. Despite the profound influence of spatial configuration on spatial experience, most of the knowledge relating to legibility is based on anecdotal interpretations of spatial form, and lacks consistent measurement techniques and an empirically verified theoretical foundation. In other words, the obvious inadequacy of definitions of preferable spatial configuration is coupled with the absence of an analytical definition of configurational variables. Thus it is not surprising that approaches describing the interrelationship between spatial configuration and spatial experience gives rise to practical difficulties, since good examples on which the approach is based necessarily involve arguable judgements.

When it comes to intelligibility we can go one stage further. The incorporation of intelligibility into the research agenda might lend strong empirical support to integrated research among relevant domains. Penn and Dalton (1994) hypothesise that the human mind may act as a "correlation detector" in that it tries to retrieve and construct various ways of making sense of perceptual data. Thus, if the mind has problems with making sense of data, it may be because correlations have broken down in the environment. The conjecture relates to Lynch's proposal that 'continuity' is an important component of an imagable environment, and gives a means of quantifying that in terms of the strength of a statistical correlation between local and global properties. It also relates to a Piagetian mechanism for 'learning' through the retrieval of that correlation by using and moving around an environment. This conjecture distinguishes between intelligibility and the other factors mentioned above in achieving legibility. The former is based on the relations between local and global spatial properties. However, the latter relies more on unconscious efforts to recall information from cognition without objective account being taken of the interrelations of the features retrieved.

From all the findings reviewed it may be suggested that the impact of configurational differences is reflected not only in cognitive representations and movement patterns, but also perhaps in the dynamics of the interrelationship between them. Figure 2.6 illustrates the related studies and their interrelationship. This integrated approach may begin to resolve a long-standing question in urban design about how we design artefacts in a way that enhances people's experience of living spaces and leads to 'liveable places', to use Jacob's term (1960).

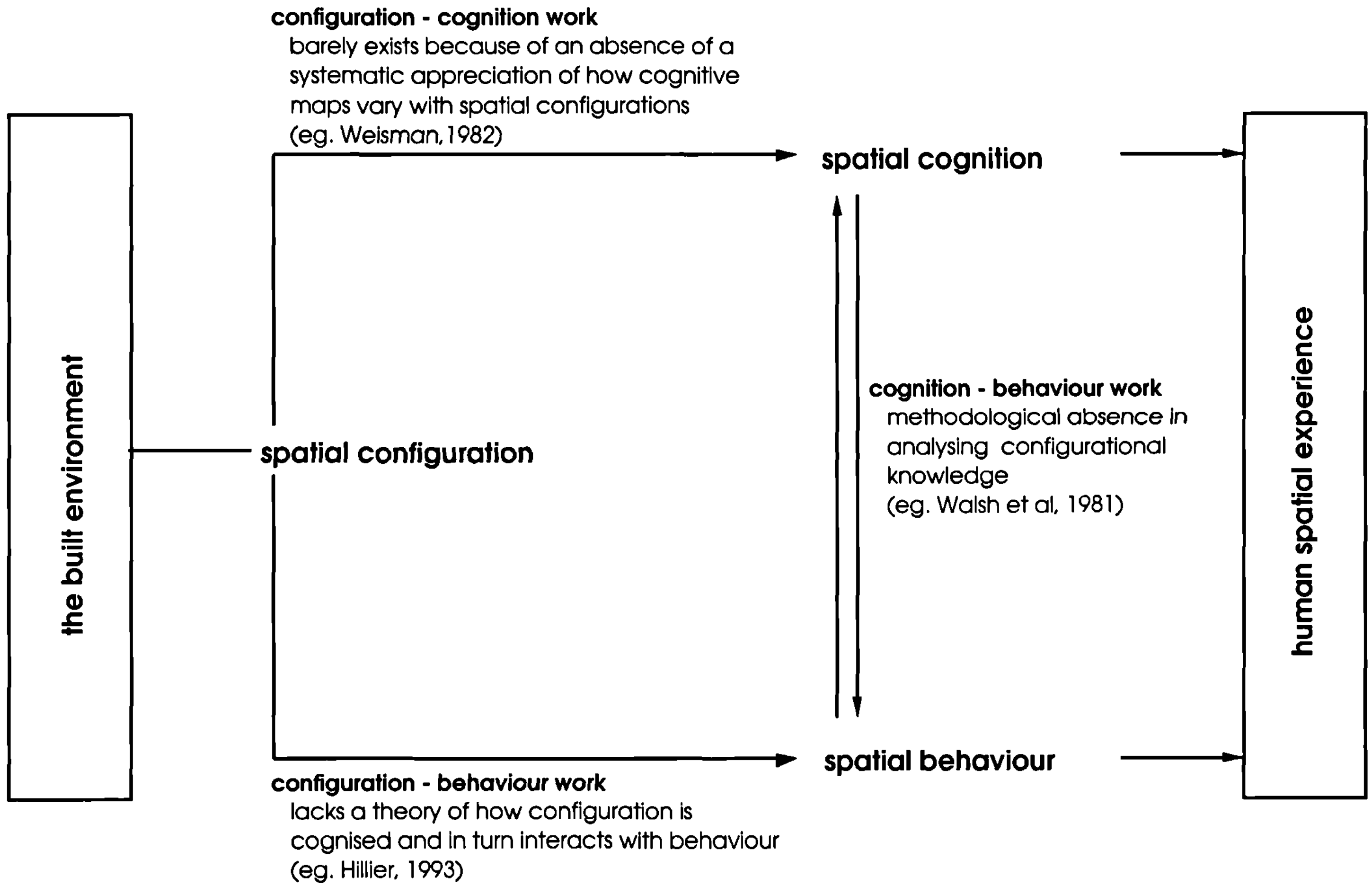


Figure 2.6 Relevant studies for spatial configuration and spatial experience interface

2.11 Summary and discussion

This review of research on the relationship between and among spatial configuration, cognitive representations and spatial behaviour describes a highly productive field. Theoretical perspectives have undergone changes in the direction of becoming more accurate conceptualisations of real-life phenomena. More importantly, scholarly curiosity is evident in several subfields, but particularly salient examples are the theories of place evaluation in terms of spatial configuration, proposed by, for example, Kaplan and Kaplan (1983), and Garling (1986), which constitute insightful advances in the theoretical basis of investigation into this relationship.

Increasing methodological and analytical sophistication has also contributed to knowledge about the relationship between human beings and the built environment. A number of measurement and analytic procedures have been developed since Lynch's pioneering work with sketch maps (i.e., Weisman, 1981; Hillier et al., 1987; Peponis et al., 1990). Also, cleverly designed field and laboratory experiments, coupled with computer simulation have replaced the case studies of early days (i.e., Kuipers, 1978; Gopal et al., 1989).

However, mainly due to the lack of a methodology and an integrative research framework, these complex interactions among the objective environment, personal cognition and overt spatial behaviour have not yet been explored. This gap in research can be described in two ways. Firstly, the neglect of perception-cognition and action studies within research based on syntactic descriptions of spatial configuration and related phenomena, and secondly, in a similar vein, the neglect of adequate descriptions of spatial configuration in the research on cognitive mapping and action. In this context, this chapter has tried to highlight commonalties and discrepancies between different fields by consistently imposing the perspective of the influences of spatial configuration on human spatial experience.

There are, however, a number of strong pointers in the literature towards an integrated theoretical framework. Piaget and Inhelder's (1958) spatial learning mechanism through action appear to be insightful in this perspective. In a similar way, Golledge (1975, 1978) and Couclelis et al's (1989) 'anchorpoint' theory and knowledge hierarchies in spatial learning are also important since 'anchorpoints' enhance spatial learning. They thus propose that places that are important in people's lives are also important in their cognitive representation. On the other hand, Hillier's notion of intelligibility (1987) suggest that there are correlations in the physical environment to be experienced according to different degrees of global and local relations in the spatial configuration. Earlier, Lynch (1960) also emphasised this characteristics using the notion of 'continuity' for attaining strong imageability. In this perspective Hillier's conjectures on intelligibility and Penn and Dalton's (1994) notion of 'correlation detector' are insightful how these theories might come together within a single framework. At more empirical level, O'Keefe's neural model of the function of the hippocampus as a cognitive mapping system appears to support this framework as at least anatomically plausible.

All these theories and conjectures are helpful in integrating related agendas, by incorporating the notion of spatial configuration and its role into the man-built environment research framework. Figure 2.7 demonstrates a conceptual man-built environment interface model in a simple form. This interface model is an interactive process composed of the three 'moments' of configuration, cognition and behaviour. Therefore this thesis adopts three methodologies to investigate their interrelationship. First, in order to analyse and understand spatial configuration in reality and in cognitive representations, Space Syntax was utilised. Second, an interview survey was conducted to gather data about cognition, using with sketch mapping. Third, an intensive observation of overt spatial behaviour was carried out to acquire information on space usage patterns. Finally all these sets of data were brought together within a single analytical framework. These procedures are described in the next chapter.

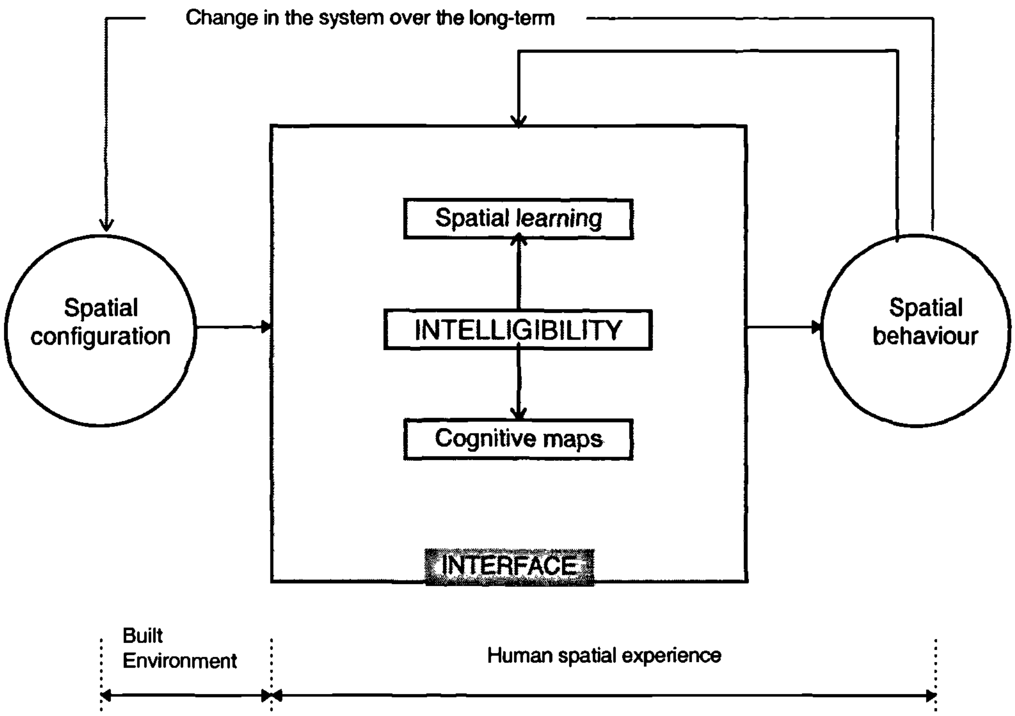


Figure 2.7 A conceptual model of spatial configuration and spatial experience interface

Chapter Three

METHODOLOGY

3.1 Introduction

This chapter aims to provide an overall approach to the research and a description of the methods, as an introduction to the empirical chapters. In the last chapter, we noted that there were a number of logical gaps in the research into human spatial behaviour. First, most research into cognition had little in the way of a consistent methodology to describe and quantify configuration. Second, configurational studies have not tackled cognition, relying almost exclusively on observed behaviour. This thesis attempts to bring all three areas together. Three methods are used: 'Space syntax' for the syntactic description of spatial configuration, an interview survey and sketch mapping exercise for measuring the perception and cognition of subjects, and 'gate observations' to obtain information about space usage patterns. These data enable an integrated investigation between the design parameters of configuration, the cognitive dimension, and the pattern of space usage in the behavioural sphere. Thus, a morphological study of neighbourhood layout and its consequences on the cognition of residents and their spatial behaviour, can be analysed and understood in terms of their functional implications in an interface between the human and the built environment.

This chapter starts with a brief description of the case study area, including the characteristics of the study area and the criteria applied for its selection. The presentation to be given at this stage is not a detailed morphological description but an overall view of the background information about the area. The detailed spatial description of the study area is the subject of the following chapter where a syntactic analysis is also carried out. We then present the basic concepts of space syntax, including its key theoretical concepts. The following section describes the interview survey for capturing data on the perception and cognition of residents in the study area, using two techniques; 'boundary delimitation' and a 'sketch map'. The general procedure of the interview, sampling, and questionnaire are explained. It then describes the syntactic analysis of spatial configuration represented in sketch maps as a developing method. The next section explains the observation technique for gathering the information about the patterns of space usage, including procedure of selecting observation locations. Finally, an overall view on the data organisation and its processing, and an outline of the analytical method is given in the following section.

3.2 The introduction of a case study area

Hampstead Garden Suburb was chosen for two reasons. Firstly, because of its morphological characteristics, and secondly, because of its historical background and design concept. The Suburb, designed by Unwin, was described as a direct outcome of the design concept of 'picturesque' and 'imageable' view of urban form (Hampstead Garden Suburb Trust, 1937), and often has been quoted as an example for the current 'urban village' movement.

The area can be subdivided into two halves in terms of both the history of its development and spatial configuration. The two neighbourhoods have a similar social, historical and demographic background and display many similarities in architectural quality and landscape scale. However, they have different spatial relationships among their elements and to the surrounding built environment[1]. These two adjacent areas are different in the degree of syntactic intelligibility. One area is relatively intelligible, the other less so. This difference provides a common basis for analyses of the relationship between configuration, cognition and behaviour.

The study area in the Suburb is encompassed by Finchley Road to the west and the A1 to the north, which consists in Falloden Way and Market Place, as shown

[1] This will be reviewed in more detail in Section 4.1.

in Figure 3.1. Hampstead Heath Extension defines the boundary of the Suburb to the south, and The Bishops Avenue is a definite boundary to the east. Within this boundary, as shown in Figure 3.2 (a) and (b), the Suburb is divided into two halves syntactically by the imaginary line along Big Wood, Central Square and the Heath Extension.

The north-west part of Hampstead Garden Suburb, the Old Suburb (Figure 3.2a), which was originally planned in 1909, has a relatively unintelligible spatial layout within the global context and in the system itself without surrounding areas. On the other hand, south-east of the Suburb, the New Suburb (Figure 3.2b), is relatively intelligible in the same way, which developed at the second stage of expansion. This morphological distinction between the two sub-areas of the Suburb will allow a systematic comparison when investigating the main argument of this thesis, coupled with the findings of the interview survey and the observation of space usage.

The north-west area contrasts with the other part in that housing density is higher and streets are shorter. Several blocks of flats, and rows of medium sized houses lie along Erskin Hill and Willifield Way. The south-east part of the area has much longer streets and rows of semi-detached houses, which were built relatively less densely. However, such a difference does not cover all the study area. The houses on Kingsley Way, Holne Chase and Winnington Road are relatively large in comparison with the rest of the area.

Figure 3.1 Hampstead Garden Suburb, London. *Source*: Ordnance Survey, 1996

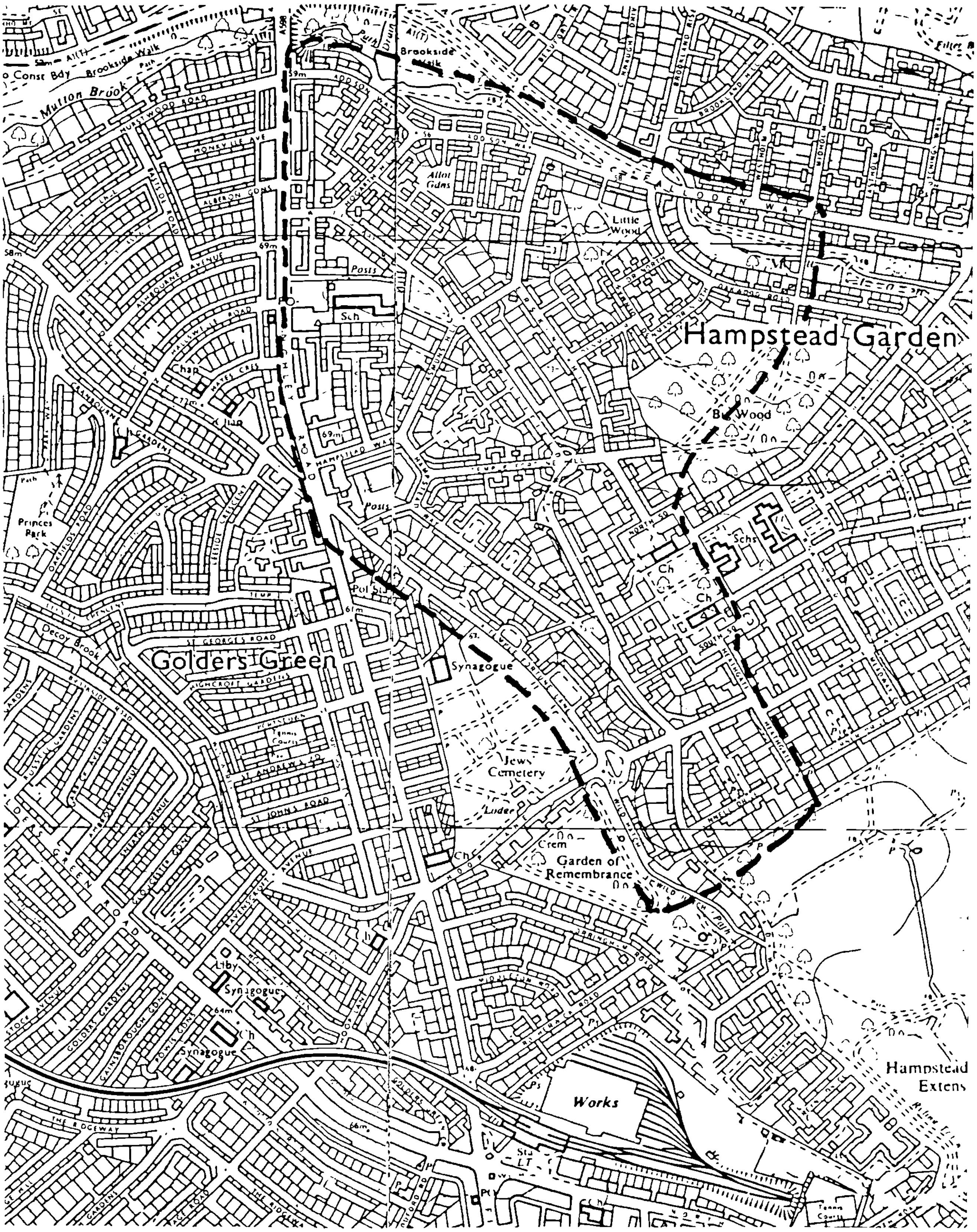


Figure 3.2a The Old Suburb. *Source*: Ordnance Survey, 1996

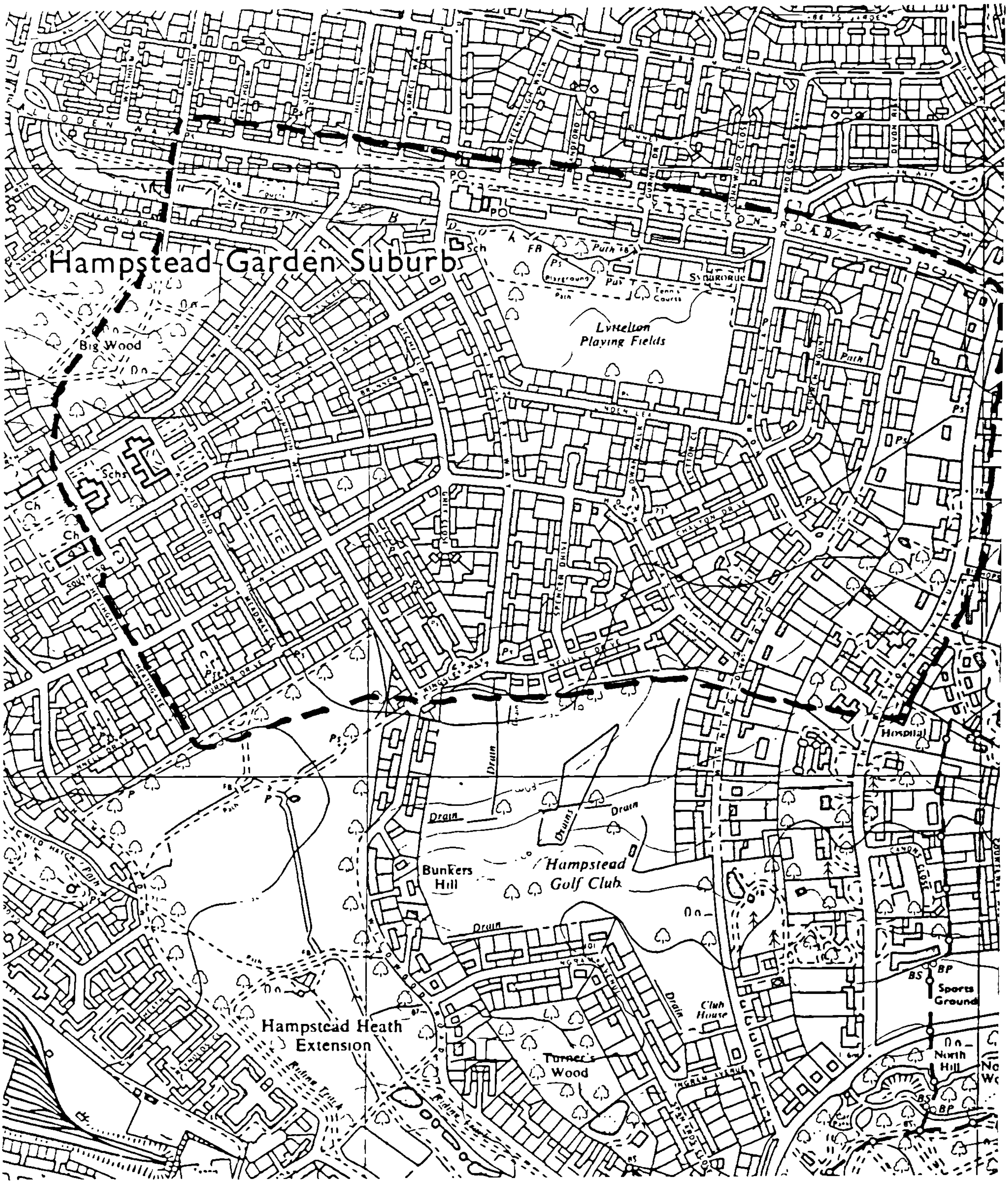


Figure 3.2b The New Suburb. *Source*: Ordnance Survey, 1996

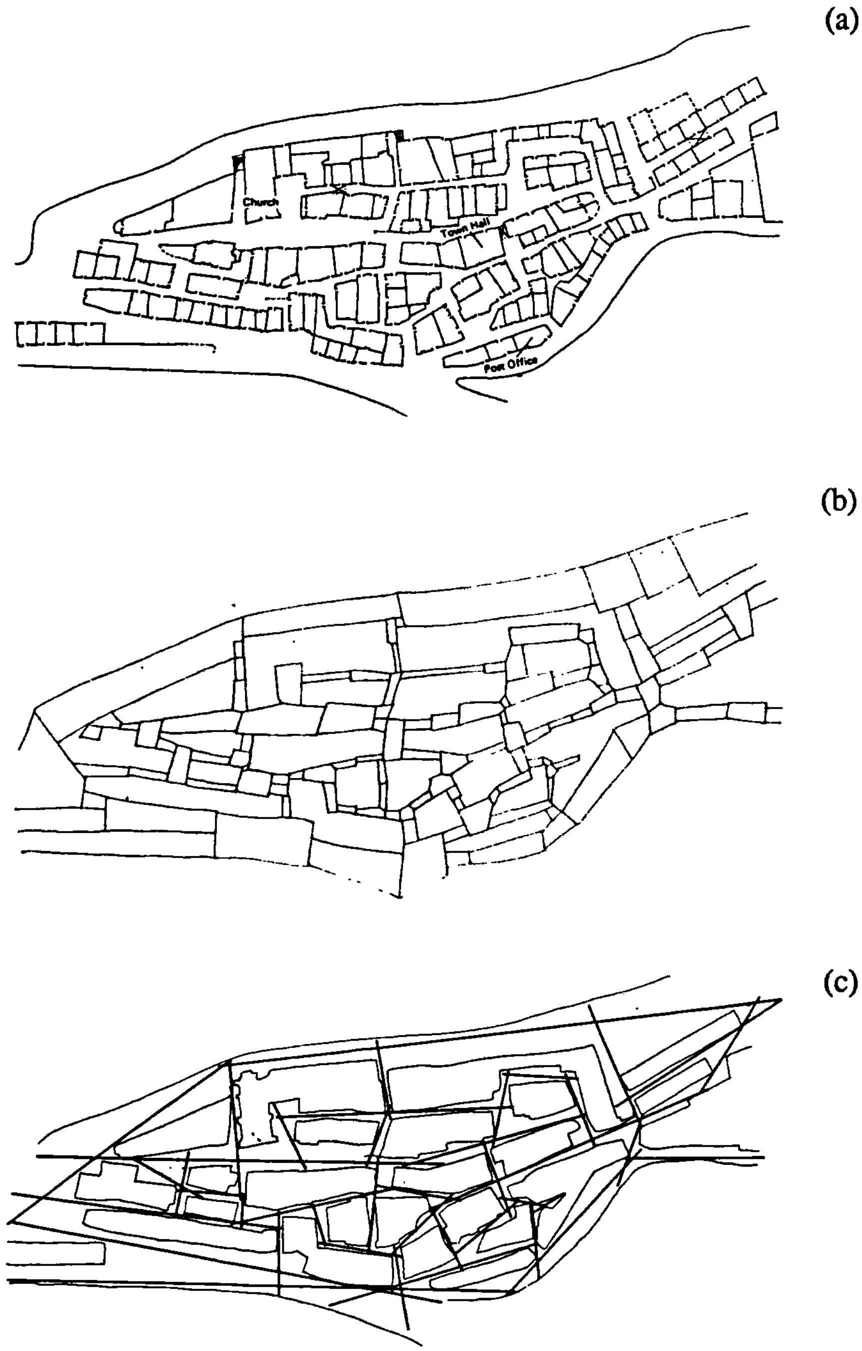


Figure 3.3 The procedure of modelling an axial map. Source: Hillier and Hanson, 1984

3.3 Space syntax

3.3.1 The basic concepts of syntactic properties

In order to describe and analyse spatial configuration using space syntax, an axial map of the open space structure of the settlement is needed. Firstly, the system of open space is divided into the smallest number of the largest possible 'convex spaces'. A convex space is a space through which no tangent to the boundary can be drawn which crosses any part of the space. This convex map will be the least set of fattest spaces that covers the whole system. Secondly, the 'axial map' of an area is drawn on the basis of the open space structure in a plan. The least sets of lines are drawn to cover all the convex spaces. Figure 3.3(a)-(c) shows the whole procedure mentioned above graphically: the open space structure (a), a convex map (b), and an axial map (c). These properties of convexity, lines of sight and changes of direction are believed to be the most fundamental properties in the analysis of spatial configuration, that is generally known as 'space syntax'.

Once an axial map is obtained, it can be analysed as a system of syntactic relations. Hillier and Hanson (1984) define that the relation of all the axial lines in the system is measured by the two basic properties of "symmetry-asymmetry" and "distributedness-nondistributedness":

> "the relation of two spaces a and b will be said to be symmetric if the relation of *a* to *b* is the same as the relation of *b* to *a*. For example, in Figure 3.4a the relation of *a* and *b* is symmetrical - as are the relations of both with *c*. In contrast, in Figure 3.4b the relation of *a* to *b* with respect to *c* is no the same as the relation of *b* to *a*, since from *a* one must pass through *b* to reach *c*, but not vice versa. ... A relation between two spaces *a* and *b* will be said to be distributed if there is more than on non-intersecting route from *a* to *b*, and non-distributed if there is only one. For example, Figure 3.4c combines nondistributedness with symmetry from the point of view of *a*: while Figure 3.4d combines distributedness with asymmetry. In effect, in a nondistributedness system there will be

never be more than on route from point to any other, whereas in a distributed system routes will always form rings (p94).

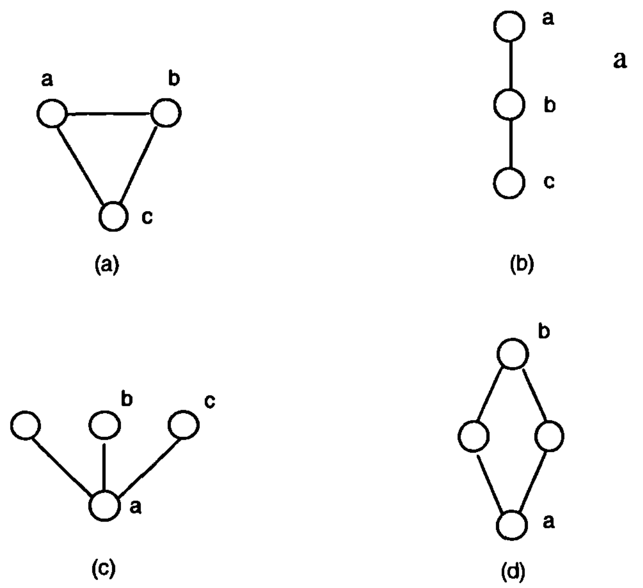


Figure 3.4 Relations of two spaces. *Source*: Hillier and Hanson, 1984, p94

These basic representational and relational concepts are adopted to perform a quantitative analysis of different spatial patterns. Practically this involves transcribing the axial representation as a graph where nodes represent lines and edges depict their intersection relations.

The process described above introduces a simple measure of 'depth', which is the most important concept in the quantitative analysis. Depth is measured in steps and corresponds to a topological measure of distance in the graph, which differs from a concept of metric distance. The depth between two adjacent spaces is 1. Thus, it represents the minimum number of spaces that must be passed through to go from one axial space to the destination. Each axial space has certain syntactic properties based on this measure. Relations of depth necessarily involve the notion of asymmetry, since spaces can only be deep from other spaces if it is necessary to pass through intervening spaces to arrive at them. The measure of relative asymmetry generalises this by comparing how deep the system is from a particular point with how deep or shallow it theoretically could be with that number of lines. To calculate relative asymmetry, take the mean depth of the system from the space by assigning a depth value to each space, and then sum these values and divide by the number of spaces in the system less one. On the basis of the mean depth so calculated, the relative asymmetry can be calculated as follows:

RA (relative asymmetry) = 2(MD-1) / (k-2)

(MD is the mean depth and k the number of spaces in the system)

In real urban systems, however, RA values are highly dependent on the total number of spaces in a system. To get rid of the system size effect 'real relative asymmetry (RRA)' is introduced.[2] RA is divided by the RA of a 'diamond' shaped system with the same number of spaces (D).

RRA = RA / RA(D)

1/RRA is defined as 'integration'. This value of well below 1 - of the order of 0.4 to 0.6 - indicates more 'segregation', while values tending to and above 1 show strong 'integration'.

Another integration measure is that of 'local integration' which considers depths only as far as three steps from a space itself and is called radius-3 integration, in contrast to 'global' or radius-n integration. Thus integration values that are calculated on the basis of all depth within a system indicate the global structure of a system while those considering fewer steps of depths indicate a more local structure. We can then produce a coloured global integration map using these integration values ranging from red for the most integrated line through the spectrum to purple for the least integrated line or on a grey-scale from black for integration to light grey for segregation. In the same way, we can produce another map of local integration.

[2] see ibid., pp 109-113 for a full treatment of this normalisation

Connectivity' is another local measurement of the system which describes how many other lines are immediately connected to each line. Control is also a local measurement, showing relations between a space and its immediate neighbours. It is measured by giving a value of 1 to each line, then summing the reciprocal of immediate neighbours, which gives values over 1 for spaces with strong control than their neighbours and values less than 1 for weak control. This measures the degree to which local relations are 'distributed' amongst neighbouring spaces.

Once the integration of each space for the whole system has been calculated, the 'integrating core', which illustrates the important deep structure of a spatial system, can be identified. In a similar context, the 'control core' can be identified, which accounts for the set of controlling spaces in the system. These two core diagrams together with the coloured global and local integration maps allow the systematic interpretation of the spatial structure of the system.

Finally, 'choice', is a global and dynamic measurement of the system, calculating the number of times an axial space is traversed as topologically shortest journeys are traced from every space to every other in a system. It indexes how many of the most direct paths connecting each of all the possible pairs of other spaces go through that particular space. Hillier et al (1987) suggests that choice provides a measure of the global 'distributedness' of relations in a system. Figure 3.5 describes various relations among the four syntactic properties: 'connectivity', 'integration', 'control' and 'choice'.

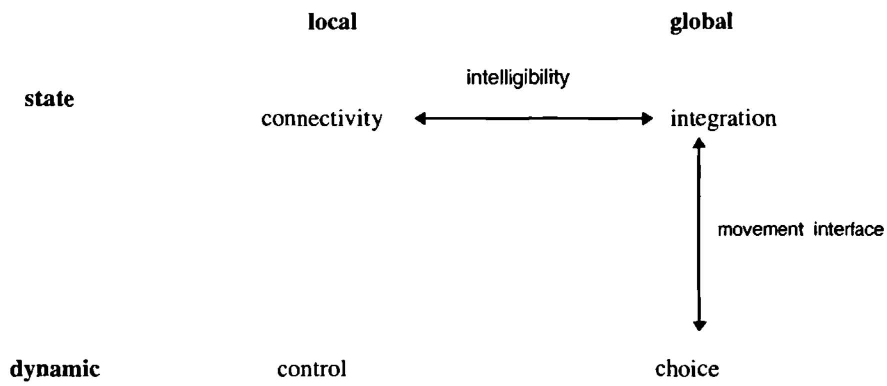


Figure 3.5 Model of fundamental measures of the axial representation. *Source*: Hillier et al, 1987, p236

3.3.2 Syntactic analysis of spatial configuration

A syntactic analysis of spatial configuration begins by representing the layout of the case study area as axial maps. Based on the computation of axial maps as reviewed in the previous section 3.3.1, two scales of axial maps of the study area were produced. One is the study area of Hampstead Garden Suburb within its global context and the other is the suburb without its surrounding areas. The former consists of 2,433 axial lines, and the latter has 180 lines. Each map is represented by its global and local integration respectively. A vehicular axial map, which represents spaces only for vehicular access excluding pedestrian footpath, was also examined.

In order to see static syntactic structure within a global context, the area is represented by a set of axial lines each displaying the least set of axial spaces that accounts for the top 10% integrating spaces, the top 11 - 25% integrating spaces, the 26 - 50% integrating spaces, the 26 - 50 segregating spaces, and the top 25% segregating spaces, and finally, the top 10% segregating. In a similar way, integrating and segregating spaces of the Suburb are calculated without surrounding areas. Two axial maps that show controlling spaces in the area were examined: the top 10% controlling spaces and the top 25% controlling spaces. By combining these two kinds of information, the top 10 integrating and controlling spaces and the top 10% globally and locally integrating spaces were identified. These maps are shown in Figures 4.7-4.15 and fully discussed in Chapter four. This syntactic properties of the Suburb were calculated in two different ways: firstly, the Suburb within its global context; secondly, the Suburb only without surroundings. The interpretation of the spatial structure of a plan is largely based on the outcome of axial analyses showing how syntactic values are distributed in that system and how they related to each other.

Once the syntactic analysis of Hampstead Garden Suburb as a whole is done, then it is further divided into two areas in terms of intelligibility, as shown in 3.2 (a)(b). One is a relatively unintelligible area, which is the old Suburb, and the other - the new Suburb- is a more intelligible area not only within its global context, but also in its own structure without surroundings. The detailed syntactic characteristics were examined in later section 4.5. These two halves of the Suburb provide a basis for systematic comparison between them in the relationship among configuration, cognition and behaviour.

3.4 Interview survey

3.4.1 General Survey Procedure

The interview survey used in this study is based on a household sample of the residents in a selected area, with home interviews in which respondents' perception and cognition of a neighbourhood were ascertained.

At randomly selected addresses, a letter was sent for asking for co-operation in a survey. Three days later, an interviewer visited and found an adult member of the household, then an appointment was made if he or she was willing to participate. The survey was conducted at an appointed time using a questionnaire. If the participant was not ready to be interviewed for any reason, the interviewer arranged to call back at another time. Several return calls might be needed to obtain a response. After three failed attempts to contact a chosen address, the sample was replaced with another randomly selected household. Tuesday through Friday were used as survey days, since people's activity on the weekend in their neighbourhood might affect the response of residents' perception and behaviour in the neighbourhood.

In the interview, residents were informed of the overall purpose and the procedure of the survey. The interviewer read out each question just before each task. The entire survey took approximately 40 minutes to complete. The survey was conducted between December 1996 and November 1997.

3.4.2 Sampling

The target sample size was about 80 private households, which was expected to be 3.1 per cent of households in the study area. In order to construct samples that are representative of the people living in households in the Suburb, data from the 1991 census was used to identify certain parameters within census enumeration districts. In both subareas of the Suburb, the number of households in each area was found from the census data, and the quotas were set according to the population in the corresponding area. The probability of any given address being selected for a survey was proportional to the number of residential units in that area.

The initial step in the sampling framework involved selecting proportionate samples from both intelligible and unintelligible areas defined by syntactic analysis, using a systematic probability proportionate to size procedure. Once both the intelligible and the unintelligible areas were defined, a field household enumeration and random household selection were conducted. For practical reasons in the analysis stage, one sample was chosen from all the households identified in an axial line, if the sample refused the interview, it was substituted with the next randomly chosen one. For the survey, within household adult replacements were allowed. The final sample size was 76. 39 are from the intelligible sub-area and 37 are from the unintelligible sub-area.

3.4.3 Questionnaire

The aim of the questionnaire was to ascertain the effects of the physical built environment on perception and cognition. The questionnaire is shown in Appendix-B. The questions aim to ascertain the information regarding the way in which people perceive and recognise the spatial structure of their neighbourhood.

The first two questions are designed to elicit data on residents' cognitive image of the area. The first is a sketch mapping task to elicit information on their recall of spatial configuration. Respondents are asked to draw a sketch map of the spatial layout of Hampstead Garden Suburb for 20 minutes, including streets, buildings and open spaces. In order to set a uniform scale and orientation to the map, two well-known places are marked on a blank A4 sized piece of paper. These two are Golders Green Station and East Finchley Station. The former is placed on the lower left corner of the paper provided, and the latter on the right upper corner, which inevitably covers all the Suburb area, so people are reminded to sketch the whole Suburb and gives the map an overall N-S orientations. The interviewee is instructed that the purpose of the sketch is as a guide for a visitor to orient himself or herself and to find their way in the Suburb. This sketch map method especially focuses on eliciting the image of spatial configuration as a whole rather than free recall of all spatial features in the area.

The second question is to determine the *boundary delimitation* of their perceived neighbourhood. Interviewees were asked to draw the perceived boundary of their neighbourhood on an A4 sized 6-inch-to-the-mile Ordnance Survey map. This map was not available to them during the previous task. A respondent's home is marked on the map.

A concept of neighbourhood was adopted to avoid respondents' confusion in boundary delimitation task. A phenomenological neighbourhood concept is adopted to identify an area centred in a subject's home that has personal significance.

Authors define the "neighbourhood" concept in a variety of ways. Among them, Lee (1968) emphasises the wording "your neighbourhood" that may bias the response in terms of an area of personal, social and psychological significance. He adopts a phenomenological approach to combine social interaction and physical geography in his definition of the neighbourhood. He argues that, by using this approach, planners and sociologists could resolve the physical-social duality inherent in the neighbourhood concept. This concept is more simply expressed in people's everyday life. Lauwe (1960) defines neighbourhood space as the network that encompasses daily and local movement in his concept of urban social space, in which a hierarchy of spaces has been proposed within which groups and individuals live, move, and interact.

In this study the neighbourhood is defined by adopting this phenomenological concept. Thus, respondents are instructed to see the neighbourhood as the area where daily and local individual life is based.

For analysis, the boundaries are superimposed on to the map of the local area. By superimposing all the boundaries, the perceived boundary of the neighbourhood is measured. Then the boundaries of two samples from the intelligible and the unintelligible area are compared to investigate the impact of syntactic characteristics.

The second part is a post-task question (questions 1-4) about the degree of difficulty experienced in carrying out the first two cognitive mapping tasks. Respondents are requested to rate their encountered difficulty in carrying out the cognitive mapping task on a five-point scale. This result is analysed in terms of the spatial configuration of respondents' neighbourhood. This post-task question is based on the conjecture that the difficulties encountered in drawing a sketch map and a boundary map may come from the lack of intelligibility of space, which may inhibit the easy acquisition of spatial knowledge. This conjecture is based on the studies of Spencer (1973) and Lee (1968) who found that heterogeneous neighbourhoods gave difficulties to respondents in representing his or her neighbourhood exactly. They contended that the more difficulties the respondents have in cognitive mapping, the smaller the size of the delimited neighbourhood becomes.

The third part of the questionnaire (questions 5-13) is designed to ascertain residents' perception and cognition of spatial structure the Suburb. The questions assess the perceived difficulties or confidence in wayfinding. Subjects are asked to write down answers or sometimes to mark them on a five-point scale.

The first question (question 5) was intended to elicit the perceived centre of the Suburb. This reflects the Lynch type survey in an attempt to find landmarks or nodes that are recognised as the centre. Question 6 asks about the experience of wayfinding in the area. Question 7 was built upon the response from question 6 if a respondent reported an experience of being lost. There then followed three related and overlapping questions (questions 8-10) to measure the respondents' degree of confidence in their spatial knowledge. Questions 11-13 were intended to identify the degree of perceived accessibility to facilities and places. Responses were placed on a five-point scale.

The final part of the questionnaire inquires into demographic issues: the respondent's sex, age, years of residency in both the Suburb and at the current address, occupation and education. This was done to ensure that the survey is representative.

3.5 Analysis of sketch maps

As noted in section 2.3 above research using sketch maps has usually focused on the accuracy of the representation. Various methods have been used to determine this, including counting the number and types of features represented and measuring the accuracy of representation of relative distances and relative orientations between features. Previous research has, however, encountered difficulty developing measures of aspects of the global topology of the sketch map and in measuring the more difficult aspects of 'continuity' that researchers such as Lynch have suggested are of importance in cognition. In this study, therefore, a method has been developed for the analysis of sketch maps in two stages.

First, the frequency with which different features were represented was calculated by counting their occurrence on the sketch maps. The frequencies are given in Appendix E and discussed in Section 6.6. Second, space syntax analysis was applied directly to the sketch map itself in order that the syntactic characteristics of the whole map considered as a configuration of spaces and features could be quantified. The main aim of this analysis was to allow a comparison between the configuration represented in the sketch map and the configuration of the real world map. This was achieved by transcribing configurational values of spaces featured in the sketch map into a single statistical database along with the analysis of the real map and the observations of patterns of space use. The data from this analysis is contained in Appendix E and is discussed in Chapters 6-9. Since the method of analysis of sketch maps raises a number of methodological issues the following sections describe this in more detail.

3.5.1 From a sketch map to an axial map

When drawing a sketch map, subjects are referred to two well-known places provided for direction and scale. The scale given by distance between these two places is 1:10000. However, some sketch maps are either smaller or larger than this reference scale. These maps are then re-sized to 1:10000 approximately in order to digitise them for axial analyses.

Axial lines are drawn based on the geometry of the sketch maps. Sketch maps are digitised in the same way as real maps described in section 3.3.1. The method used is: first, scan a sketch map and import it into a graphics program; second, draw axial lines using the scanned map as a background picture; third, process the axial map for syntactic analysis using Axman. Figure 3.6(a)(b) shows two examples of axial maps drawn using a relatively well and a poorly drawn sketch maps.

As discussed in section 2.5.5, sketch maps generally contain errors and distortions and thus do not represent the real world exactly. Most common distortions are in generic aspects of the maps such as widening a street, straightening of a curved street, orthogonalising of non-perpendicular intersections, as shown in Figure 3.7(a)-(c) respectively, and omitting less 'important' spaces. All these distortions tend to result in fewer axial lines in sketch maps than in reality. Thus the sketch maps generally have fewer segments on a street and are more integrated. These characteristics of sketch maps, which are created by distortions and errors in representing the real world, are subjected to axial analyses in order to elicit syntactic characteristics of spatial configuration in cognitive maps. Empirical evidence for this is given in later section 6.5.

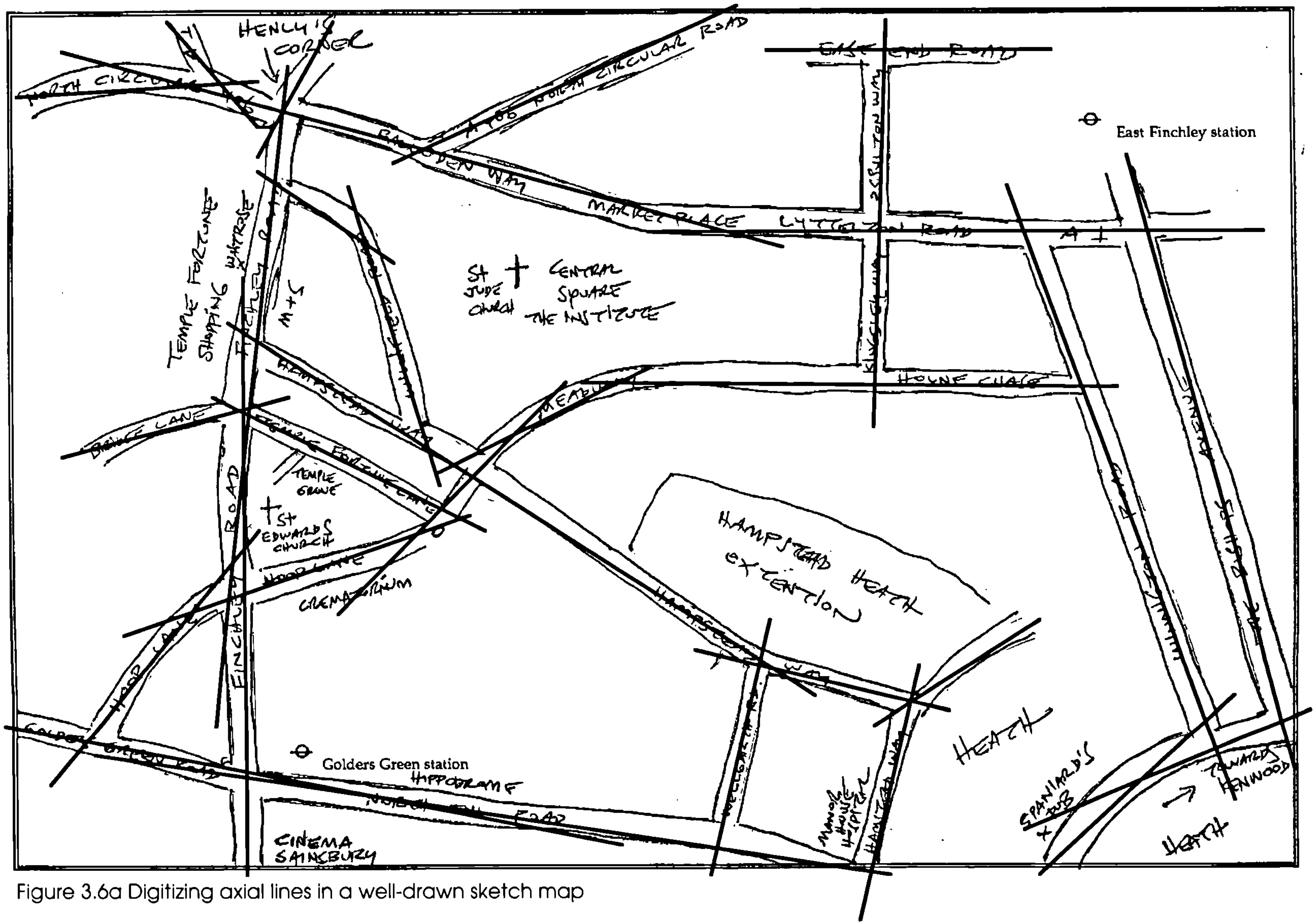


Figure 3.6a Digitizing axial lines in a well-drawn sketch map

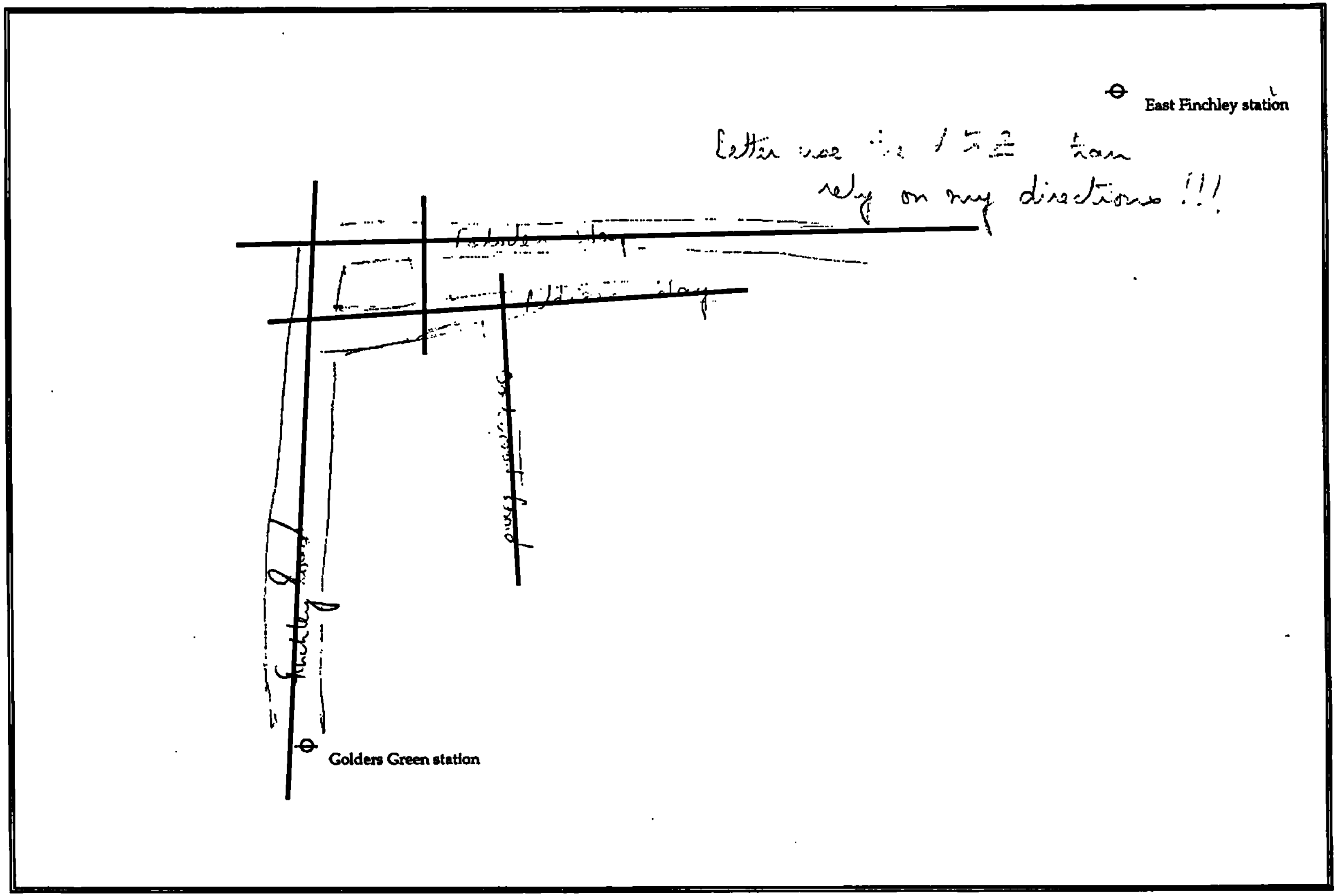
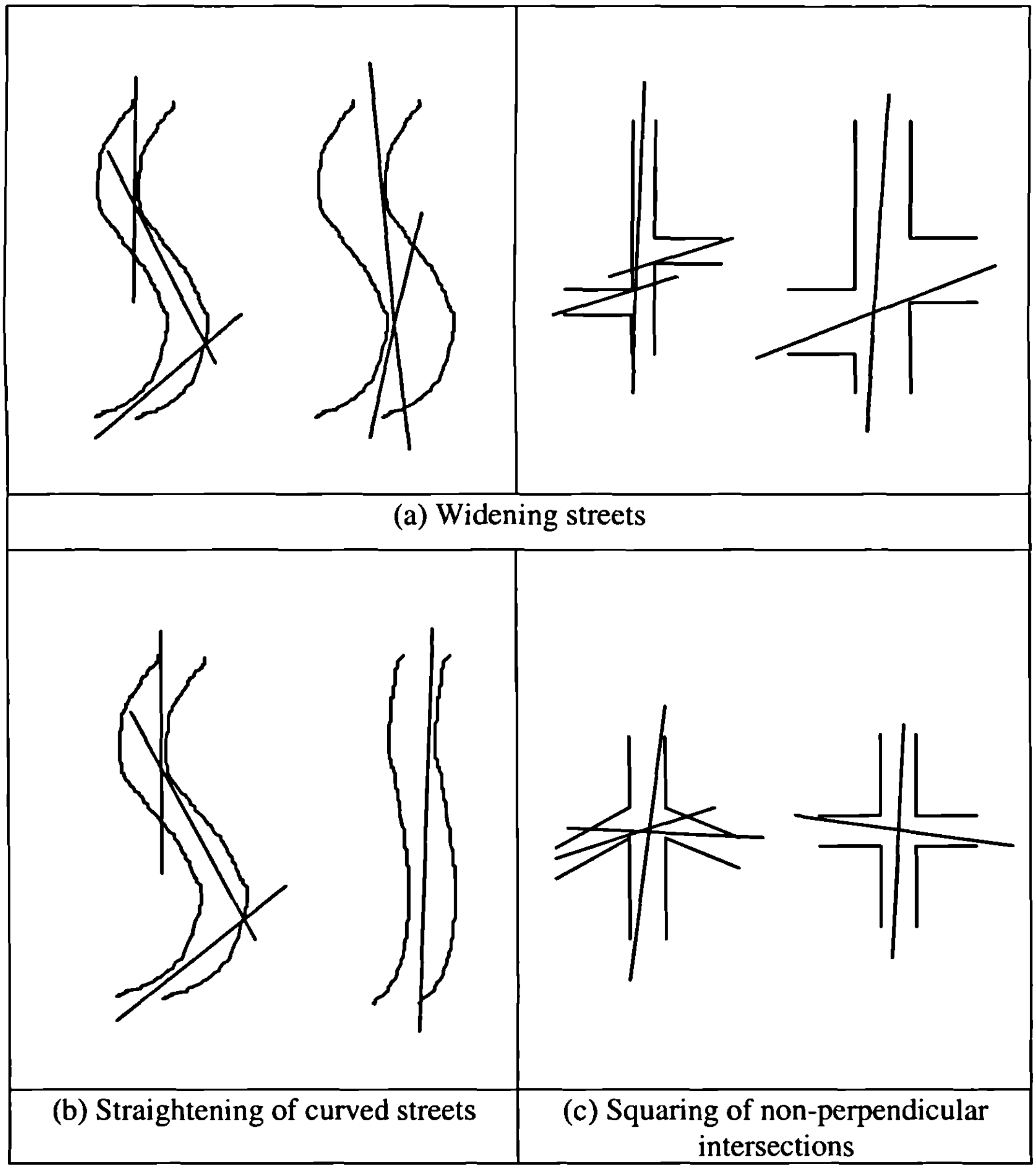


Figure 3.6b Digitizing axial lines in a poorly-drawn sketch map



(a) Widening streets

(b) Straightening of curved streets

(c) Squaring of non-perpendicular intersections

Figure 3.7 Distortions of reality in sketch maps (Left and right figures in each cell represent those in the real world and in sketch maps respectively.)

3.5.2 Translation of syntactic values of a sketch map to an axial map of the real world

According to the syntactic analyses of sketch maps, each line has its own syntactic value. Thus the following task is to translate syntactic values measured in the sketch maps to the axial map of the real world. This process is necessary to investigate a statistical relationship between syntactic properties in sketch maps, those in reality and observed movement densities. Thus we can interpret their possible interrelationship at empirical level.

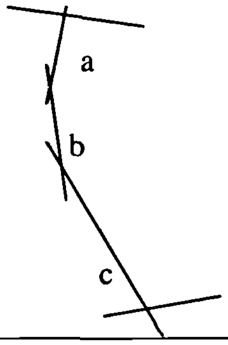
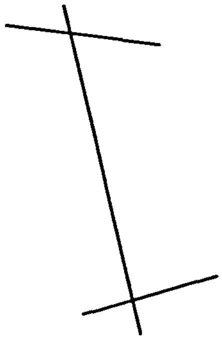
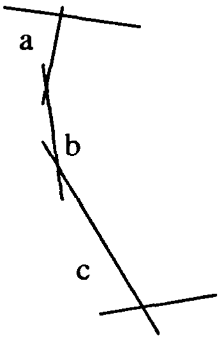
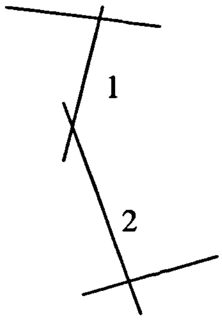
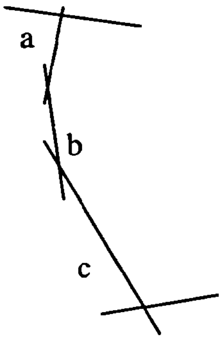
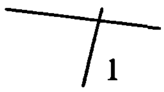
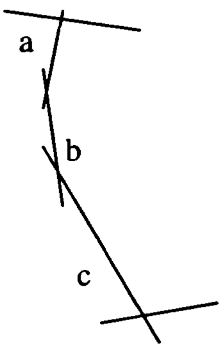
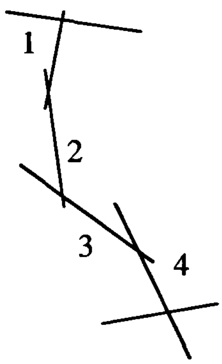
This procedure involves defining which axial lines in sketch maps correspond to which lines of the real map. By examining sketch map features such as intersections, street layout, landmarks and their labels, this translation of syntactic values can be done.

Although the procedure shows a correspondence between axial maps of sketch maps and that of the real map, some confusion may arise especially when numbers of axial lines on a street are differently drawn by straightening a street which is curved in the real map. In this case we need to apply a consistent rule.

By investigating respondents' sketch maps, it was found that there are generally two ways to depict a street. One is to draw a whole street and the other to draw only a part of a street. When a whole street is drawn, the number of digitised axial lines can be different compared to those in reality. The number of axial lines can be lesser than, the same as, and greater than reality. For example, Finchley Road consists of 3 axial lines in reality. However its lines in sketch maps are generally less than or the same as 3 lines and never greater than 3 lines in this study. General rules applied in these cases are explained in Table 3.1 with possible examples.

The above method is applied to all 73 sketch maps and thus each axial line in reality has a number of syntactic values based on its appearance in sketch maps. Then these are averaged. For example, Finchley Road is depicted 67 times in all 73 sketch maps. Accordingly, its sketch map syntactic value is produced by

Table 3.1 Translation of syntactic measures of sketch maps to the axial map of the real world

Axial lines in reality	Axial lines in sketch maps	Interpretation
		A street is drawn as one axial line although it is in three lines in reality. In this case, all segments (a, b, c) get same syntactic values processed by sketch map.
		A street is drawn in two lines. By examining a sketch map line-1 represents line-a, b and line-2 depicts line-c. Thus (a) and (b) have same syntactic values of line-1, and line-c gets a value of line-2.
		Only a part of a street is drawn in sketch map. Line-1 represents line-a, and whether it covers (b) or up to (c) is decided by examining a sketch map.
		A street is drawn in more segments in sketch maps than those of reality. This case was never encountered in this study. Line-c is drawn in two lines (3 and 4) in sketch maps, thus syntactic values of line-c takes average value of the two lines.

taking the mean of 67 syntactic values in sketch maps. If an axial line does not appear in any sketch map then it is excluded from the analysis. The results of this analysis is shown in Appendix-E and discussed in Section 6.7.

3.6 Observation of space use patterns

For the observations of space usage, the 'observation gate' technique was used to obtain empirical data on pedestrian and vehicular flows on streets. 148 gates were selected randomly from all the segments of axial maps of the Suburb. They are located on the middle of a segment on each axial line. This technique allows us to capture information on patterns of movement across the area. The locations of gates are shown in Figure 7.1 and 7.2 (pp190-191).

Movement was observed during five time periods; 8-10 am, 10-12 am, 12-2 pm, 2-4 pm and 4-6 pm. The observation strategy used is a stationary observer counting all the pedestrians and vehicles crossing a notional "gate" across the segment. Ten-minute observations were carried out in each segment in each of five time periods of the day, giving 50 minutes of coverage through the day. This allows mean hourly flows past each gate to be calculated. The mean hourly flows at each segment are shown in Figures 7.1-2 and used in the analysis described in Chapter seven. To ensure collection of unbiased movement data between the two sub areas, the intelligible area and the unintelligible area were observed simultaneously on the same days.

3.7 General data organisation and analysis plan

In order to investigate the relationship between and among spatial configuration and cognition of residents and movement patterns, a set of regression analyses and t-tests were performed.

The syntactic variables of the real map used were integration, local integration and choice. Variables of the cognitive maps were: first, the size of perceived neighbourhood from the residents' boundary delimitation on the actual map; second, the comprehension of spatial features in the sketch maps, measured by counting the number of appearances of identifiable elements, such as paths, open spaces and facilities; and finally, the syntactic properties of sketch maps measured by axial analysis. Movement variables are the mean all-day flow rates in pedestrians and vehicles per hour in all observed street segments in the Suburb. The three sets of variables are displayed in Appendix-E.

The characteristics of the syntactic variables in the real world were regarded as independent variables, and the syntactic properties of sketch maps and movement variables were treated as dependent variables in the statistical analysis. The interrelationships examined were between spatial configuration and spatial cognition in Chapter six; spatial configuration and spatial behaviour in Chapter seven, spatial cognition and spatial behaviour in Chapter eight. For the relationship between spatial cognition and spatial behaviour, the cognitive variables were treated as the independent and the behavioural variables as dependent variables. Finally, the interaction among all three sets of variables was investigated using multiple regression analysis in Chapter nine.

Chapter Four

MORPHOLOGY OF HAMPSTEAD GARDEN SUBURB

4.1 Introduction

The aim in this chapter is to understand the spatial layout of the Hampstead Garden Suburb. This requires a description not just of each element of an area but a description of a whole system of spaces and buildings constituted as a pattern.

This chapter takes place in three stages. Firstly, it reviews development of the Garden Suburb including its historical background and design principles. Secondly, a computer analysis of axial maps of the study area is produced in order to describe its spatial structure. This is subjected to a thorough investigation focusing on the pattern of the spatial layout. The Suburb is analysed within its global context and without the surrounding context as well. This provides an in-depth understanding of local spatial structure and its possible consequences for users. These two ways of looking at the spatial structure enables a discussion about the effect of spatial configuration on spatial experience. This is followed by looking at the area using a simple statistical analysis of the interrelations between syntactic properties. Finally, the area is revisited and described according to all these findings. This chapter finishes its arguments with a discussion of the original design concepts and their realisation in space.

4.2 Development of the Suburb

4.2.1 Historical background

Hampstead Garden Suburb lies on the north side of the Hampstead/Highgate Ridge five miles from Central London (see Figure 3.1). It is a residential community of some 16,000 people, featuring a domestic scale of architecture combined with rich and plentiful landscaping. Hampstead Garden Suburb is an exceptional residential environment in terms of both buildings and landscapes.

On March 6th, 1906, the Hampstead Garden Suburb Trust, Ltd. was established by Henrietta Barnett for the purpose of buying 243 acres of land near the Hampstead Heath Extension. Raymond Unwin was appointed as an architect and surveyor in 1906. He was responsible with his partner, Barry Parker, for the preparation of the plan of development and for designing a large number of the early houses and supervising the plans and elevations of houses designed by other architects. Edwin Lutyens was associated with him as a consulting architect and he designed many of the principal buildings in the area.

In order to accomplish the new ideas about development in the mind of Barnett and Unwin, the Trust promoted a Private Bill to overcome local bye-laws and regulations. It passed into law as the Hampstead Garden Suburb Act in 1906. The Act not only allowed Unwin to develop the Suburb in line with Barnett's dream, it also became the basis on which the first Town Planning Act was built.

4.2.2 Design concepts and spatial layout

Barnett wanted the Suburb to be a place where thousands of people, of all classes of society, of all sorts of opinions, and all levels of income, could live in helpful neighbourliness[1]. In accordance with the general ideas underlying the whole

[1]Barnett wrote that the broad lines of the scheme in the pamphlet which was prepared on the occasion of the twenty-first birthday of the Suburb were:

1) That persons of all classes of society and standards of income should be accommodated, and that the handicapped be welcomed.

2) That the cottage and houses should be limited to an average of eight to an acre.

3) That the roads should be 40 feed wide, and that the fronts of the houses should be at least 50 feet apart, gardens occupying the intervening space.

4) That the plot divisions should not be walls but hedges or trellis or wire fences.

5) That every road should be lined with trees, making when possible a colour scheme with the hedges.

6) That the woods and public gardens should be free to all the tenants without regard to the amount of their ground rent.

7) That noise should be avoided, even to the prohibition of a Church or Chapel or Institute.

8) That lower ground rents should be charged in certain areas to enable weekly wage earners to live on the Estate.

9) That the houses be so planned that none should steal each other's outlook or rob its neighbour of beauty.

conception of the estate by Barnett, Unwin laid out the Old Suburb in 1909/1912. He designed a series of 'gates', with specially dominant groups of buildings marking the entrance to the Suburb by considering the relationship between the Suburb and the approaches to it from the surrounding main roads. The New Suburb was laid out after 1918 under the direction of J C S Soutar. The Suburb was developed in several phases over the next 20 years, but most of them were built according to the plan of 1912. Figure 4.1 shows the historical development of the Garden Suburb.

The relevant provisions of the Act, which applied to the laying out and making of roads were:

> "Any road not exceeding 500 feet in length constructed primarily for the purpose of giving access to a group of houses in the Garden Suburb and not designed for the purpose of through traffic (known as an accommodation road), may with the consent of the local authority be exempted from any operation of any bye-laws of the local authority relating to the width of new streets and footways." (Section 5)

Thus it recognised the difference between cul-de-sac roads of limited length and other roads. Many groups of houses were arranged to command a view down roads by using buildings as terminal features in street pictures. A great deal of attention was paid both to the houses to produce a particular effect in the streets and to the planning of buildings at junctions and at the bends of the roads. The development plan provided for a certain number of through roads, but a large part of the development was designed to enable houses and flats to be built in closes, quadrangles and crescents. It seems to be a direct outcome of the design concept of 'imageable' view of urban form and often has been quoted as an example for the current 'urban village' movement that wants to see a return to 'legible' urban design.

Spatial layout thus became much more like an organically grown arrangement instead of a grid pattern, although it is completely planned village. Probably the best examples are Willifield Way and Hampstead Way. Kellerman (1982),

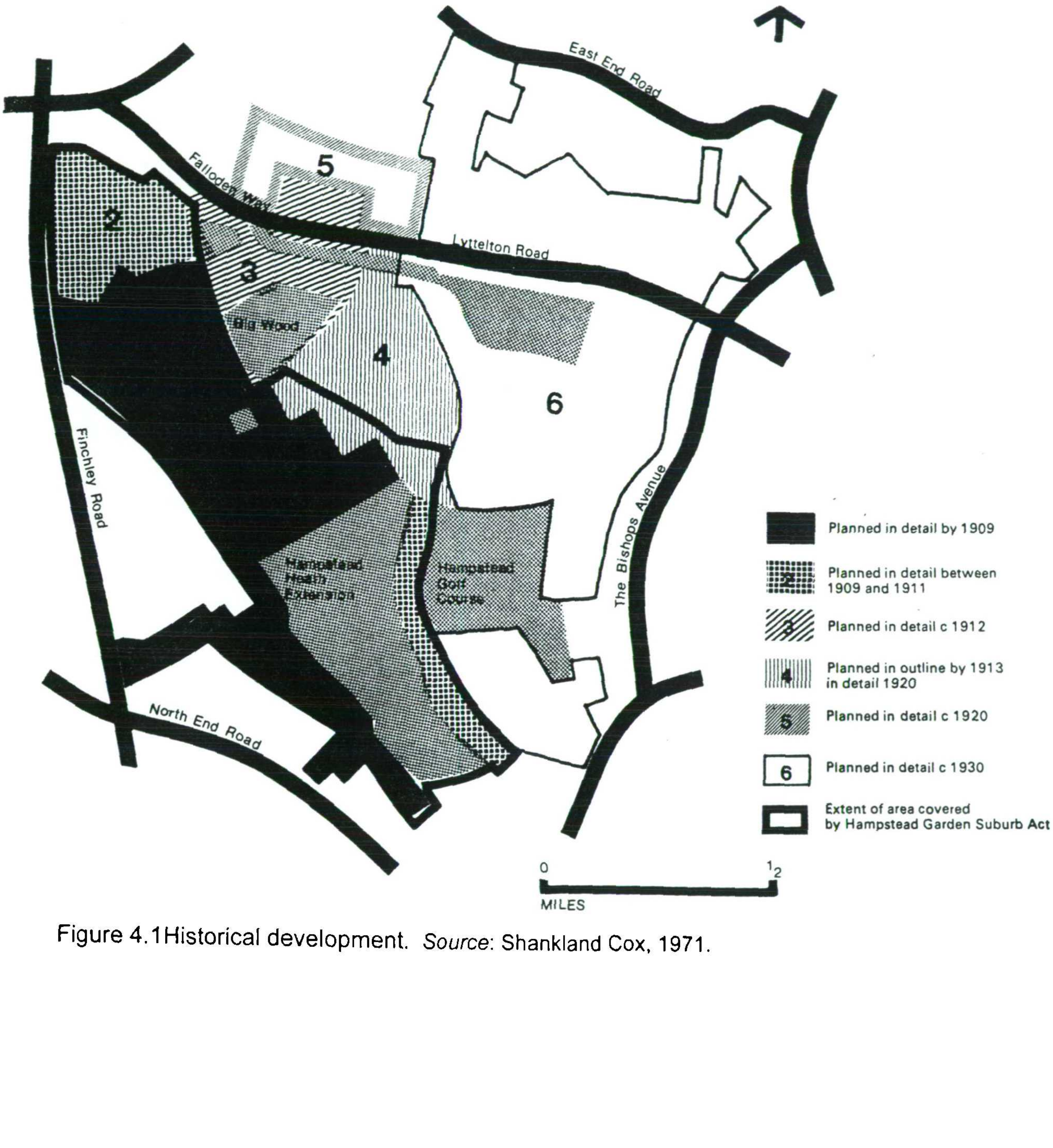


Figure 4.1 Historical development. *Source*: Shankland Cox, 1971.

describing the layout of the Suburb, remarks that the feeling created by the relationship of houses, gardens, trees and public greens are that this is how nature intended them to be and that somehow they all just fell into place. Unwin (1909) himself emphasises the variety and the picturesque view in the street pictures. These are expressed by the different groups, the different types and sizes of dwelling and by every detail of the design maintaining the general sense of unity.

Interestingly, there is a difference both in architecture and in landscaping between the earlier part of the Suburb and the later part that was planned after 1918 (see Figures 3.2(a) and (b)). Mostly it is due to the decision to relinquish the most important social and physical ideals which had guided the Garden Suburb's planners before the War, largely as a result of the inflation of building costs in 1919-1920. Thus the layout of the New Suburb after 1918 was developed for conventional houses for sale and there was less attempt to create a socially balanced community as in the Old Suburb.

4.3 Morphology of Hampstead Garden Suburb within its global context

This section analyses the spatial layout of the Suburb as an interrelated system. It attempts to describe the spatial structure of the urban neighbourhood by a syntactic analysis of its configuration. It thus provides a logical way to understand configurational characteristics of the Suburb.

4.3.1 Description of spatial configuration

Within the Garden Suburb the dominant feature in the landscape is the Central Square where the cluster of public buildings is situated (Figure 4.2). Hampstead Heath Extension and Big Wood are the most extensive landscape in the Suburb. At the local level a large number of open spaces are located at the back of houses and connected to the streets and each other by a network of footpaths. These provide a pleasant atmosphere for residents and are hardly visible from the street. Figure 4.3(a) is the figure-ground map of the Suburb. The public open spaces are represented as white, and the rest is in black. In the Figure 4.3(b),

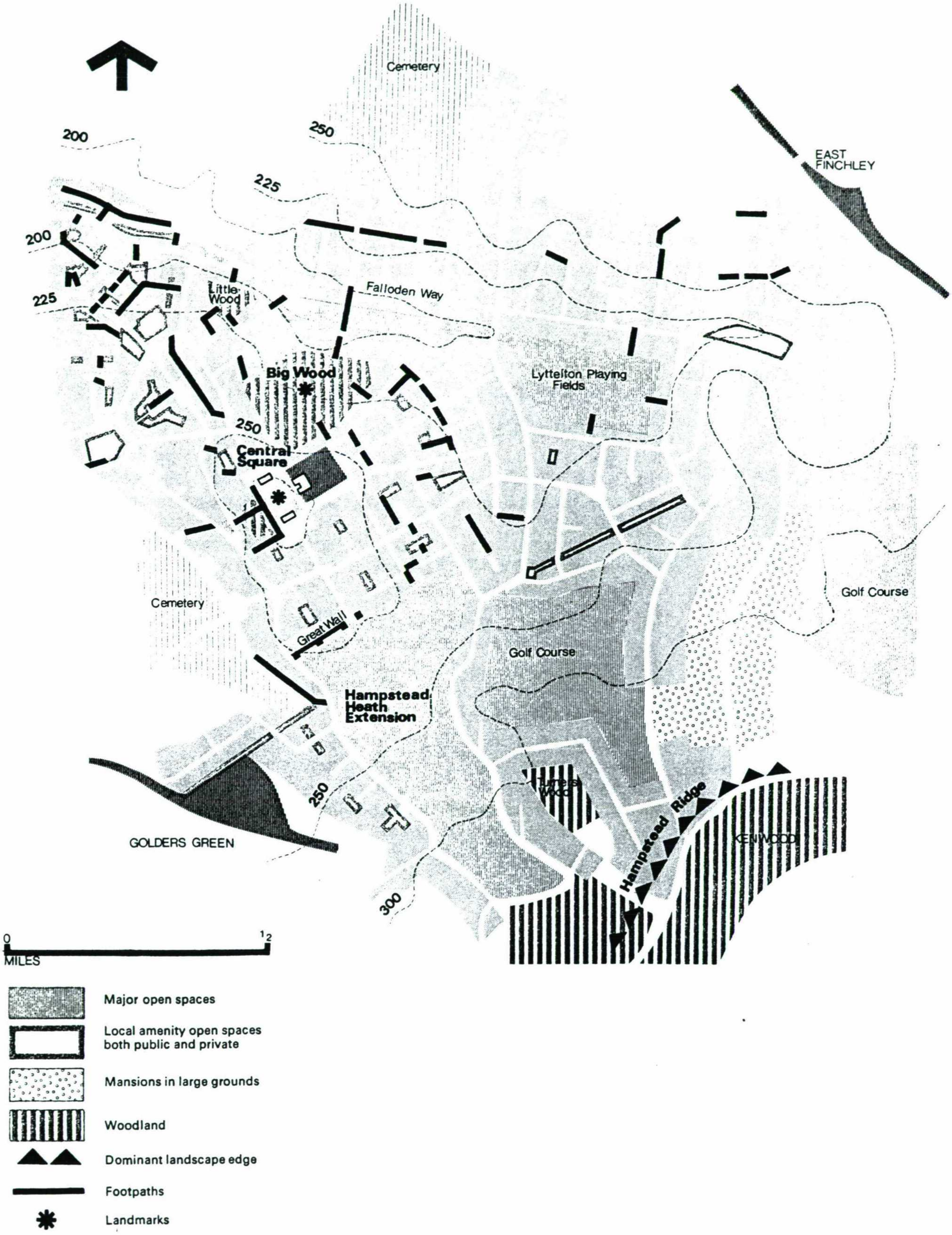


Figure 4.2 Landmark features. *Source*: Shankland Cox, 1971.

Figure 4.3a Figure-ground map, Hampstead Garden Suburb

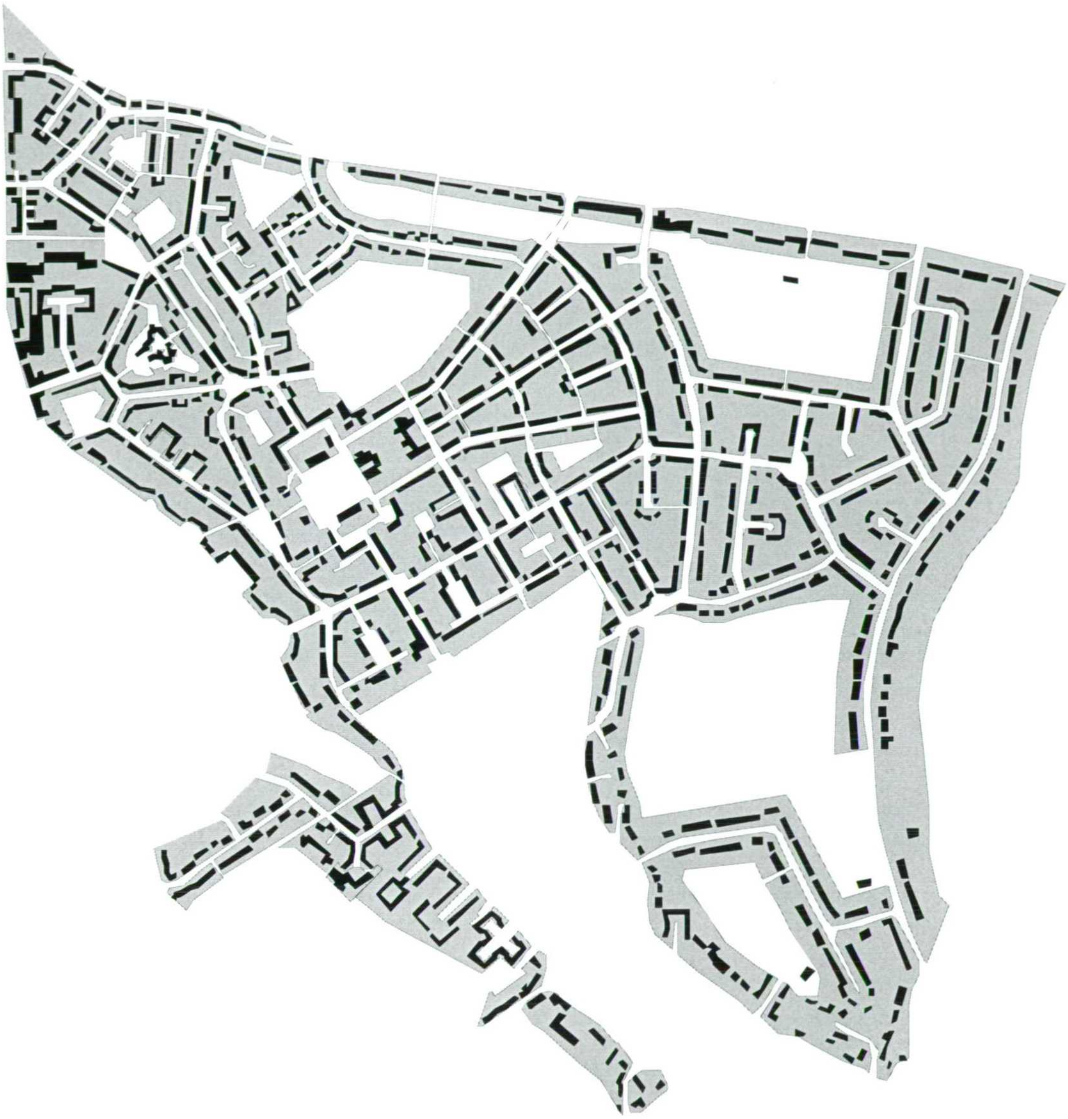


Figure 4.3b Figure-ground map, Hampstead Garden Suburb

buildings are represented as black, the private space as grey and the public space as white. They show a pattern of spatial arrangement in that the Old suburb, the north-east part, seems to have a lack of regularity, on the other hand, the New Suburb, the south-west, has more regularity. However, it is difficult to explain the spatial structure objectively and analytically just using these figures. In order to analyse the inter-relation of spaces and the characteristics of the spatial pattern as a whole, a more analytic way of looking at it is needed.

Figure 4.4 represents the existing system of public spaces in Hampstead Garden Suburb within its global context. The study area, marked with dotted lines, is composed of 158 lines coloured according to the spatial property termed 'integration' in Space Syntax analysis. The red coloured lines are most integrated, with a high integration value, and the lines are coloured through orange, yellow, and green, blue and purple. This reflects the permeability of each space from every other space in the area on all possible simplest journeys between spaces.

The Suburb is well connected to its surrounding area especially to Finchley Road and the A1. It has 18 streets and pedestrian pathways connecting outward. Of these, 10 spaces are connected to Finchley Road and the rest to the A1. Hampstead Garden Suburb is located between two highly integrated spaces, the A1 and Finchley Road. Nevertheless the area is relatively segregated within the global context; most of the lines are green despite its proximity to the two most integrated spaces.

The axial map immediately shows a dramatic change in the scale of lines compared to the surrounding area in that generally the axial lines of the suburb are much shorter. More importantly, however, the way shorter lines are related to each other and to the surrounding area, creates a high degree of axial discontinuity from the surrounding area, especially from the A1 and Finchley Road. There is no single axial line that goes from the periphery into the centre of the area. This is coupled with a great deal of depth once the Suburb is entered, especially from the upper Finchley Road. The design of the Suburb

Figure 4.4 Global integration, Hampstead Garden Suburb

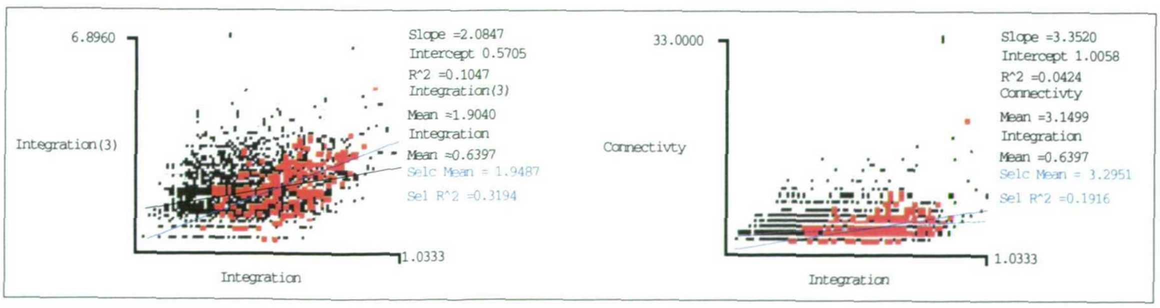


Figure 4.5 Scattergrams of the Suburb within its global context plotting each line

keeps open its entry points located in the most integrated spaces, but it seems to use depth purposefully to control access to the heart of the area.

The syntactic identity of the Suburb can be investigated using a scattergram which shows the area within its surrounding context. Figure 4.5 is a scattergram plotting each line in the axial map as a point according to its degree of global integration on the horizontal axis and its degree of local integration on the vertical axis. Each point is an axial line, which makes up the axial map of the Suburb. The regression analysis between the global integration and the local integration reveals spatial characteristic of an area within its global context. All the spaces in Hampstead Garden Suburb are picked out as red in the scattergram. The regression line of the Suburb is slightly across the main regression line, which implies that the most integrated lines within the area are more locally than globally integrated. However, the scatter is not tight and does not form a linear set. The regression is even worse without the outlier of Finchley Road which is on the right upper corner of the scatter. This suggests that the Suburb does not have a good relation between local and global integration of spaces. A similar correlation between global integration and connectivity is found. Figure 4.6 shows the existing system of public spaces in the Suburb for vehicular access. It represents the vehicular accessibility of each space from everywhere in the system.

Table 4.1 shows the comparison of a mean integration between the pedestrian axial map and the vehicular map. As can be seen from the table, the global integration of the vehicular map is not much different to that of the pedestrian map. Generally the integration in the vehicular map is decreased as a whole. This effect is greater in the Old Suburb where most of the footpaths are located, especially in the Central Square area and in the west side of the Square. As a consequence, both global and local integration are reduced. This is inevitable since the vehicular map eliminates important footpaths which links together the spatial elements in the area, for example, Farm Walk, that connects Hampstead Way and Temple Fortune Lane, and a series of footpaths from the Square to Temple Fortune Lane. On the contrary, the New Suburb keeps most of the

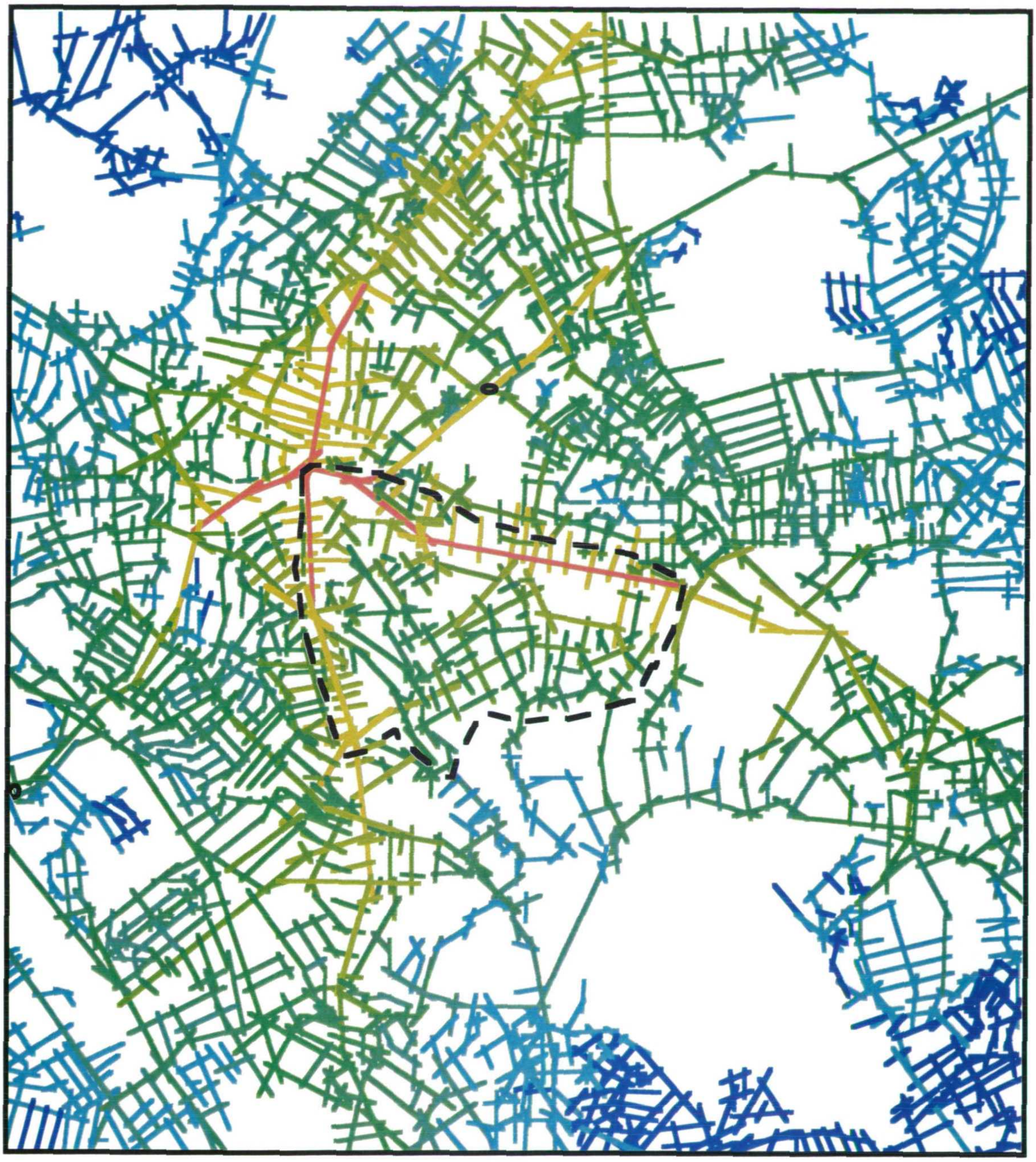


Figure 4.6 Global integration of vehicular axial map, Hampstead Garden Suburb

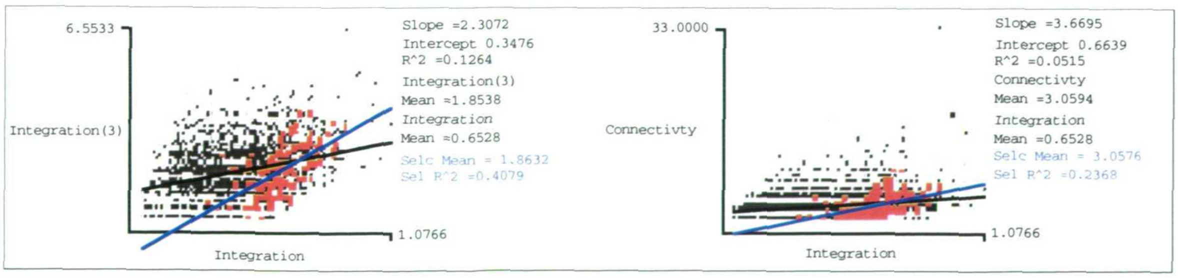


Figure 4.7 Scattergram of the Suburb within its global context

elements of the pedestrian map. Only some of them, which are trivial in terms of spatial layout, are eliminated in the network, and these are scattered at the south of the Meadway, Constable Close and Ruskin Close.

Table 4.1 The comparison of integration between the pedestrian map and the vehicular map

	Pedestrian axial map	Vehicular axial map
System as a whole		
global integration	0.81	0.76
local integration	2.09	1.86
The Old Suburb area		
global integration	0.82	0.76
local integration	2.01	1.68
The New Suburb area		
global integration	0.81	0.77
local integration	2.14	1.98

4.3.2 Interpretation of the global spatial structure

In order to look at the spatial structure of the area, axial maps are re-drawn from the most integrated spaces to segregated spaces. This enables the examination of the distribution of the spaces with figures of the 10%, 25%, 50% most integrating spaces, and 25% most segregating spaces. Figure 4.8(a) shows the integration core as black thick line, the 10% most integrating spaces, of the area. The figure shows that the area is segregated from the surrounding areas by the fact that most of the spaces picked out are connecting spaces towards the periphery. Most of these spaces are connected into two peripheral spaces, Finchley Road and the A1, which are the two most integrating spaces globally.

Figure 4.8(b) is next with the 15% most integrating spaces in the area. The figure picks out most of the major streets to the north west of Central Square, and shows a big group of spaces around the east of the Square, near the A1 Falloden Way. Northway, leading to Central Square, and Hoop Lane are the main entrance spaces from the Finchley Road, among the most 10% integrating spaces, and Meadway, the spine of the Suburb is among the most 25% integrating spaces. Figure 4.8(c) shows the 50% most integrating spaces in the

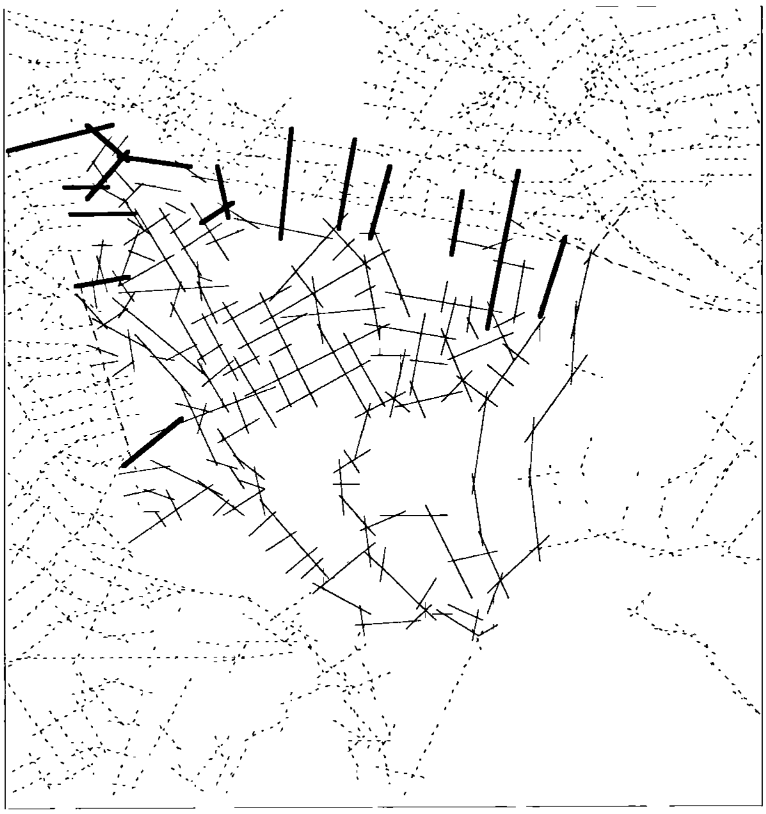


Figure 4.8a
Top 10% most Integrating spaces in Hampstead Garden Suburb

Figure 4.8b
10-25% most Integrating spaces in Hampstead Garden Suburb

Figure 4.8c
26-50% most Integrating spaces in Hampstead Garden Suburb

Figure 4.8d
26-50% most segregating spaces in Hampstead Garden Suburb

Figure 4.8e
10-25% most segregating spaces in Hampstead Garden Suburb

Figure 4.8f
Top 10% most segregating spaces in Hampstead Garden Suburb

area. Figure 4.8(d) is the other extreme and maps the 26-50% segregating spaces. The figure shows that these spaces are clustered in the southern part of the area, and some of them are pedestrian only footpaths. In a similar way, Figures 4.8(e) and (f) are 11-25% segregating and top 10% segregating spaces in the Suburb.

Figure 4.9(a),(b) shows all the axial spaces above the mean integration and all those below. Figure 4.9(a) shows the high integration system, which picks out a clustered area and covers most of the area except two parts of the Suburb; the north west of the Central Square and the southern part of the Square down to the Heath Extension and Hampstead Golf Club. The number of spaces above the mean integration is 90, and spaces below is 68.

In a similar way, using the control value, we can take the least set of lines that accounts for 10% of the control spaces in the system. Figure 4.10(a) shows axial spaces at Hampstead Garden Suburb which account for the top 10% of the control value. It shows a strong control system in the centre of the area: Meadway and Litchfield Way. The rest of the spaces are dispersed throughout the area. The controlling spaces are dispersed without linking in the Old Suburb, however, most of them are connected each other and reach across the New Suburb. As shown in Figure 4.10(b), the next 15% controlling spaces in the Suburb confirm that most of the spaces are dispersed across the Suburb. Conversely, in the New Suburb, they are not only high in their control value but also occupy more salient spaces in the area, which are connected to the skeleton space of the area. Most of the least controlling spaces in the area are cul-de-sacs.

By combining integration maps and control maps, a series of points can be made, accounting for the global and local spatial structure of the Suburb. Only five lines are in the top 10% integrating and controlling spaces, as shown in Figure 4.11(a). All of these spaces are located on the edge of the Suburb, linking the Suburb to the periphery, the most integrating spaces globally. These lines are short, do not reach the centre and finish at the periphery. Figure 4.11(b) shows the next 15% most integrating and controlling spaces. It confirms the previous

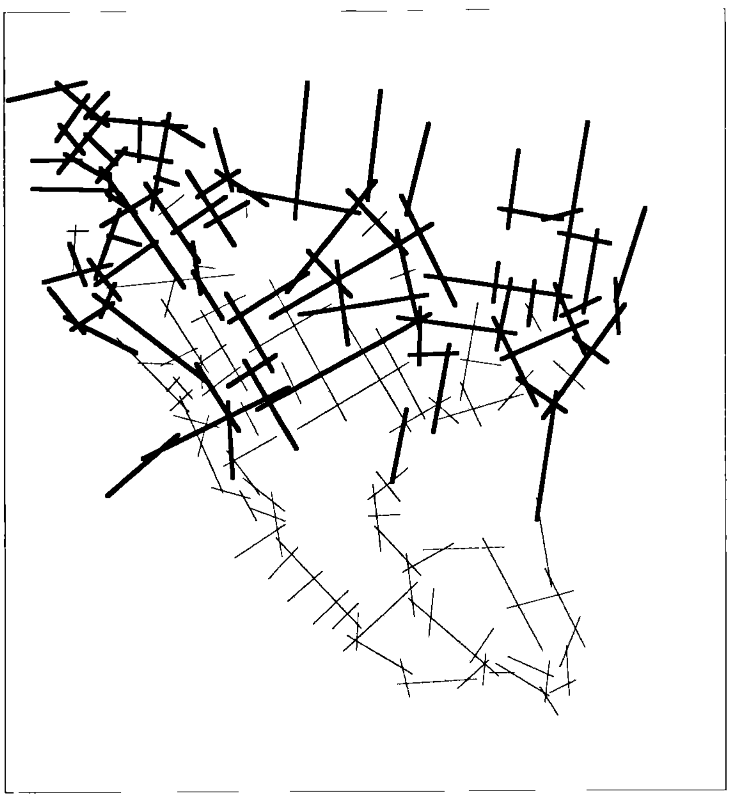


Figure 4.9a
Spaces above the mean integration

Figure 4.9b
Spaces below the mean integration

Figure 4.10a
Top 10%
control spaces

Figure 4.10b
10-25%
control spaces

Figure 4.11a
Top 10% integrating and control spaces

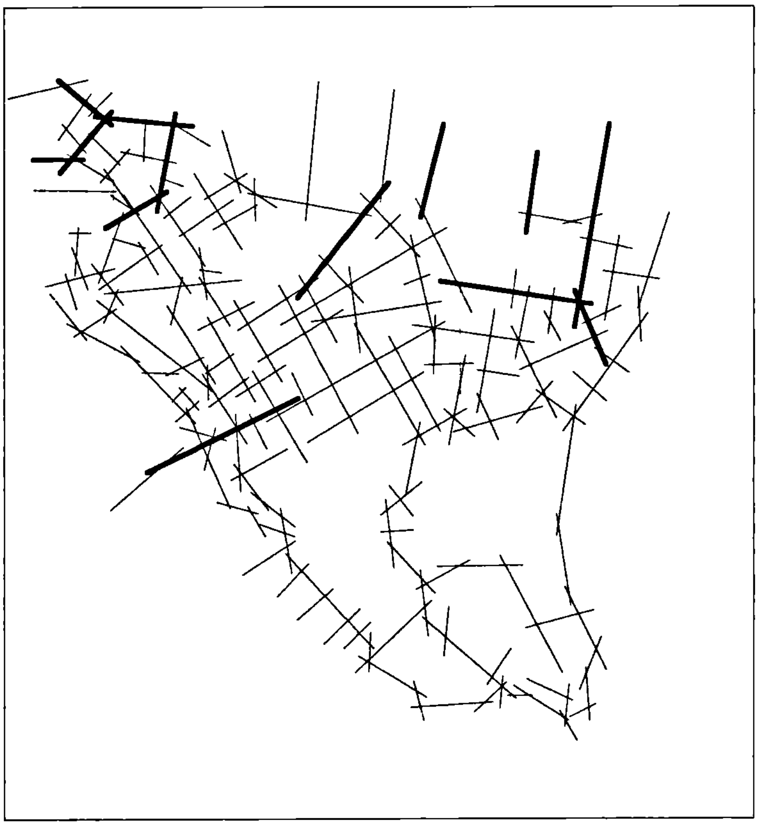


Figure 4.11b
10-25% integrating and control spaces

finding that spaces picked out are directed towards the centre. Meadway is the exceptional case, which is a free-standing space located in the middle of the area, linking the Old and the New Suburb.

In conclusion, in Hampstead Garden Suburb, there are no spaces that pass into the centre of the area from the outer world, and it needs several steps to get to it. In addition, the series of integration maps confirm that the Suburb has a sequence of layers not only from the outer world, but also from the very heart of the area. It can be concluded that the Suburb has a structure with an 'onion-like' shape which has a series of layers encompassing a core. The outer layer is more globally integrated whilst the deeper one is less integrated globally and more integrated locally. By examining the spatial structure of the Suburb itself without its surrounding areas the following section enables an in-depth discussion of the spatial configuration of the area.

4.4 The spatial structure of the Suburb without surrounding areas

4.4.1 Global integration of the Suburb

Figure 4.12 illustrates the global integration of spaces in Hampstead Garden Suburb without its surrounding areas. This figure clearly picks out the strong syntactic core of spatial structure, which the integration map within the global context (see Figure 4.4) can not identify. It includes Meadway, Litchfield Way, Holne Chase and Heathgate. Meadway is the most integrating space in the Suburb, which is the central organising element, the spine of the Suburb. The second groups are, for example, Litchfield Way, Holne Chase and Heathgate, coloured in orange, and stretched out from the spine.

4.4.2 Further analyses of the spatial structure of the Suburb

In order to understand the spatial morphology of the Suburb without the surrounding areas, an analysis of the distribution of syntactic properties of spaces and the pattern of their arrangement is essential. Thus a set of maps has been produced, including globally integrating spaces, control spaces, locally integrating spaces and their combinations.

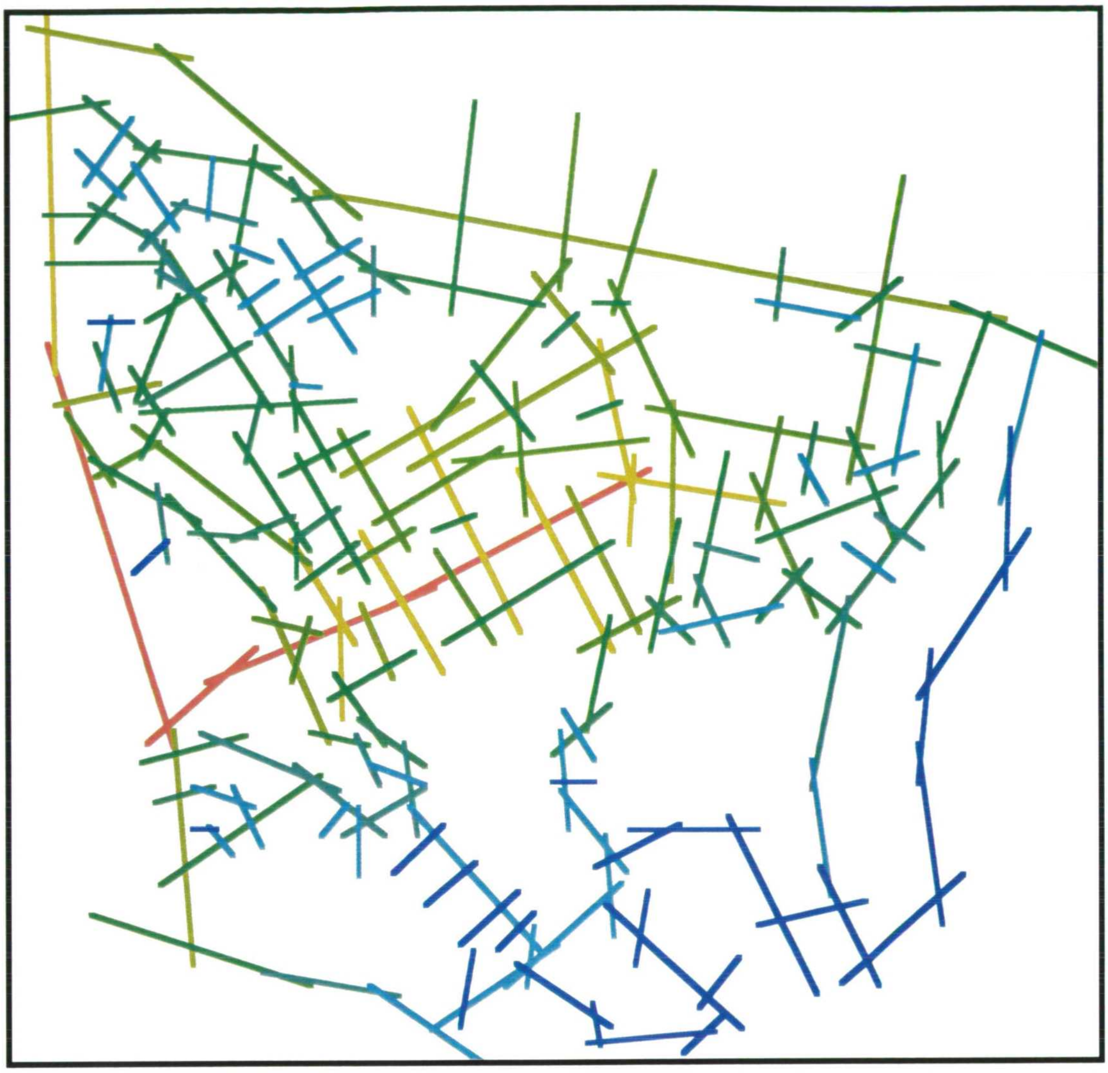


Figure 4.12 Global integration without its surroundiong areas

Figure 4.13a
Top 10%
locally
integrating
spaces

Figure 4.13b
10-25%
locally
integrating
spaces

Figure 4.13c
25-50%
locally
integrating
spaces

Figure 4.13d
10-25%
locally
segregating
spaces

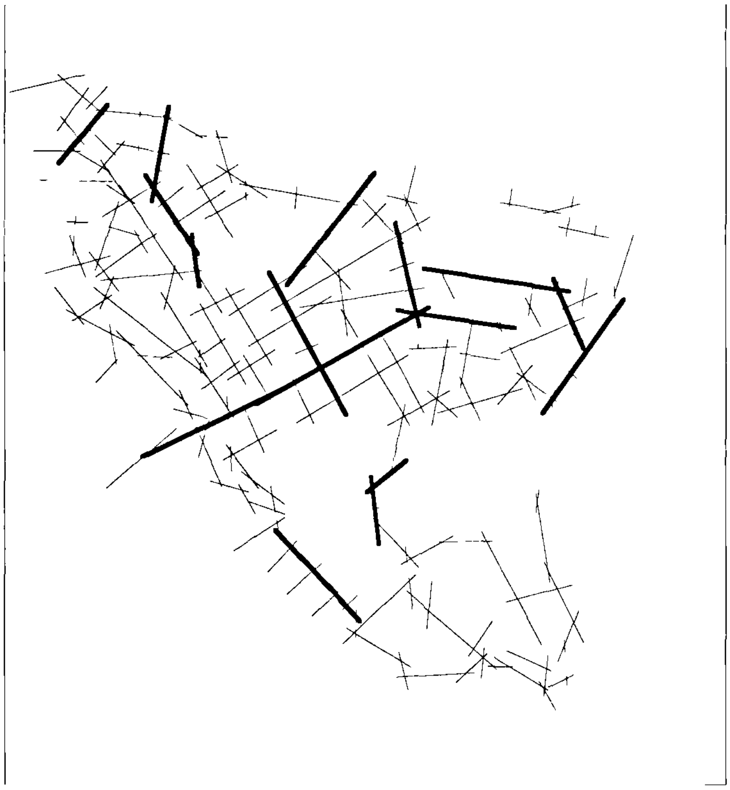


Figure 4.14a
Top 10%
locally control
spaces

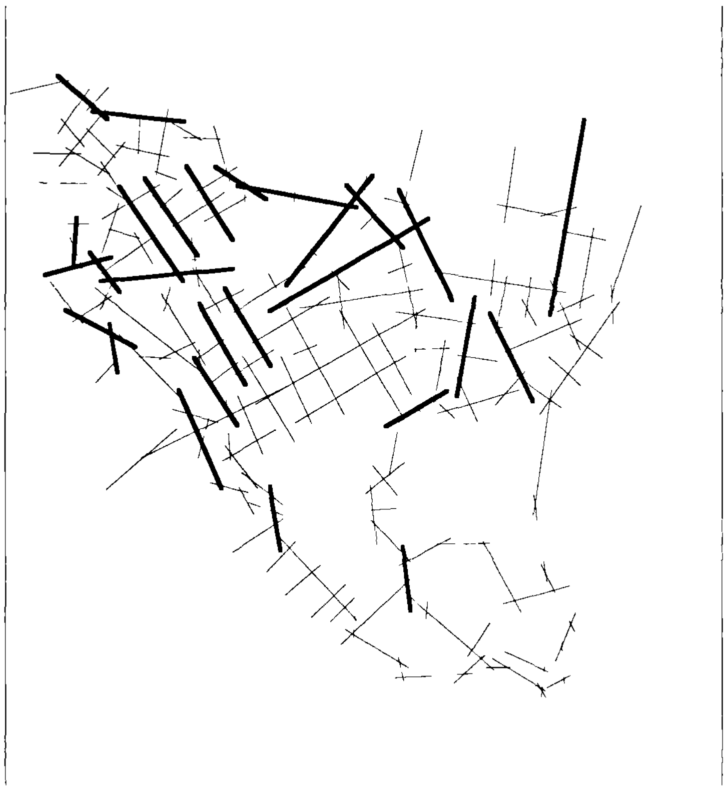


Figure 4.14b
10-25%
locally control
spaces

Figure 4.15
Top 10%
locally
integrating
and control
spaces

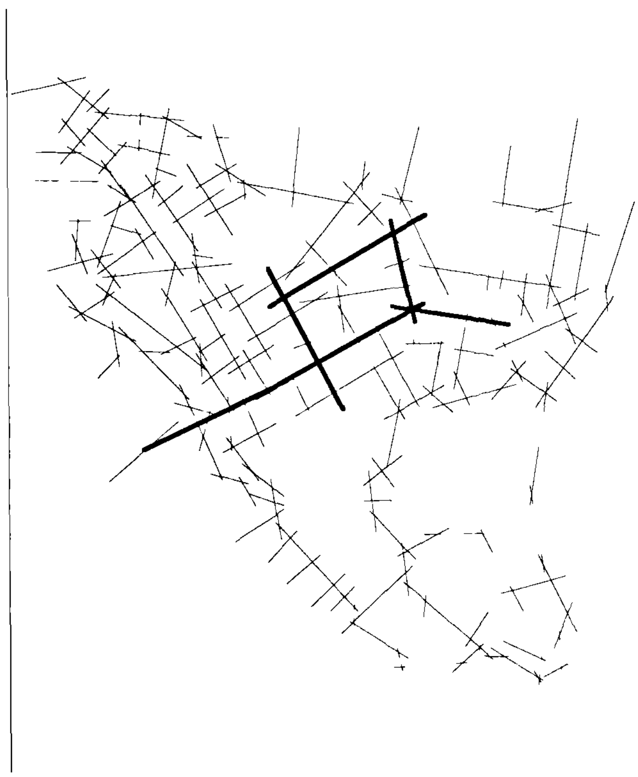


Figure 4.16
Top 10%
globally and
locally
integrating
spaces

Figure 4.13(a) shows the 10% most globally integrating spaces in the area. The figure shows that the core, Meadway and connecting spaces, is concentrated in the deep part of the Suburb. This catches most of the key open spaces in the Suburb, such as Central Square, Heath Extension, Bigwood, Littleton Playing Field and Hampstead Golf Club. The next 15% most integrating spaces are distributed in the outer spaces of the core and create another layer towards the periphery (Fig. 4.15(b)). The majority of the spaces are located within the New Suburb like the previous figure, and they connect the Suburb into the periphery. The figure picks out most of the important spaces in the New Suburb, however, it has failed to pick out the main spaces of the Old Suburb. Figure 4.13(c) shows the 26-50% most integrated spaces. It shows a dramatic difference in the distribution of spaces between two areas of the Suburb by picking up most of the through roads in the Old Suburb: Willifield Way, Addison Way, Erskin Hill and Temple Fortune Hill. On the other hand, in the New Suburb, trivial spaces across the area are picked out; most of the main spaces in the New Suburb are represented in the top 10% most integrating spaces (Figure 4.13(a)). Figure 4.13(d) is the other extreme of the 25% most segregating spaces. The figure shows that they are pushed away from the centre and located near the periphery of the Suburb as might be expected in view of the edge effect of the system, except for one cluster around Denman Drive in the Old Suburb.

The next two figures illustrate the spaces that are the controlling spaces in the area. Figure 4.14(a) shows the spaces which have the top 10% control values. This shows the strong control system at the centre of the Suburb, including most of the major spaces in the New Suburb and two streets in the Old Suburb, Hogarth Hill and Erskin Hill. Figure 4.14(b) shows next 15% most controlling spaces in the Suburb, and most of major spaces in the Old Suburb are picked up. On the other hand, most through streets in the New Suburb are within the top 10% control spaces of the whole Suburb.

By combining these two kinds of information, Figure 4.15 illustrates the spaces which are the most integrating and controlling in the area in the top 10% of these measures. These are the spine of the Suburb: Meadway, Litchfield Way, Holne

Chase and Bigwood. Figure 4.16 shows the top 10% most integrating spaces globally and locally. It consists of the same spaces as the previous figure except Middleway. The good match of spaces in these two figures (Figures 4.15 and 4.16) suggests the existence of a strong local core in the Suburb. All the spaces are elements of the New Suburb, constituting the spine of the whole Suburb.

4.4.3 Local integration of the Suburb

Figure 4.17(a) illustrates the local integration of spaces in the Suburb, which measures the average depth of spaces within the immediate neighbourhood: syntactically three steps away from itself. It shows how integrated or segregated each space is locally. Figure 4.17(b) shows the local integration of the Suburb without its surrounding areas.

Of the internal spaces of the Suburb, Meadway is the most integrated space locally as well as globally. Litchfield Way and Holne Chase extend from Meadway, and constitute the strong core locally. The figures show clearly that the New Suburb has a distinct core focused on a series of highly strategic alignments. On the contrary, in the Old Suburb, the spaces are not much differentiated by their local integration, and thus, do not form any conspicuous core within it. The New Suburb is well distributed in its integration value from the integrated to segregated spaces, but in the Old Suburb we can identify many clusters of segregated spaces even though they are adjacent to highly integrated spaces.

4.4.4 Conclusion; Syntactic characteristics of the Suburb

Syntactic analysis reveals that any single space, which is connected to the periphery, completely fails to penetrate the deeper parts of the area. With syntactic segregation from the outer world and a series of layers in its spatial structure, the suburb seems to have many attributes in common with a modern housing estate in its spatial configuration. However, the Suburb has a quite different spatial characteristic, with a mixture of integrated and segregated spaces.

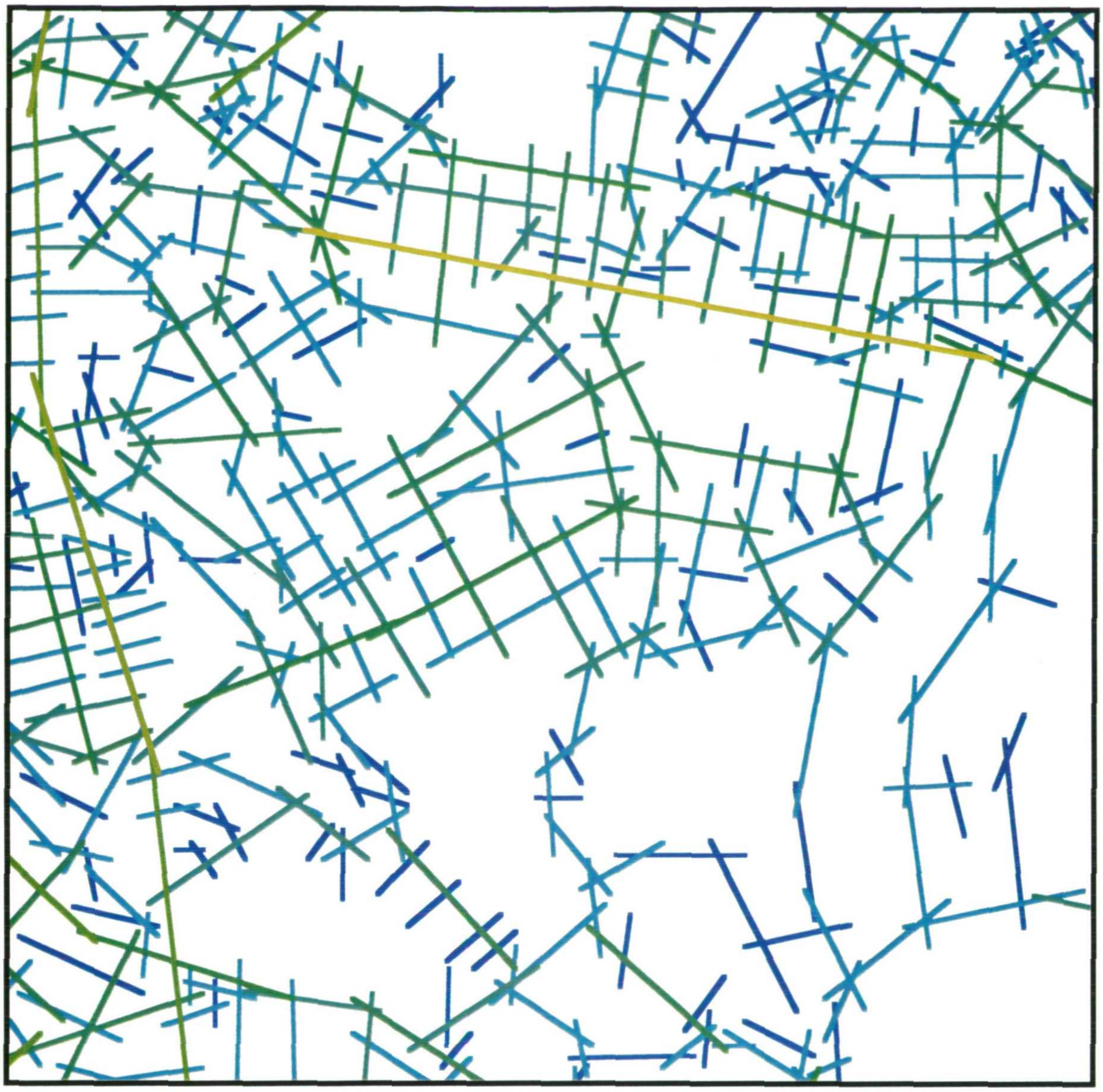


Figure 4.17a Local integration of the Suburb

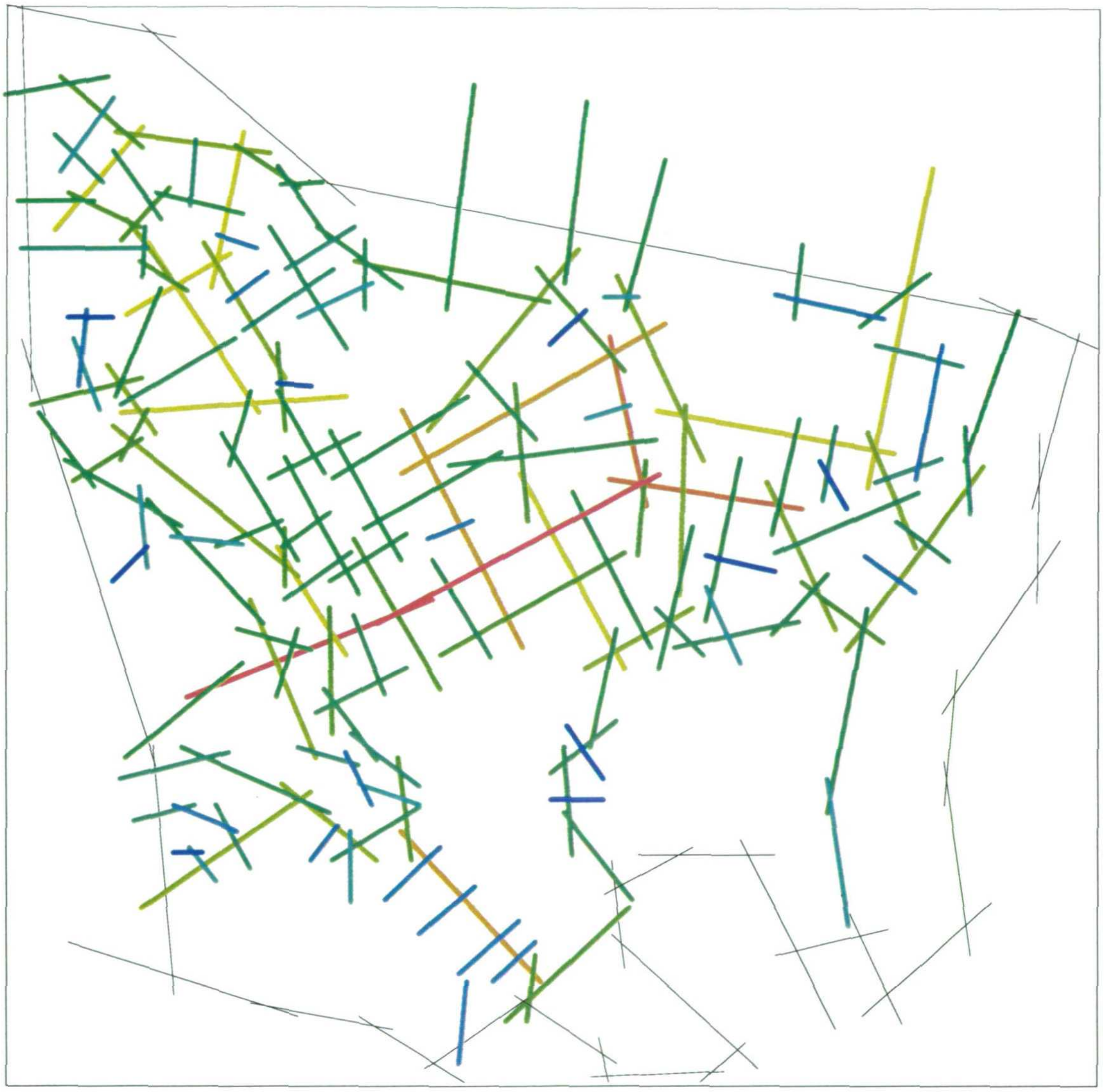


Figure 4.17b Local integration(3) of the Suburb without its surrounding areas

The Suburb is syntactically speaking 'onion-like' layer: the inner most layer is a landmark at the centre, and each subsequent layer, connects the centre to the next outer layer. This relationship is repeated to the outer most layer. Each part of adjacent layers is rather independent syntactically, thus, the each layer is quite distinct. To get to the Suburb from the outer world which is more integrated in the global context, people need to proceed through several sequenced layers to get to the centre of the Suburb, which is less integrated globally. This is a reversal of the traditional settlement. Nevertheless, there are extensive footpaths linking not only adjacent layers but also separated layers directly. Most of these connections are hardly seen by strangers or those in cars.

In conclusion, the Suburb is axially conspicuous not only in terms of the tendency to be more globally segregating towards the centre of the area, but also by the short length of the axial lines creating a system which is deep from the outer world. Furthermore, no single axial line links directly between the centre and the periphery in any direction. Therefore, the Suburb is not recognisable syntactically from the outer world for the stranger, whilst its local identity as a settlement is much more consolidated as an independent system.

All these findings suggest that Hampstead Garden Suburb is locally structured to create an inhabitant-inhabitant interface rather than an inhabitant-stranger interface. The characteristics of the spatial structure reinforce the encounter system by maximising the contacts between inhabitants and inhabitants and at the same time efficiently excluding through movement by 'strangers'.

4.5 On the experience of spatial configuration: intelligibility vs. unintelligibility

4.5.1 Two sub-areas in the global context

Figure 4.18 is a close-up of the axial map of the area in the global context. There is a good mixture of integrated and segregated lines. However, from the axial constitution of the area, it is not difficult to recognise the difference in spatial layout and its scale between the Old and the New Suburb. The pattern of

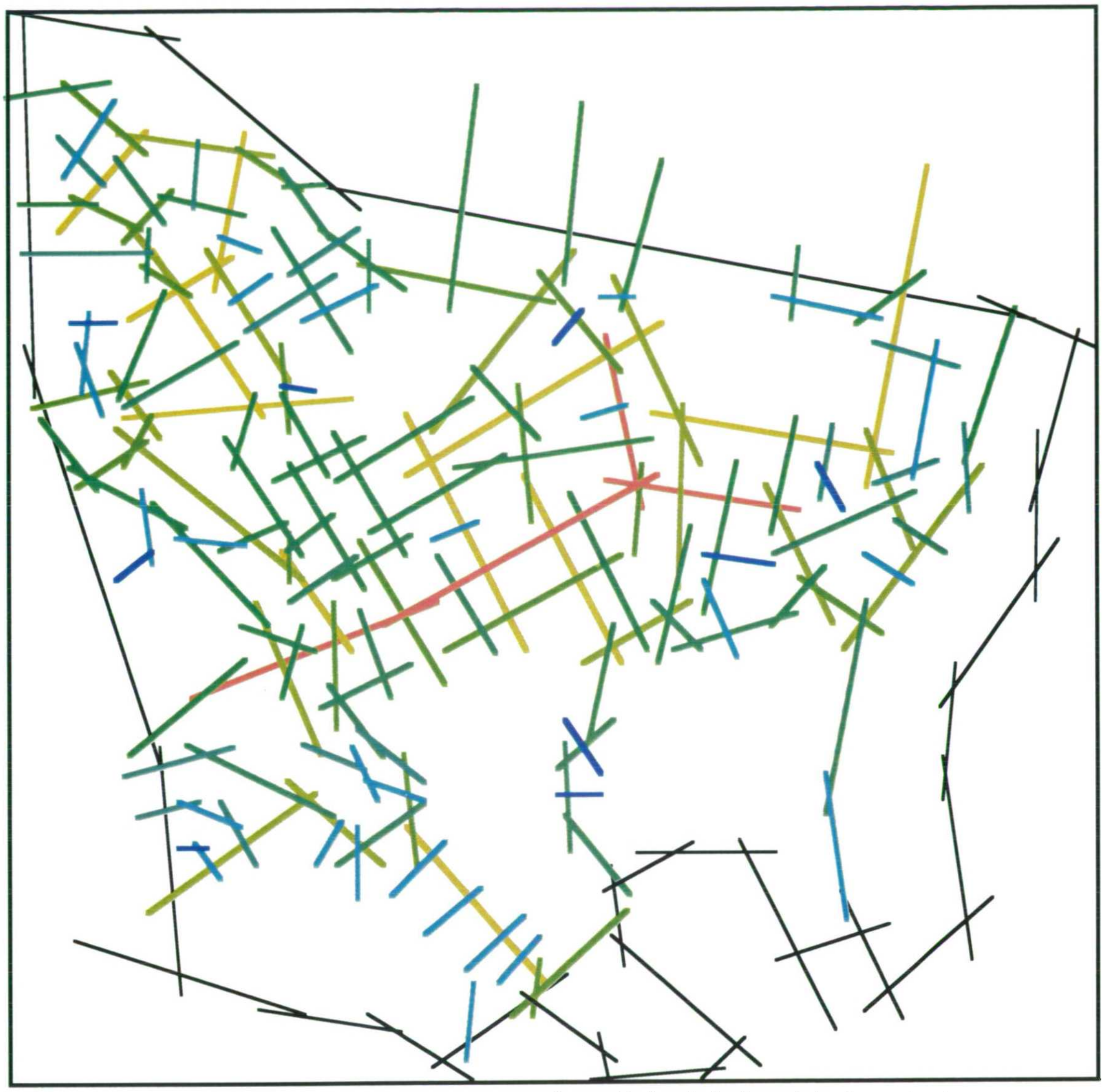


Figure 4.18 Close-up of spatial integration of the Suburb in its global context

open spaces in the Old Suburb is complex and dense, but it is relatively simple and on a larger scale in the New Suburb. By looking closely at the axial lines in the New Suburb, an integration core of orange lines can be found. This constitutes the main routes in the area: Kingsley Way, the main access from the A1, Northway which is the shortest access to Central Square from the A1, and Meadway which has the highest control value. Conversely, the integration core of the Old Suburb picks up Asmuns Hill, Willifield Way, Erskin Hill, and Denman Drive North, thus it fails to identify the main routes of the area. In the north part of the area Hogarth Hill, and upper Erskin Hill, which are adjacent to the two main integrated spaces, the A1 and Finchley Road, have high integration value. However, the rest of the area is quite segregated, especially towards the Central Square. All these differences in spatial morphology between the two areas suggest further investigation is necessary on spatial configuration to provide a better understanding of the intelligibility of the area, which may be a salient intervening variable in the exploration of the built environment.

With respect to the spatial configuration of the two areas in the global context, two sub-areas can be identified according to syntactic intelligibility. Figure 4.19 represents the two sub-areas in the Hampstead Garden Suburb. The configuration of each system will be described based on intelligibility as measured by the correlation between global integration and local integration.

Figure 4.20(a) shows the degree of intelligibility of the Old Suburb area, and illustrates the spaces as the dark points in the whole scatter. The scattergram of the area within the global context indicates that the spatial structure of the area is unintelligible. The scatter is dispersed, hence it is difficult to find any general trend. There is a poor relationship between local and global integration, indicating a very unclear relation between the local and global structure. The scatter does not cross the regression line of all spaces to create a well-structured local area effect. The unstructured complexity and density of spaces has the effect of making the system unintelligible.

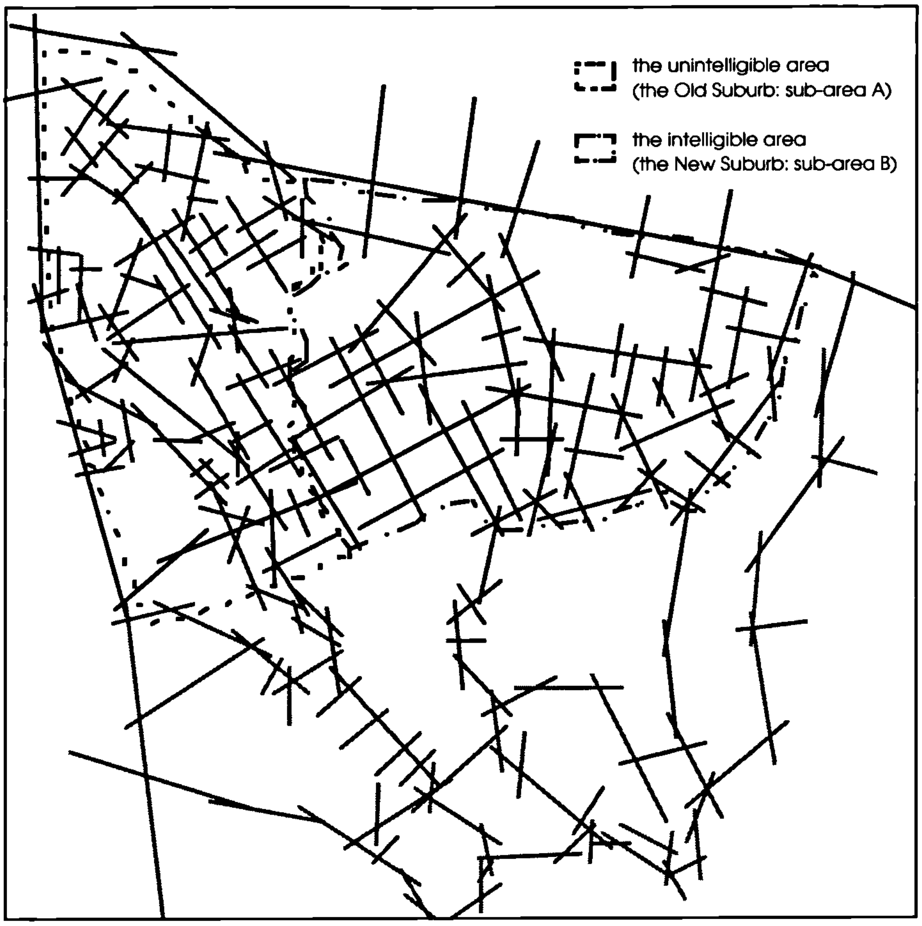


Figure 4.19 Two sub-areas in the Suburb by intelligibility

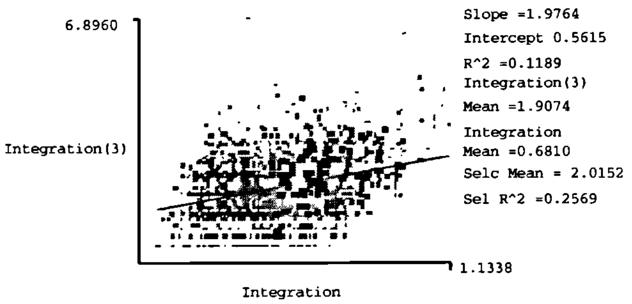


Figure 4.20a The Old Suburb area within its global context

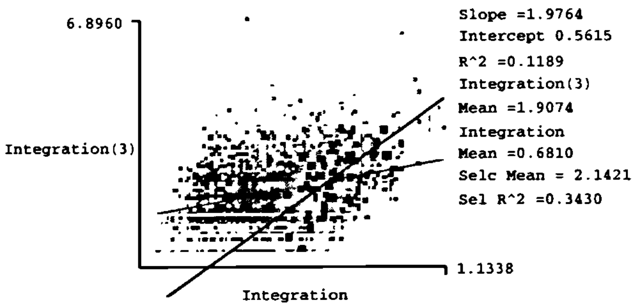


Figure 4.20b The New Suburb area within its global context

Conversely, the scattergram of the New Suburb picked up in dark in Figure 4.20(b), indicates that the spatial structure of this area is relatively intelligible. The regression line is steeper than that of the whole Suburb, which means there is a strong local area effect and the area is much more intelligible within the global context. This is a local intensification of the grid, which means the scatter crosses over the correlation of all the spaces into the higher levels of local integration. Open spaces in this area are laid out in a similar way to the pattern of the surrounding area.

Considered in terms of the definite physical boundary of the Suburb by the Al and Finchley Road, the scattergrams show a clear difference in spatial configuration in the two sub-areas. The New Suburb area is much more intelligible: the spaces are well distributed from red to blue across the area, which are well mixed in their integration value, whilst the Old Suburb is relatively unintelligible, and isolated in that most of the spaces are green and blue.

4.5.2 Two discrete systems in the Suburb

The findings in the previous section suggest that the two systems in the Suburb are very different in terms of their spatial configuration within a global context. The next question is how these two areas differ in their internal structure without surrounding areas. By looking at their structure both globally and on its own, we can gain a more thorough understanding of the likely morphological effects on spatial experience.

Figure 4.21 illustrates the global integration of sub-area A (the Old Suburb). It shows that the syntactic core is in ring form, and the core itself is in a loop, thus it can be said that the spatial configuration is a closed system. On the contrary, Figure 4.23 illustrates clearly the core of sub-area B (the New Suburb) is a Y shape, stretching outward from the centre. This system tends be highly permeable inwards as well as outwards.

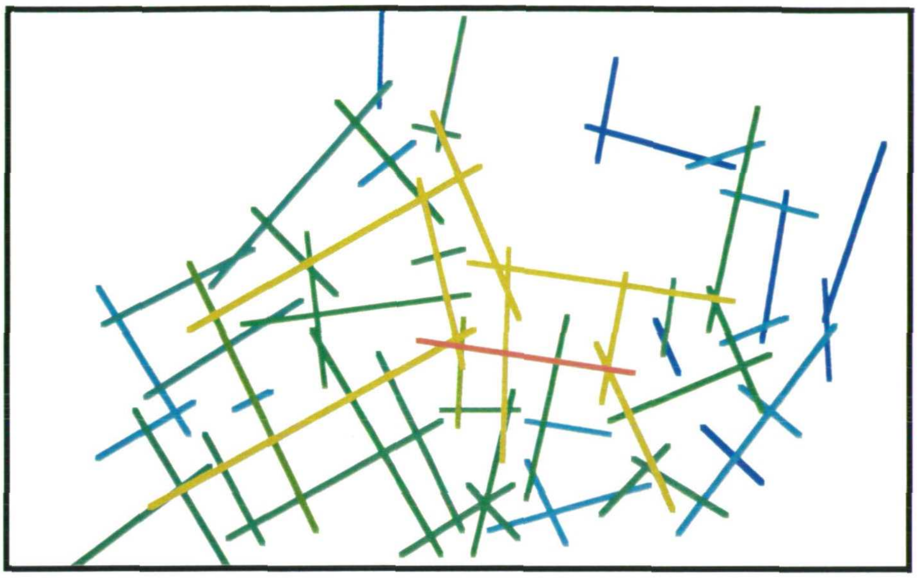


Figure 4.21 Global integration of subarea B

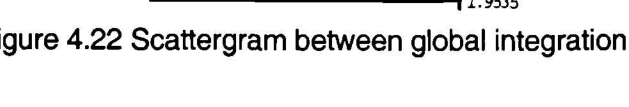


Figure 4.22 Scattergram between global integration and local integration in subarea B

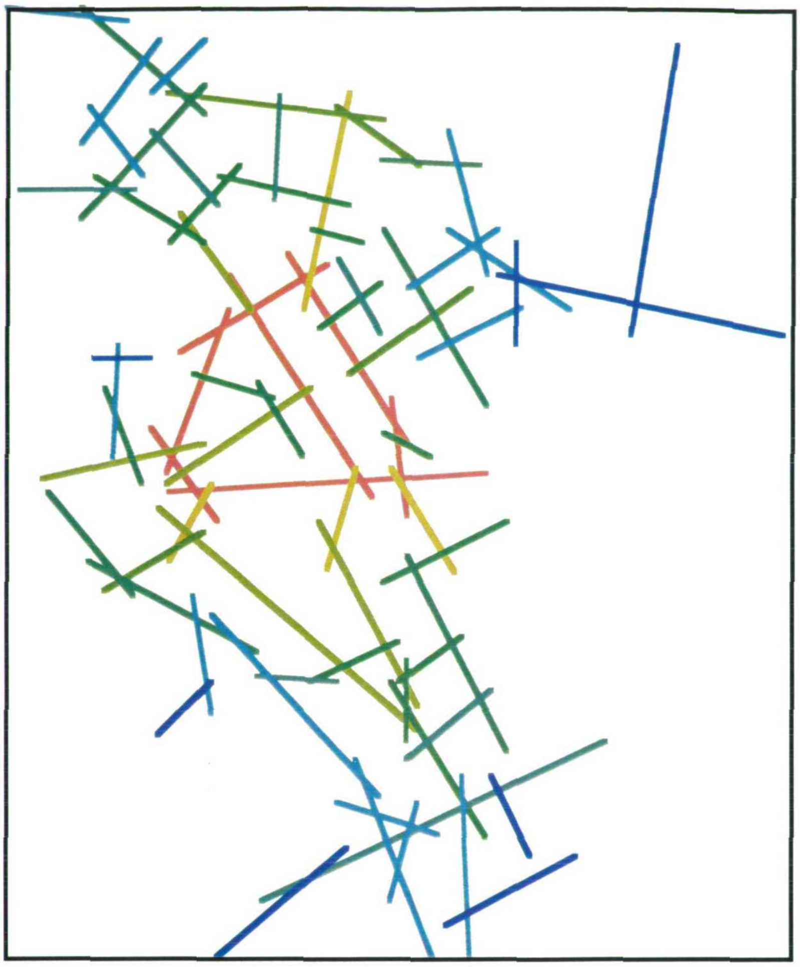


Figure 4.23 Global integration of subarea A

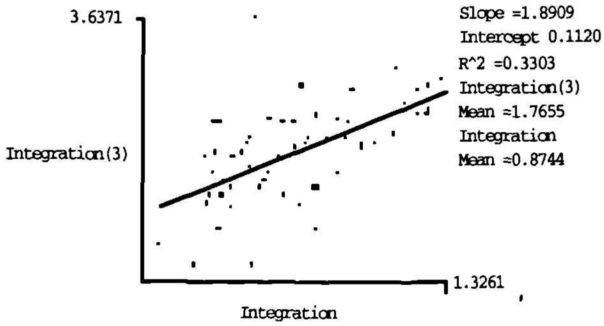


Figure 4.24 Scattergram between global integration and local integration in subarea A

Figures 4.22 and 4.24 show the relationship of global integration of the spaces to local integration in the two areas respectively. The figures show that, in sub area A, the relationship between global to local integration of spaces is unclear, with an r-squared value of 0.33. On the contrary, in sub-area B, the scatters form a linear set of points with an r-squared value of 0.772, which indicates a strong relationship between global integration and local integration, so that this area is highly intelligible in itself.

Table 4.2 summarises the difference between the two systems. As can be seen from the table, there is a difference between the two areas in the local integration of the two systems. Sub-area B is locally more integrated at 1.816 than that of sub-area A at 1.765. As for global integration, there is a big difference between the two areas. Sub-area B, with global integration of 1.175, is much more globally integrated than that of area A at 0.874.

Table 4.2 The syntactic characteristics of the two subareas without their surrounding areas

	The Old Suburb area (sub-area A)	The New Suburb area (sub-area B)
Global integration	0.874	1.175
Local integration (3)	1.765	1.816
R squared (global integration-local integration(3))	0.33, p<0.0001	0.772, p<0.0001
R squared (global integration-local integration(3))	0.284, P<0.0001	0.680, p<0.0001

From these findings we can conclude that there is a fundamental difference in spatial configuration between the two areas, in terms of their own internal structure as well as within their global context. This difference in the organisation of the spatial elements brings a variance in the permeability in the two areas. This may influence the experience of the space psychologically as well as physically. These issues comprise the main areas of investigation in this thesis.

4.6 Revisiting to the Suburb

In this final section of the chapter an attempt is made to describe the Suburb, based on the findings of syntactic analysis, by interpreting it as a pattern of elements and their systems of connections.

4.6.1 The settings

The Suburb is located between the top two most integrating spaces, Finchley Road and the A1. Finchley Road is a main street where most of the shops and other commercial offices and flats are located. On the other side, Market Place had been a main shopping area, but the role of 'local markets' has shifted to Finchley Road.

The most integrated entry to the Suburb from Finchley Road (see Figure 4.18) is Hoop Lane between the Cemetery and the Crematorium, intersecting with Temple Fortune Lane, Hampstead Way and leading to Meadway. The second entry from Finchley Road is Hampstead Way, where groups of shops are located. Once entered, roads radiate northeast and southeast. Addison Way is the next most integrated entry which runs through upper part of the Suburb to Falloden Way. On the opposite side, Addison Way is the most integrated entry, but Kingsley Way is the major one probably due to the easy access to the spine of the Suburb, the Meadway. Following is Addison Way, Winnington Road, then Norrice Way, and finally Northway.

4.6.2 The core of the Suburb

The most integrated space in the area is the Meadway (see Figure 4.12), which is the spine of the Suburb, but lacks any facilities or amenities. It is mostly a through route, not a site of static activity.

The figure shows that the spine of the Suburb is slightly biased towards the southern end, and makes the system shallow towards open spaces from the core: the Heath Extension, Hampstead Golf Club, Central Square and Littleton Playing Field. Conversely, most of the residential areas, located to the north of Meadway, have a peaceful environment with several steps from the busier core of the Suburb, minimising the interface with the through and distributive movement from the core.

The syntactic core is more highly concentrated in the deep part of the Suburb, and no single space links the centre to the periphery. It is quite the opposite of the core within its global context. Nevertheless the findings are comparable, showing that the Suburb tends to be segregated from the surrounding area syntactically even though it is situated between two globally integrating spaces: Finchley Road and the A1.

4.6.3 The spine and connections

A connection system among spatial elements is influential on the experience of space and activity within it. The main connection system from the spine is a series of streets and footpaths that are anchored by important locations for the life of the Suburb. These anchors include religious and social facilities, parks, the square and landmarks. The spaces along the connections have a particular attraction for people, drawing and shifting them from one destination to another.

Figure 4.25 shows the spine and the connections of the Suburb. The spine, the Meadway is represented in black and the connections are marked dark to light grey according to the degree of integration. Among the main connections, Holne Chase is the most integrated connection to the spine, and it can be regarded as an extension of the spine. The next one is Heathgate anchored at Central Square on one side and the Heath Extension on the other. Litchfield is the next connecting space, then follows Bigwood, linking Bigwood and the Heath Extension.

Along with the strong spine and its connection system, the Garden Suburb has an extensive network of public footpaths, which connect places and layers of spatial structure. A great deal of attention was paid to the footpaths across the area so that the whole suburb has a well-connected network. They weave spatial layers, hence easily bringing people from one place to another, and providing for greater usage of the area. This integrates the various parts of the Suburb by linking activities and pedestrian movement across it. Thus it may play a salient

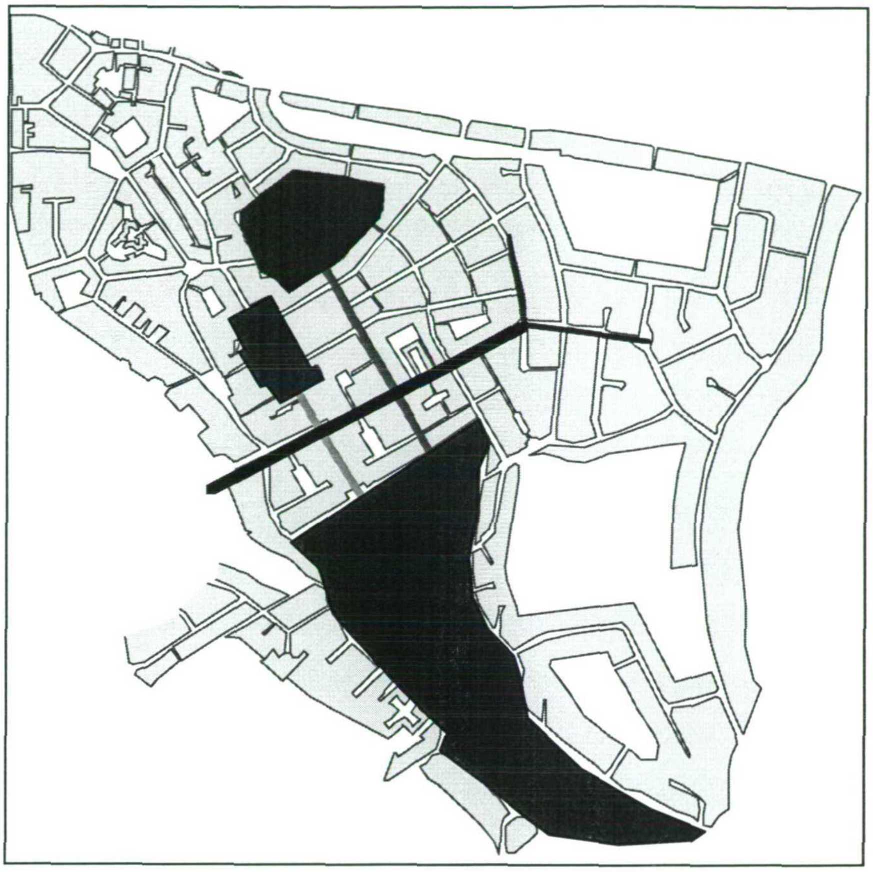


Figure 4.25 The Suburb's spine and its connections

role in creating a sense of community cohesion. Some paths are exposed but many of them are hidden, and as a result, they are hardly recognisable for strangers. For instance, there are two ways to get to Central Square: one is the formal one from Erskin Hill, Northway, Southway or Heathgate, which takes you through the sequence of the spatial layer, the other example is a much more informal footpath, which connects Temple Fortune Lane, through Hampstead Way to Central Square. It compresses several layers and shifts people directly from the outer dimension to the inner most part of the Suburb.

4.6.4 Open spaces and connections

The Suburb has an exceptional landscape, such as parks and communal gardens, which are linked by an extensive network of footpaths. Open spaces are prevalent across the area, some are adjacent to the spine and some are secluded. Some are found by courtyards and relate well with their surroundings. Some are broad sweeps of ground between houses and road. The Heath Extension, Central Square, Bigwood and Littleton Playing Field are the most important places. Among them, Central Square and the Heath extension are the two major open spaces linked by the Heathgate, running across the spine. Two open spaces perform as landmarks and magnets for people and activity: Central Square is the dominant symbol of the Suburb, and Heath Extension is the Suburb's largest open space.

Central Square, including two main churches and the formal gardens between them, is the most formal part of the Suburb and an impressive landmark located at the highest point as well as a central part of the suburb. It is situated in the hub of the Suburb between the Old and the New Suburb, and tends to be a transition zone between them. It serves as the Suburb's major open space. It is the place for various activities and the benefits of the square are more for the resident. However, for visitors and strangers it can be hardly noticed due to its location in the syntactically deep part of the Suburb. The Square is at the deep part in the Suburb not only in the global context but in the local context. The

Square is encompassed by four axial lines, and their mean global integration[2] is much lower at 0.755 than that of the Suburb, at 0.81. Central Square consists of big lumps of relatively segregated groups of lines globally, however, it is different locally. The Square is more integrated in its local context, with a mean integration of 2.054, higher than that of the whole Suburb at 1.949. This shows that the Square is not located in the syntactical centre globally, but plays a more important role in locally.

To the east, there is an Institute devoted to communal activities, and a secondary school, and to the west, there are tennis courts and open spaces. Two axial roads, Heathgate and Erskin Hill, stretch from the Square, and two churches are the landmarks from each direction of both streets. The main approach to the Square from the north is Erskin Hill, and which is terminated by the Free Church which looks down on it from the top of the hill. Heathgate is the opposite approach from the south, which faces the St. Jude's Church. Northway and Southway provide the main access to the Square from the A1.

To the south of the Suburb, the Heath Extension, the most popular and the biggest open space, is encompassed by two contour roads - Wildwood Road where large houses are laid along it and the south end of Hampstead Way, devoted to flats and groups of houses. The integration of spaces approaching the park is relatively low, but the space is highly permeable from the core of the Suburb.

Bigwood is located near the centre of the Suburb geographically, and can be approached from the Old and New Suburb easily. It is accessible from Northway, Oakwood Road, Temple Fortune Hill and Denman Drive. All these streets except Denman Drive are relatively well integrated globally and locally. One of the most popular recreational open space is Littleton Playing Fields, which is conventional in appearance, but is extensively used by Suburb

[2] The mean integration of the place takes the average of the all the spaces where entrances are located.

residents.[3] It is enclosed by the A1, Linden Lea, Norrice Lea and Kingsleyway. The place has a high degree of permeability with high integration both globally and locally.

4.7 Dreams and realities

When the Suburb was built, the purpose was to develop an estate on the outskirts of a large city in such a manner that it would afford healthy conditions of life, the maximum of social amenity and would, in so far as physical conditions could achieve it, foster the community spirit which is so lacking in the ordinary suburb. However, these Barnett's ideas seem to be far from realised in reality.

Three main reasons can be identified. First, one of the most serious shortcomings is that the Suburb does not have a proper centre, although the development plan was prepared and an area of land at the highest point, which was also fairly central, was selected for the Community Centre. Great care was taken to secure centrality of the Square by the axial roads leading to it. Nevertheless, it could never fulfil the same function as the high street of a traditional town. Its syntactic characteristics also limit its potential as a centre of the area. The Square is located not only in the deep part of the Suburb geographically but also in the relatively segregating place syntactically. Meadway is identified as the most integrating space within the Suburb, however it has no shops and communal facilities. By having shops and facilities around the periphery of the Suburb - Finchley Road and Market place, the area was drawn outward. Second, the growth of car ownership transformed the pattern of residents' spatial behaviour. This increased mobility does not let people stay within the neighbourhood with its lack of communal and shopping facilities. Thus their social lives may come to be driven out from the Suburb. More importantly and finally, the spatial morphology of the Suburb tends to circumscribe the achievement of social cohesion and a lively community. Due to both the split of the Suburb into two halves and the series of layers in its

[3] Shankland Cos & Associates, 1971, Hampstead Garden Suburb: A Conservation Study, p24

spatial structure, community life can not be fully exerted. In addition, there is no clear inhabitant and stranger interface, which is essential to create liveliness in the neighbourhood. This syntactic characteristic, coupled with the non-existence and misplacement of the centre, has damaged the Barnett's dreams.

The spatial layout of this 'picturesque' and 'imaginable' pattern after the Garden Suburb has now become popular in housing schemes[4]. Modern housing estates for example are spatially segregated from their surroundings which the garden city movement bequeathed to modern town planning. This can become especially problematic in creating 'virtual community'[5]. Without a comprehensive understanding of the effect of spatial configuration on peoples' mind and behaviour it might bring far more serious results if it continues to be put into practice.

4.8 Chapter Summary

This chapter describes the spatial layout of the Suburb. The spatial realisation has been investigated in terms of the degree of intelligibility, which may affect the spatial experience of residents.

All the findings of the syntactic analyses suggest that the Hampstead Garden Suburb consists of a series of layers, however, each layer is connected through the system by parks and footpaths. As a consequence, the spatial configuration of the Suburb encourages residents to make contact with each other, whilst in some degree it tends to alienate strangers and discourages exploration of the area. This hidden spatial structure of the Suburb, the connections with footpaths and parks, may intensify two different systems by providing different degree of spatial experience; one for the inhabitants and the other for strangers. These

[4] The Hampstead Garden Suburb Trust (1937) describes that this 'picturesque' and 'imaginable' movement is based on experience gained at Hampstead Garden Suburb and Letchworth. Raymond Unwin, who designed the Suburb, was a chief officer of the Ministry of Health after war, to guide local authorities to adopt this modern form of development.

[5] Hillier (ibid, p194) argues that urban safety is a certain aspect of the structure of the virtual community - that is the pattern of probabilistic interfaces - created by spatial design. For the description of 'virtual community' see section 2.2.

locally structured spaces enable the interface among inhabitants rather than between inhabitants and strangers.

At the same time, there is a syntactic split of the Suburb into two halves: one is an intelligible New Suburb and the other is an unintelligible Old Suburb. This may yield completely different spatial experiences across the Suburb and affect social cohesion among residents. This conjecture is tested in the next chapters.

Chapter Five

THE IMAGE OF HAMPSTEAD GARDEN SUBURB

5.1 Introduction

This chapter discusses the findings of the interview survey in Hampstead Garden Suburb. First, the characteristics of the samples selected for the interview are shown. Second, the analysis of the cognitive representation is addressed. This includes cognition of spatial configuration and the perceived neighbourhood boundary. This is complemented by the findings of a series of questions about architectural legibility and spatial knowledge of the area.

5.2 Characteristics of the sample

Seventy-six residents at 76 households out of 5706 households in Hampstead Garden Suburb, were interviewed, and 75 completed a questionnaire. Of the total subjects, 2 refused to undertake sketch mapping and 4 rejected the boundary delimitation task for measuring the perceived size of the neighbourhood.

Females comprised 56 per cent (n=43) of the sample and males were 43 per cent (n=31) as shown in Table 5.1. There is 1 respondent for whom the gender was not recorded. The ratio of female to male respondents in the sub sample-A from the Old Suburb is 59 per cent (n=23) to 41 per cent (n=16), and 56 per cent (n=20) to 43 per cent (n=15) with 1 missing case in sub sample-B from the New Suburb.

Table 5.2 shows the four age bands of the sample. 35 per cent of sample is recorded as 60 years or over, and 35 per cent of the sample are between 40 to 59 years old. Thus 70 percent of the sample is over 40 years. This is similar in both samples A (69%) and B (71%). The distribution of the sample by gender

Table 5.1 Sex of respondents

	total		sample A		sample B	
	(n= 74)	%	(n=39)	%	(n= 35)	%
female	43	58.1	23	59	20	57.1
male	31	41.9	16	41	15	42.9

* missing cases: sample A 1

Table 5.2 Age group of respondents

	total		sample A		sample B	
	(n= 74)	%	(n=31)	%	(n= 35)	%
under 20 years	2	2.7	1	2.6	1	2.9
20-39	20	27	11	28.2	9	25.7
40-59	26	35.1	10	25.6	16	45.7
60 or over	26	35.1	17	43.6	9	25.7

* missing cases: sample A 1

Table 5.3 Number of people in the sample by gender and age

	total		female		male	
	(n= 74)	%	(n= 43)	%	(n= 31)	%
under 20 years	2	2.7			2	6.5
20-39	20	27	16	37.2	4	12.9
40-59	26	35.1	15	34.9	11	35.5
60 or over	26	35.1	12	27.9	14	45.2

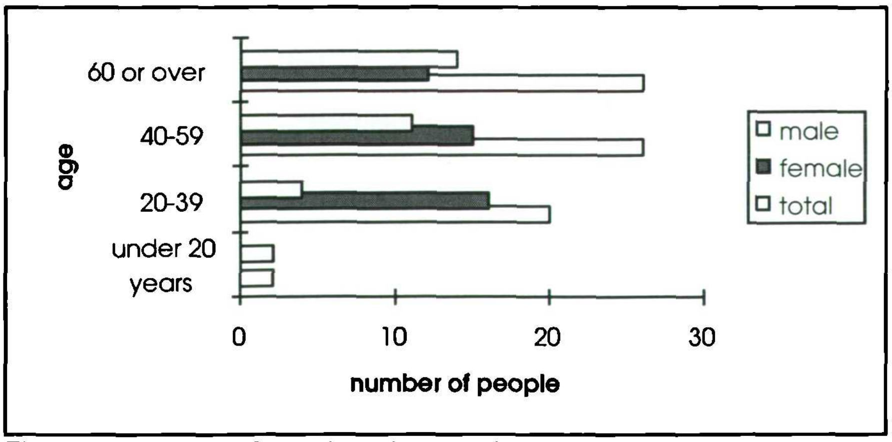


Figure 5.1 Number of people in the sample by gender and age

Table 5.4 Comparison of the sample and the 1991 census by gender and age

	total (%)		female (%)		male(%)	
	sample	census	sample	census	sample	census
16- under 20 years	2.7	6.2		5.9	6.5	6.4
20-39	27	33.9	37.2	32.6	12.9	35.5
40-59	35.1	30.5	34.9	29.1	35.5	32.5
60 or over	35.1	29.4	27.9	32.5	45.2	25.6

and age is shown in Table 5.3 and Figure 5.1. For under 20 years, there are only 2 respondents from sample A and B. To assess how well the sample represent the population of the Suburb, the sample is compared with the 1991 census in Table 5.4. It shows that the sample represents the actual age range of the population well. The distribution corresponds well over the range as a whole even though there is a slight difference between the percentages in the same groups.

Table 5.5 shows the occupational break-up of the sample. It shows that most of the respondents are professional, 52.8%, followed by housewives at 17.7%. There is not much difference in the distribution of occupations in both groups even though no deliberate attempt was made to seek a balance between the two sub-samples when conducting the survey. For instance, 58% (22) are professionals in sample-A compared to 47% (16) in sample-B. Housewives are 13% (5) and 21% (7) in sample A and B, respectively.

Table 5.6 shows the education levels of respondents. 56% (42) of them have a university degree, 27% (20) are college degree holders and 16% (12) have up to secondary school education. People educated to university degree and upward are dominant at about 83%. There is not a significant difference in education level between the two sub-groups. For example, 54% of the respondents in sample-A and 60% in Sample-B are educated at university degree level and upward.

The distribution of residency is identified in two ways: first, the duration of residency at the current address, and second, the duration of residency in the Suburb. The former is shown in Table 5.7(a). About 69 per cent of the respondent have a residency of more than five years at the current address. There is not a significant difference in the residency between the two groups. For example, 64% (25) of respondents in sample-A have stayed at the same address for more than 5 years, and 74% (26) in sample-B. Table 5.7(b) shows the duration of residency in the Suburb. It can be seen from the table that 80

Table 5.5 Occupations of respondents

	total		sample A		sample B	
	(n=72)	%	(n= 38)	%	(n= 34)	%
small businessmen	6	8.3	4	10.5	2	5.9
professionals	38	52.8	22	57.9	16	47.1
students	7	9.7	2	5.3	5	14.7
office workers	8	11.1	5	13.2	3	8.8
housewives	12	16.7	5	13.2	7	20.6
skilled workers	1	1.4			1	2.9

* missing cases: sample A 2, sample B 1

Table 5.6 Education levels of respondents

	total		sample A		sample B	
	(n= 74)	%	(n=39)	%	(n= 35)	%
Secondary school or less	12	16.2	4	10.3	8	22.9
College degree(2 years)	20	27	14	35.9	6	17.1
University or upwards	42	56.8	21	53.8	21	60

Table 5.7a Length of residency at current address

	total		sample A		sample B	
	(n= 74)	%	(n= 39)	%	(n= 35)	%
less than 1 year	3	4.1	2	5.1	1	2.9
1- less than 3 years	12	16.2	8	20.5	4	11.4
3- less than 5 years	8	10.8	4	10.3	4	11.4
more than 5 years	51	68.9	25	64.1	26	74.3

* missing cases: sample A 1

Table 5.7b Length of residency in Hampstead Garden Suburb

	total		sample A		sample B	
	(n= 74)	%	(n= 39)	%	(n= 35)	%
less than 1 year	3	4.1	2	5.1	1	2.9
1- less than 3 years	6	8.1	4	10.3	2	5.7
3- less than 5 years	6	8.1	2	5.1	4	11.4
more than 5 years	59	79.7	31	79.5	28	80

* missing cases: sample A 1

Table 5.8 Chi-square test between the two samples
(significance level: 5 per cent confidence)

Factor	Chi-squared value	D.F.	Significance
Sex	0.0254	1	not significant
Age	3.841	3	not significant
Education	4.330	2	not significant
Occupation	4.525	5	not significant
Residency at current address	1.474	3	not significant
Residency in Hampstead Garden Suburb	1.608	3	not significant

per cent of the respondents have lived in Hampstead Garden Suburb for more than 5 years. The residency in both sub-areas does not have a significant difference. 80% (31) of subjects in sample-A, and 80% (28) in sample-B have resided at the Suburb for more than 5 years.

In conclusion, differences in sample characteristics between the two are examined using a chi-squared statistical test. The results are summarised in table 5.8. There is not any significant difference between the two samples. This confirms that the samples represent the population of the two areas well, and provides fair ground for a series of statistical test to examine difference between them.

5.3 Cognition of Hampstead Garden Suburb

5.3.1 The image of the built environment

- **The image of spatial configuration**

In order to construct the image of the Suburb, the frequency of appearance of comprehensible elements in sketch maps are counted. A composite image of all 73 sketch maps was drawn according to this frequency.

Figure 5.2(a) illustrates the frequency of streets according to their appearance in the sketch maps. Frequency is recorded on axial map of the Suburb coloured from red for the most frequently drawn through to orange, yellow, green, blue and finally purple as the least depicted street. Finchley Road is depicted in 92% of the sketches, or sixty-seven sketches out of seventy-three, and Hoop Lane appears in 75% (55 times). When considering the Suburb only without the peripheral streets and connecting spaces to and from peripheries, Medway appears most often in 70% (51) of the sketches. Then followed Hampstead Way at 55%, and Northway, the approach road to Central Square from the A1 is next, appearing in 51% of the sketch maps (37).

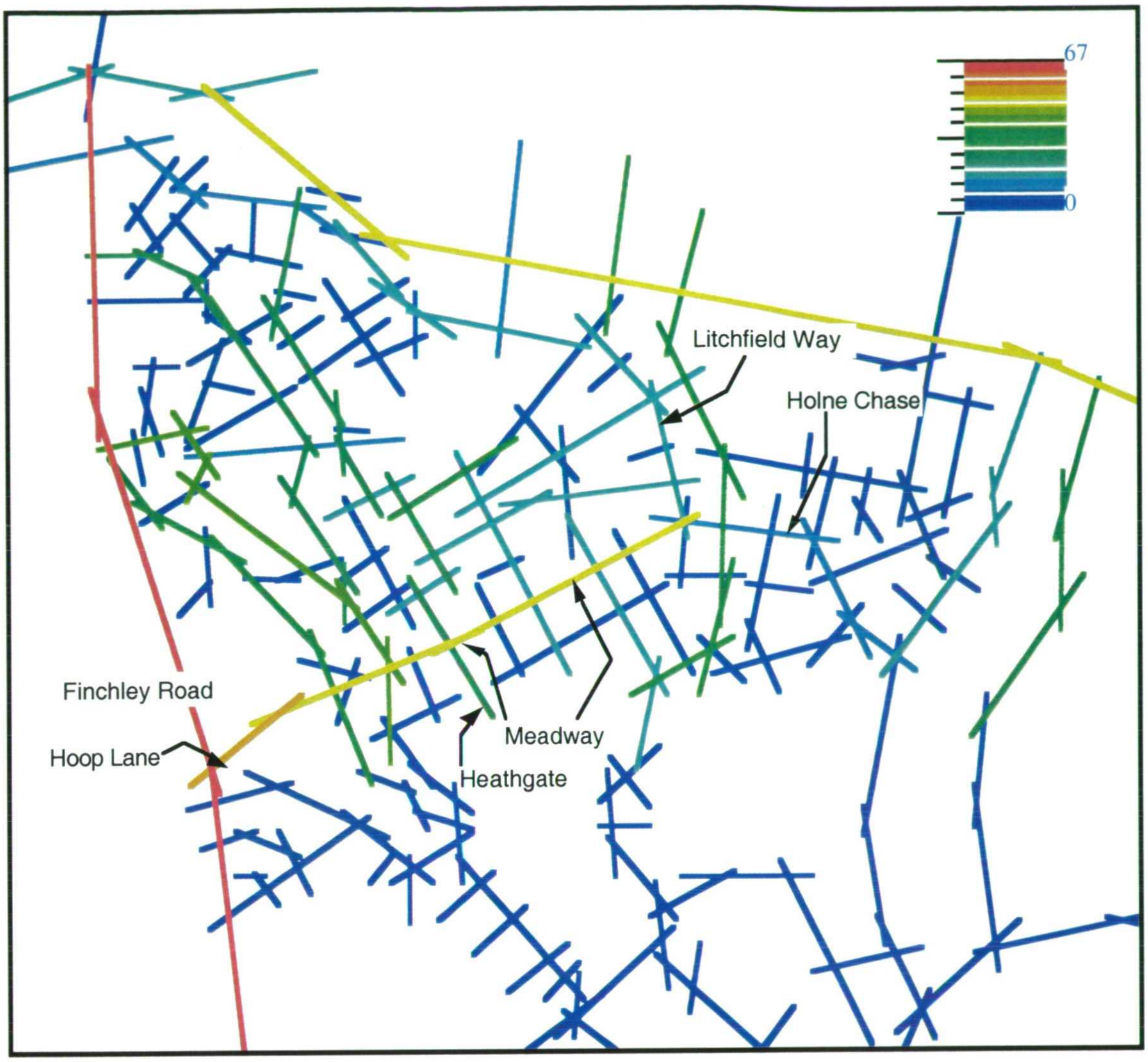


Figure 5.2a Frequency of appearance of streets in sketch maps

This method regards a whole street as one element in counting the frequency of its appearance on the sketches. However, it seems to create a classification problem by treating a whole street as a single entity. For example, people sometimes recognise and draw a street in several parts or one part only even though they are the same street in reality. Analysis also shows that the same part of the street was recognised and drawn differently by the respondents. For example, Hampstead Way, running from north to south across the Suburb, has several segments, but the one that intersects with Meadway is drawn more often than any other segment.

In order to resolve this classification problem, the current research further divides each street into segments according to their visibility, which is the same as digitising an axial map. The frequency of the appearance of a segment of a street on the sketches is recorded. Figure 5.2(b) illustrates the image of paths by segments in the Suburb. Finchley Road 2, coloured as red, is the most often mentioned at 79.5% (58 times) out of 73 sketch maps. Hoop lane is second at 75.3% (55). It is followed by Meadway 2 at 68.5% (50). Considering the Suburb only without surroundings, Meadway 1 is first, followed by Meadway 2 and then Hampstead way 5, which intersects with Meadway 1.

Figure 5.3 represents the perception of landmark features in descending order of frequency. Central Square, which is marked as ❶, appears in 63% of the 73 sketches and the Heath Extension is depicted second most frequently at 47.9%. The Institute follows closely at 41.1%. Figure 5.4 illustrates the perceived core of the Suburb as a conceptual diagram, by combining Figures 5.2 and 5.3 for both paths and landmarks. Features are displayed in their actual positions coloured from black to light grey, proportionate to the frequency. Black represents the most frequently drawn and light grey the least depicted on the sketch maps. Meadway 1 is most frequently mentioned on the sketch maps,

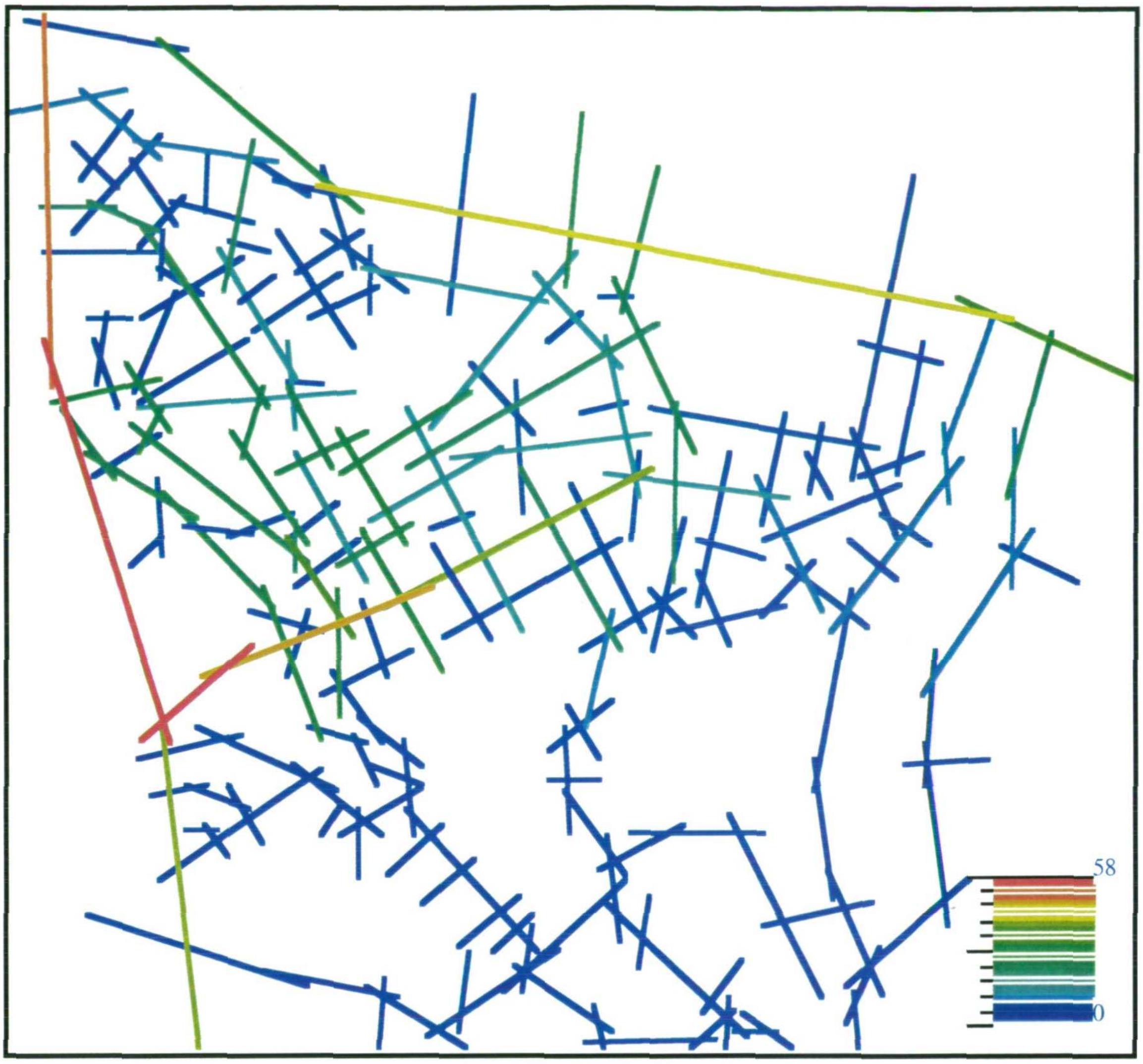


Figure 5.2b Frequency of appearance of streets by segments in sketch maps

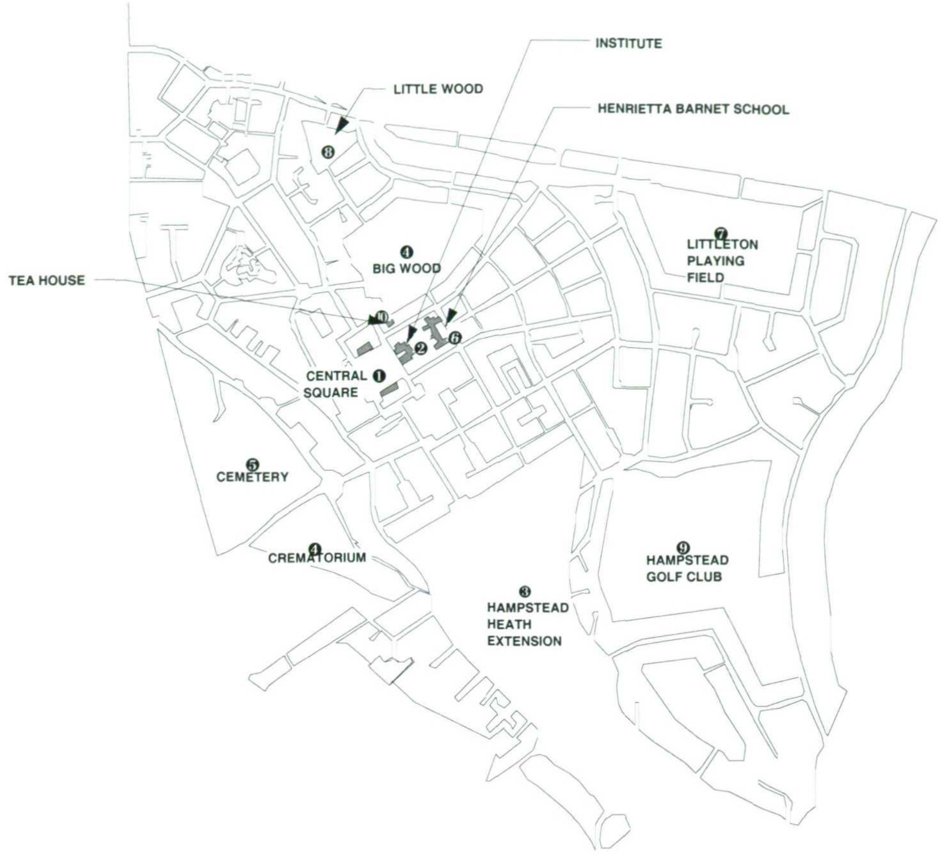


Figure 5.3 Order of frequency of landmarks in sketch maps

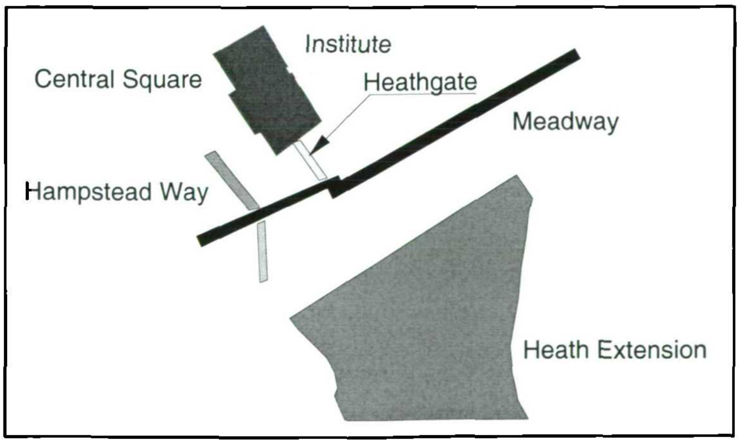


Figure 5.4 Perceived core of Hampstead Garden Suburb

followed by Central Square. Central Square, including two churches, the Institute and Henrietta Barnett School, is described as a dominant landmark in the Suburb by residents. This is confirmed again by the question asking the perceived centre of the Suburb, and this issues is further addressed later in section 5.3.4. These are major features of the Suburb along with Hampstead Way 5, Heathgate and the Heath Extension. Syntactically speaking, as discussed in chapter four, Central Square is located in a deep part of the area, and is quite segregated from the rest of the area in its global context.

The findings support that the syntactic analysis of the Suburb in chapter four, which defined the Suburb as an 'onion-like' shape of spatial structure[1]. A more in-depth interpretation of the syntactic description of sketch maps is described in chapter six.

- **The comparison of comprehensible elements**

Table 5.9 Comprehensible elements on the sketch maps

Neighbourhood (sq. km)	Total (n=73)	Sample A (n=37)	Sample B (n=36)
Mean	21.9	20.6	23.3
STD	9.47	9.25	9.64
t-Test	t-test value = 1.176, p=0.2437		

* Ho: $\mu1-\mu2 = 0$ Ha: $\mu1-\mu2 \neq 0$, missing cases; sample B (2), α level = 0.0500

Table 5.9 shows the average number of depicted elements on the sketch maps. It shows that residents in the Suburb depicted about 22 elements on their sketches. People in the unintelligible part of the area, sample-A, depicted 21 items on average and sample B 23 items.

In order to investigate the effect of intelligibility on the ability to recall and draw comprehensible elements, the average number of the elements on sketch maps is compared between the two groups. As shown in the table, the t-test fails to

[1] Chapter four discusses the spatial structure as 'onion-like' which causes different spatial experiences for inhabitants and strangers. It may bring about a consolidated inhabitant and inhabitant interface system rather than an inhabitant and stranger interface in the Suburb.

display a significant difference between the two samples (t-test value = 1.176, p=0.2437). This shows that the number of depicted elements on the sketch map is not influenced by the intelligibility of a subject's immediate neighbourhood. These findings suggest that the intelligibility of an area, which is defined by the syntactic attributes of residential location in its global context, does not affect the ability to draw more items on the sketch map.

5.3.2 The boundary of the perceived neighbourhood

In order to investigate the impact of morphological intelligibility on the perceived neighbourhood size, the boundary of the perceived neighbourhood is compared between the two samples. The edge and boundary of the neighbourhood is identified by superimposing all the respondents' maps. These are compared in turn to see the differences in size between the respondents living in the intelligible and the unintelligible area. Figure 5.5 shows the superimposed neighbourhood boundaries of all the respondents. Figure 5.6(a) displays the perceived neighbourhoods of respondents in the intelligible area and Figure 5.6(b) the neighbourhoods in the unintelligible area.

To the West, Finchley Road was drawn in 86% of the sketches (61 times) as the dominant boundary in the whole sample. Both groups see the Finchley Road as a definite boundary. This may be explained by its high integration value compared with the rest of the spaces mentioned as a boundary. A close examination of the maps reveals that sample-B delimits the boundary beyond Finchley Road more often than sample-A. This indicates that the sample from the intelligible area has a bigger boundary to the west than the sample of the unintelligible area. The superimposed boundary to the North indicates the A1 as the major boundary. Respondents in sample B delimit their boundary further north of the A1. Hill Top and Brim Hill comprise the second boundary beyond the A1, and East End Road is the most northerly boundary. On the other hand, in sample A from the unintelligible area, the constitution of the boundaries is similar to sample B, but the frequency of incidences gets smaller, further north

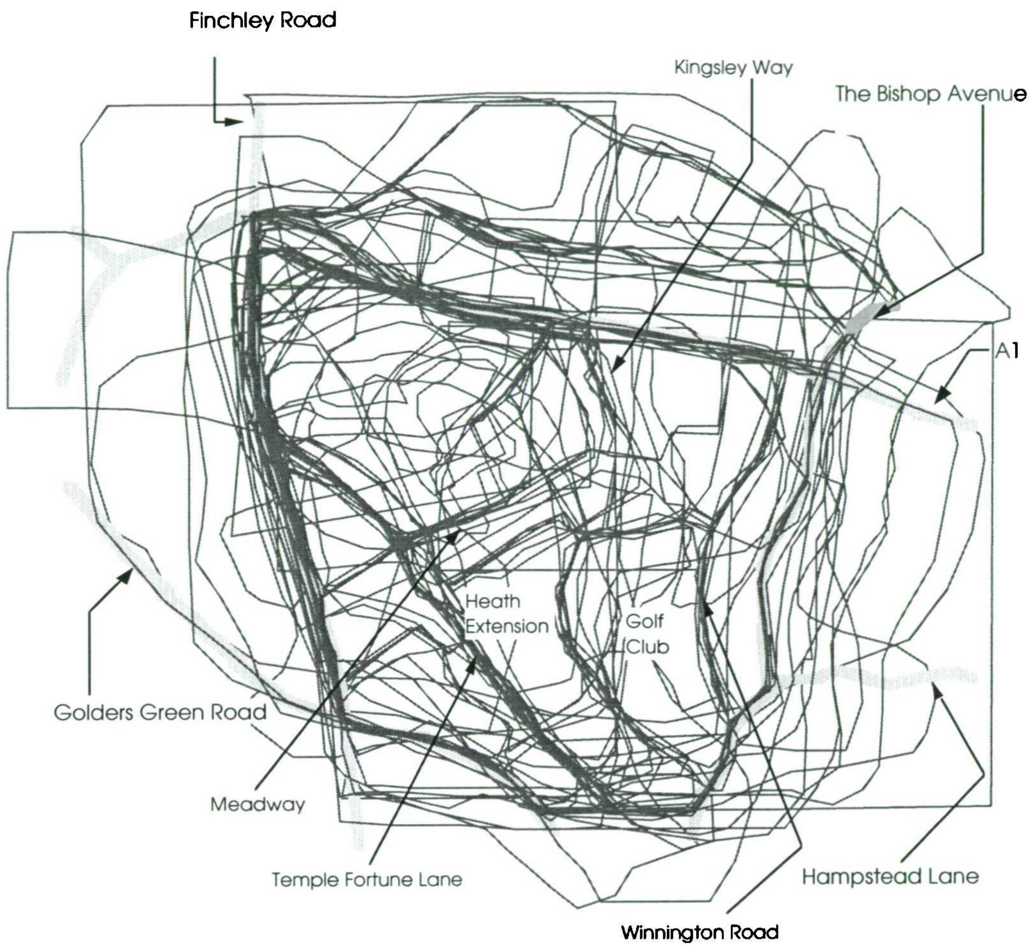


Figure 5.5 Superimposed boundaries of neighbourhood by all subjects

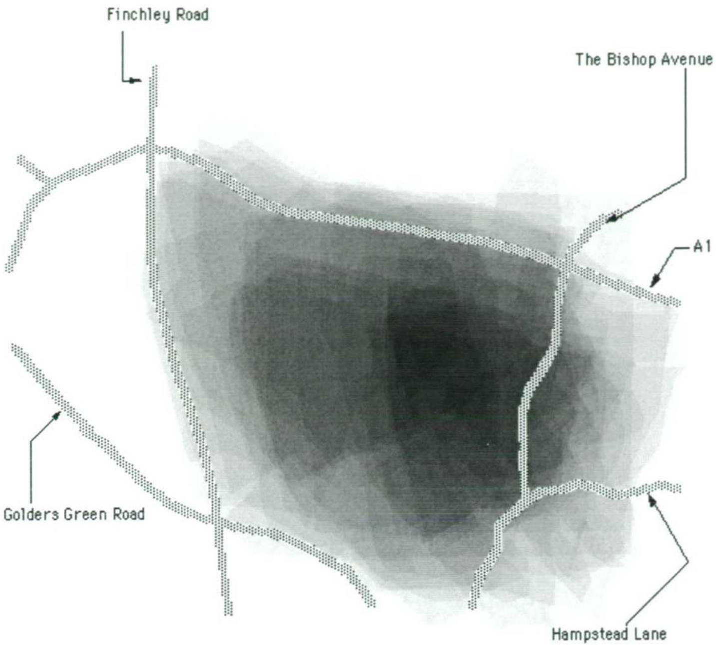


Figure 5.6a Superimposed neighbourhoods by sample A (the unintelligible area)

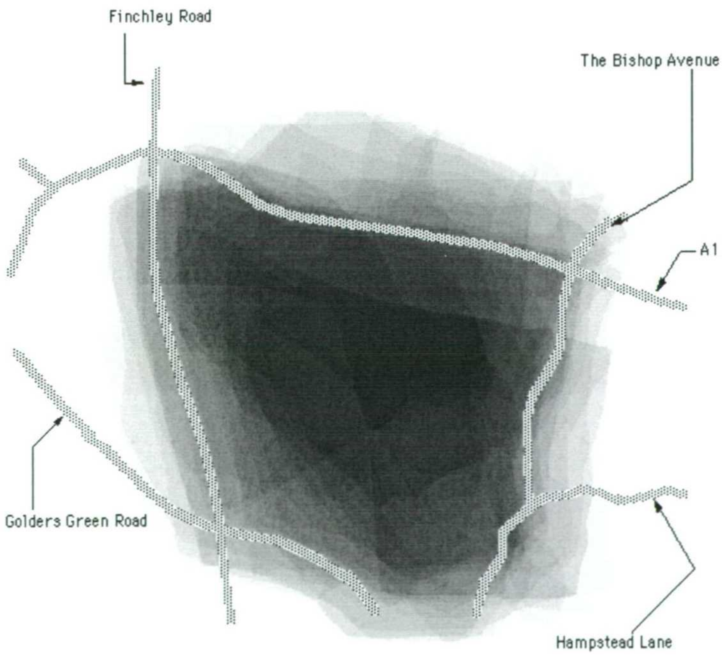


Figure 5.6b Superimposed neighbourhoods by sample B (the intelligible area)

of the A1. In some cases, boundaries are even within the Suburb, which is sized down to Addison Way and Hogarth Hill that joins with the Finchley Road. Conversely, the boundary is rarely drawn below Addison Way in sample B from the intelligible area.

The Bishops Avenue is depicted as the dominant boundary to the East in both samples. The first tangible boundary is upper Northway towards the A1 and Kingsley Way, the second, Wildwood Road, and the third the Winnington Road, which runs parallel with The Bishops Avenue. Nevertheless, the majority of the boundaries lie between Winnington Road and The Bishops Avenue. The comparison of the boundary between the two groups shows a big difference. Over 90 per cent (30) in the sample from the intelligible area draw the boundary to the east beyond The Bishops Avenue, on the other hand, in sample A, only 8 per cent (3) illustrated the boundary beyond it.

To the South, there are three identifiable boundaries. Hoop Lane and Meadway comprises the smallest boundary, and most of them are from respondents in the unintelligible area. The next is the northern boundary of the Heath Extension and Hampstead Golf Club, which is identified by both groups, but by more subjects from sample-A. The dominant boundary to the South in the whole sample is the southern boundary of the Heath Extension and Hampstead Lane, up to the southern end of Hampstead Golf Club. This definite physical boundary of two open spaces might have an effect on the perceived boundary. Again, these figures show that the perceived boundaries of people in the intelligible area are further extended to the South than those of people in the unintelligible area.

5.3.3 Intelligibility and perceived neighbourhood size

The size of the perceived neighbourhood is compared between the two samples to investigate its relationship with the intelligibility of subjects' neighbourhood. It is hypothesised that people living in the intelligible area would have a bigger perceived neighbourhood size than people in the unintelligible area.

Table 5.10 shows the size of respondents' perceived neighbourhoods. The average size of the neighbourhood is 2.497 sq. km in the whole sample. That of sample-A from the unintelligible area is 2.047 sq. km, whilst, sample-B from the intelligible area has 3.016 sq. km on average. The t-test shows that there is a significant difference in the neighbourhood size between the two samples (t-test value = 3.185, p=0.0022, α level = 0.05). This suggests that people in the intelligible part of an area have a significantly bigger neighbourhood than respondents living in the unintelligible area even though they are in the same local area.

Table 5.10 The size of the perceived neighbourhood

Neighbourhood (sq. km)	Total (n=71)	Sample A (n=38)	Sample B (n=33)
Mean	2.497	2.047	3.016
STD	1.374	1.392	1.172
t-Test	t-test value = 3.185, p<0.0022		

* Ho: $\mu1-\mu2 = 0$ Ha: $\mu1-\mu2 \neq 0$, missing cases: sample A (3); sample B (1), α level = 0.0500

Figure 5.7 displays a histogram of respondents' neighbourhood size. It shows a bi-modal distribution. Hence it is subjected to a separate analysis by splitting the sample into two groups: group-L, with neighbourhood size from 0.3 sq. Km to 2.1 sq. km, and group-M, 2.1 sq. km and above. Table 5.11 shows that, in sample-L, 75% (27) of subjects are from the unintelligible area. On the other hand, in sample-M, 73 per cent of subjects are from the intelligible area. This result confirms the hypothesis that individuals who delimit a bigger size of neighbourhood are mainly from the intelligible area.

This result including the previous section's shows that that respondents living in the intelligible area regard their neighbourhood as larger. Thus it can be inferred that people in an intelligible area generally have a bigger neighbourhood than people in an unintelligible area. These findings suggest that the intelligibility of an area where people reside, positively affects the perception of the neighbourhood size.

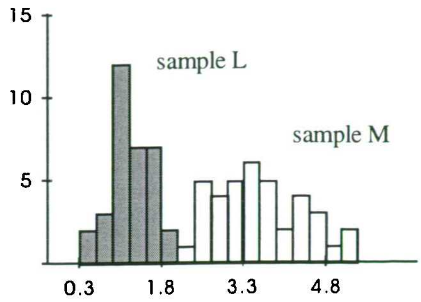


Figure 5.7 Distribution of frequency of neighbourhood size

Table 5.11 Frequency breakdown of the histogram of perceived neighbourhood size

	sample L	sample M
subarea A (an unintelligible area)	27(75%)	10(27%)
subarea B (an intelligible area)	9(25%)	27(73%)
total	36	37

5.3.4 General perception of the Suburb

In this part of the chapter, residents' cognition of spatial configuration and their perceived image of the Suburb are investigated through the subjective questions on the questionnaire. The following series of questions ask about the perceived legibility of the built environment in the Suburb.

- **Perceived street layout**

In this part of the questionnaire we attempt to investigate cognition of spatial configuration. It is hypothesised that people in an intelligible area may have a clearer and more obvious spatial pattern in the mind than those who live in an unintelligible area.

Subjects were asked:

> "Do you think that the street layout of Hampstead Garden Suburb is arranged in a clear and obvious pattern? "

This was answered on a five-point scale from 'fairly well' to 'not at all'. Figure 5.8 shows the frequency of responses at each level. The vertical axis shows the percentage of people at each level of clearness and obviousness of the street

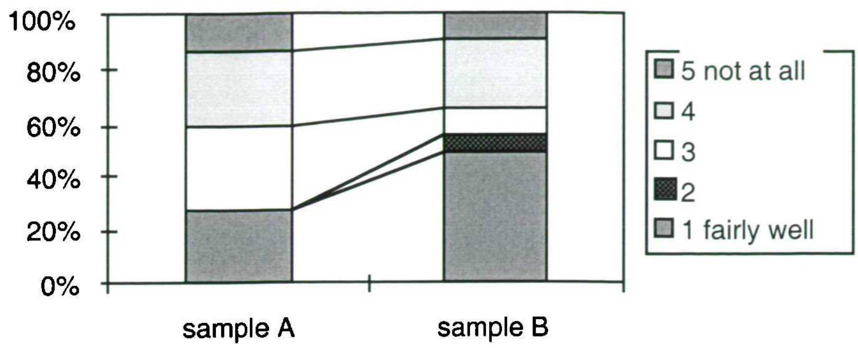


Figure 5.8 Perceived street layout of the Hampstead Garden Suburb

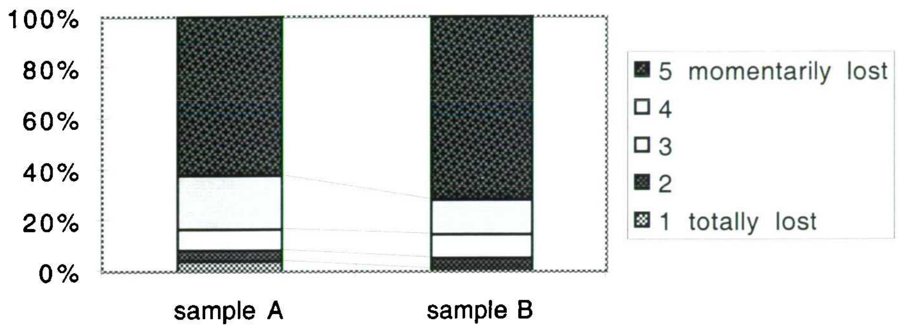


Figure 5.9 Experience of the degree of getting lost for the two samples

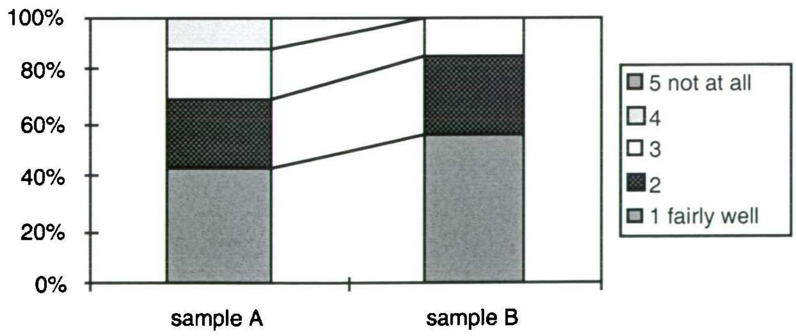


Figure 5.10 Comparison of spatial knowledge of the Suburb

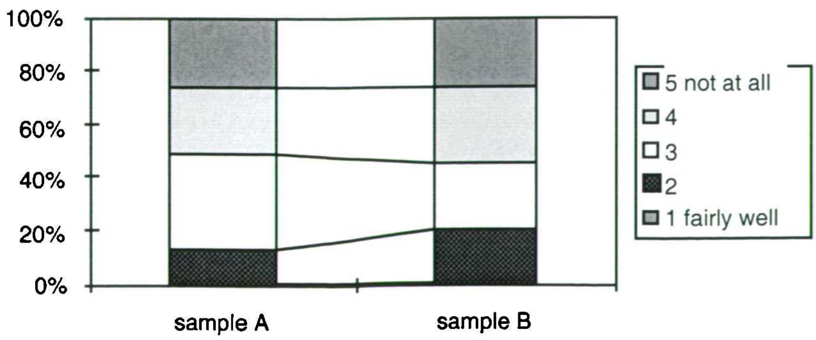


Figure 5.11 General architectural legibility in the Suburb

layout in the Suburb. The horizontal axis compares the two sub-samples, sample A and sample B; the former is in the unintelligible part of the Suburb and the latter is in the intelligible area. The figure shows that more than half of the subjects in the intelligible area describe the spatial layout of the Suburb as 'fairly well', which is double the percentage of sample A at 25%. Not surprisingly, in sample B, fewer people answered as 'not at all' . However, the difference between the two samples is not at a significant level (chi-squared = 4.3, D.F. = 4, $p = 0.3616$).

These findings may suggest that the degree of legibility relates positively to the syntactic intelligibility of the area where respondents live. In other words, people living in an intelligible part of an area may perceive the street layout of the local area as a clear and obvious pattern, and that those in unintelligible areas will perceive a less clear pattern..

This finding may do not support the contention of Eyles (1968) and Spencer et al (1971). They both argue that people perceive an area nearer to themselves more clearly than a distant area, the awareness of which is sometimes hazy. The result of this research is rather contradictory to their argument in that intelligibility defined by the respondent's residential location within the global context becomes a salient factor in the perception of legibility as opposed to physical proximity. This, however, needs further investigation.

- **Spatial knowledge**

The next several questions measure respondents spatial knowledge of their local area: their experience of being lost, their ability to direct places and the ease of figuring out the layout of the Suburb.

People were asked about the degree of experience of becoming lost in the Suburb, and the reactions were recorded in a five-point scale from 'totally lost' to 'just momentarily lost'. Figure 5.9 shows the percentage of respondents in each level of being lost. Although there is not a significant difference (chi-square = 5.454, D.F. = 4, $p = 0.2438$), the distribution of data shows notable difference between the two samples. Respondents from sample-B reported no cases of 'totally lost' and less than 30 percent of people described being more than 'just momentarily lost'. On the contrary, in sample-A from the unintelligible area, 2 per cent of subjects answered 'totally lost' and 40 per cent more than 'just momentarily lost'.

Next, respondents were asked about their confidence in their spatial knowledge of the area:

> "Do you think you'd be able to direct a stranger to many places in Hampstead Garden Suburb? (e.g., parks, churches, schools, houses...)"

Figure 5.10 compares the percentage of responses between the two samples in terms of spatial knowledge and its confidence. Significant difference is not detected (chi-squared = 3.6, D.F. = 3, p = 0.3080). However, the figure shows that 85% of subjects (17) claimed that they could direct a stranger more than 'well' in sample-B, whilst only 69% of the people answered at the same level in sample-A. The result seems to suggest that people in an intelligible part of an area have more confidence in their spatial knowledge about the local area than people living in the unintelligible area.

The final question aims to measure perception of legibility and the ease of wayfinding in the Suburb. People were asked;

> "All things considered, do you think Hampstead Garden Suburb is a relatively easy or difficult place to figure out and in which to find your way?"

Figure 5.11 shows the comparison of the percentage of respondents between the two samples. In sample-B, 20 per cent answered the ease of figuring out and finding a way in the Suburb as 'fairly well', whilst about 10 percent answered more than 'well' in sample-A. However, there is no significant difference statistically (chi-squared = 1.375, D.F. = 4, p = 0.8486).

The trends of all the responses to questions relating to architectural legibility and spatial knowledge of the Suburb are in the expected direction even though there is no significant difference between the two samples. People in the intelligible part of an area appear to have better legibility about their built environment and more confidence in their spatial knowledge than people living in the unintelligible area.

- **Perceived centre**

In order to find out the perceived centre of the Suburb, subjects were asked;

> "What area do you see as the centre of the Hampstead Garden Suburb area? Is there one building, street or place that you see as the centre of the Suburb?"

Table 5.12 The perceived centre of Hampstead Garden Suburb

	total (n= 73)	%	sample A (n= 38)	%	sample B (n= 35)	%
Central Square	61	83.6	36	94.7	25	71.4
Market Place	6	8.2	2	5.3	4	11.4
Heath Extension	2	2.7			2	5.7
Golders Green station	1	1.4			1	2.9
Finchley Road	1	1.4			1	2.9
Meadway	1	1.4			1	2.9
Littleton playing field	1	1.4			1	2.9

* missing cases: sample A:1; sample B:1

Table 5.12 illustrates the percentage of respondents in each category of perceived centre in the Suburb. Over 80 per cent of respondents mentioned the Central Square as the centre of the Suburb. The table shows that the perceived centres are more diffused across the area in sample-B, conversely, 95 per cent of subjects in sample-A mentioned the Central Square as their perceived centre.

When considering the location of all the mentioned centres, their distance from subjects seems hardly affect the result. From the previous section it has been identified that people in the intelligible area have more extensive spatial knowledge. This helps explain this result in that, owing to a comprehensive knowledge of spatial layout, their perception of the area may be not confined only to one dominant centre, but appears to be more scattered across the whole Suburb.

5.4 Post-task question

This section investigates a possible relationship between a respondent's encountered difficulties during the cognitive mapping task and his or her syntactic attributes of residential location. It is hypothesised that people who live in an unintelligible part of an area are likely to have much more difficulty in completing the cognitive mapping task than people living in an intelligible area because of their lack of self-confidence in the knowledge of spatial configuration. Respondents were asked to assess their difficulties encountered during the task on a five-point scale from "not at all", "a little", "some", "much", to "very much".

Respondents were asked about the encountered difficulties when carrying out two cognitive mapping tasks: sketch mapping and boundary delimitation. Figure 5.12 and Table 5.13 show the experienced difficulty for the sketch map task. The table and figure indicate that, in the sample of the intelligible area, about 9% of respondents were categorised as having no difficulty, compared to 23% in the sample from the unintelligible area. Figure 5.13 and table 5.14 show the encountered difficulty in the boundary delimitation task. They show that 71% of the sample in the intelligible area mentioned a difficulty. In contrast, 54% in the unintelligible area reported difficulty.

This result fails to support the hypothesis that the people in an unintelligible area might have more difficulty in cognitive mapping than people in an intelligible area. The result shows a negative relationship, which is the reverse of the hypothesis. This unexpected result might be caused by the difference in the size of the perceived neighbourhood between the two samples. The findings in section 5.3.3 reveal that the people in the intelligible part of an area have a bigger perceived neighbourhood than the people living in the unintelligible area. Thus, if the neighbourhood size gets bigger, more difficulty might be expected in figuring out an area, since there is more information to recall. The results experienced problem with the cognitive mapping technique is related to the size of the perceived neighbourhood.

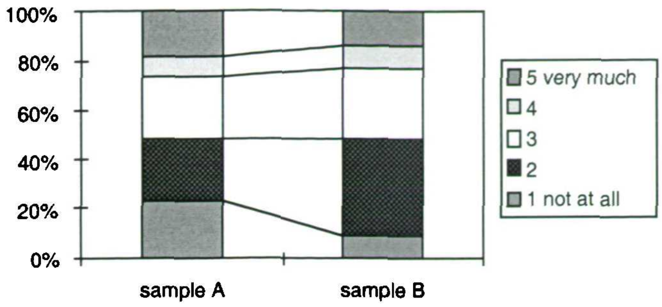


Figure 5.12 Difficulties encountered in drawing a sketch map

Table 5.13 Difficulties encountered in drawing a sketch map

	total (n= 74)	%	sample A (n= 39)	%	sample B (n= 35)	%
Not at all	12	16.2	9	23.1	3	8.6
A little	24	32.4	10	25.6	14	40.0
Some	20	27.0	10	25.6	10	28.6
Much	6	8.1	3	7.7	3	8.6
Very much	12	16.2	7	18.0	5	14.3

* missing cases: sample A 1

Table 5.14 Difficulties encountered in boundary delimitation

	total (n= 73)	%	sample A (n= 38)	%	sample B (n= 34)	%
Not at all	27	40	17	43.6	10	29.4
A little	25	34.2	11	28.2	14	41.2
Some	12	16.4	5	12.8	7	20.6
Much	1	1.4	1	2.6		
Very much	8	11	5	12.8	3	8.8

* missing cases: sample A:2

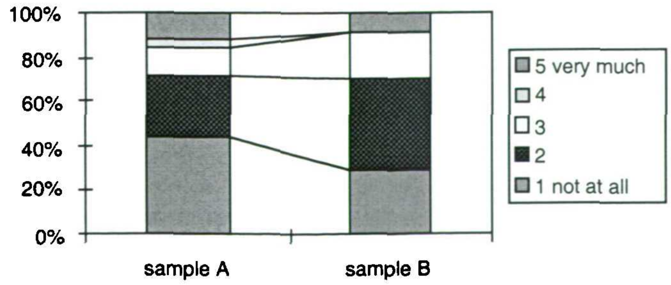


Figure 5.13 Difficulties encountered in boundary delimitation

5.5 Conclusions and implications

Before making a conclusive comment about the findings in this chapter, the characteristics of a sample per se needs to be mentioned. The sampling procedure involves no problem, but the sample is slightly biased towards the highly educated and the elderly in Hampstead Garden Suburb. However, this research is not aimed at investigating the relationship between cognitive mapping and demographic issues. It explores the relationship between spatial configuration and spatial cognition and compares responses of the two samples systematically in order to investigate the role of syntactic intelligibility. Therefore, as long as the limited bias is consistent in the two samples, it is not a obstacle to this research.

In spite of the limitation outlined, a number of tentative conclusions can be drawn with regard to the analyses so far. The first finding is that intelligibility of respondents' residential location may affect positively the clarity of the perceived image of the street layout, the navigation experience and confidence in one's spatial knowledge. This appears to lead to good spatial knowledge and a well-structured perceived image about the wider local area. The second finding is that intelligibility positively affects the size of the perceived neighbourhood. People in the intelligible area extend their neighbourhood boundary across the whole local area, but those in the unintelligible area mainly focus on their immediate neighbourhood. Their perceived neighbourhood size is therefore smaller than those of people in the intelligible area.

Based on the findings, it is tempting to suggest that spatial configuration is related with perception and cognition of the physical built environment. Intelligibility appears to be an intervening variable that causes differences in this association. This may suggest possibility of extending Hillier's intelligibility to cover not only the relationship of spatial layout to the physical world, but also the psychological dimension. At the same time, the findings enable an analytic interpretation regarding the role of spatial configuration in studies of spatial perception and cognition.

However, these findings open up the necessity of further exploration issues around an interface between spatial configuration and cognitive maps. The following chapter attempts to analyse sketch maps using the 'space syntax' technique, which provides a new way of looking at them. It thus attempts to provide empirical evidence on the role of spatial configuration in studies of perception and cognition, as well as on the relationship between spatial cognition and spatial configuration.

Chapter Six

SPATIAL CONFIGURATION AND SPATIAL COGNITION

6.1 Introduction

Having carried out both a descriptive account of spatial configuration of the study area in Chapter Four and an interpretation of the residents' perception and cognition in Chapter Five, this chapter investigates the relationship between them. This chapter comprises the first part of three analytical chapters which aim to disentangle the interrelationship between spatial configuration, spatial cognition and spatial behaviour.

This chapter does not assume that only configurational factors are in themselves responsible for user's cognition, but aims to investigate the manner in which the arrangement of spatial elements is associated with cognition of the physical built environment. Thus it is hypothesised that such configurational variables as types of syntactic property - the overall plan layout of a setting - may have an impact on cognitive representation.

The issues covered here are: firstly, the relationship between respondents' perception and cognition of the area and the syntactic attributes of their residential location; secondly, the syntactic characteristics of sketch maps; thirdly, the association between the syntactic properties of sketch maps in the mind and spatial configuration in the physical environment, and finally, the comparison between spatial configurations in reality and that of sketch maps in cognition.

6.2 Cognition of open spaces and syntactic characteristics

This section examines the relationship between the frequency of appearance of open spaces and landmarks on sketches and their syntactic characteristics. The syntactic values of open spaces, such as parks, squares, are calculated as the mean of all axial lines where entrances are located.

Table 6.1 shows their frequency and syntactic attributes. The table shows that Central Square is depicted most often on sketches at 46 times out of 73 sketches, and it is followed by the Heath Extension (35), the Institute (30), and the Crematorium (26). Table 6.2 shows the correlation coefficient between their frequency of appearance and syntactic variables. It is hard to find significant relationship between the two variables.

Figure 6.1(a) and (b) are scatters of global integration and local integration horizontally and the frequency vertically in both samples A and B respectively. They show that there is not any significant relationship between these two variables.

6.3 Neighbourhood perception and syntactic attributes of residential location

The section investigates the relationship between two cognitive variables: the perceived size of a neighbourhood and the frequency of appearance of comprehensible elements on the sketch maps, and the syntactic attributes of the subjects' residential location.

The two cognitive variables are derived from the sketch maps. The neighbourhood size is calculated from the boundary delimitation on the map, and frequency is identified by counting spatial elements on the sketch maps. The syntactic attributes of a subject's residential location are calculated from the axial analysis of the Suburb.

It is hypothesised that there may be a positive relationship between these variables. People living in an integrated space, either globally or locally, might

Table 6.1 Frequency of open spaces and landmarks identified on sketch maps and their syntactic values in reality

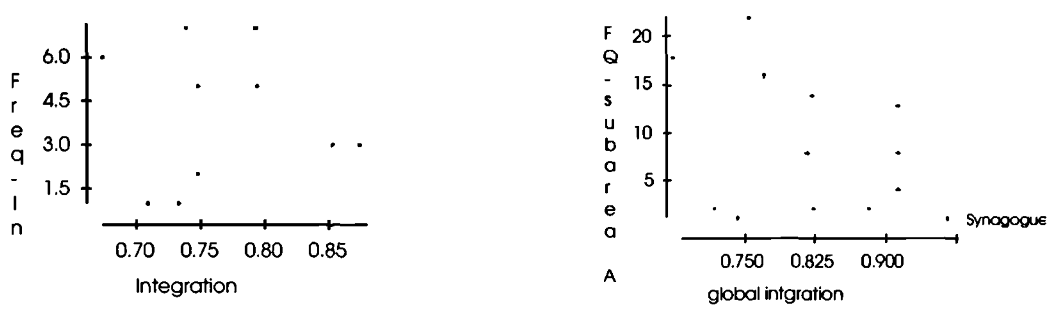
Open spaces and landmarks	total	Frequency subarea A	subarea B	global integration	local integration
Central Square	46	22	24	0.755	2.054
Heath Extension	35	18	17	0.673	2.875
Institute	30	16	14	0.771	2.21
Big Wood	26	14	12	0.823	2.286
Crematorium	26	13	13	0.915	3.136
Henrietta Barnet School	19	8	11	0.818	3.000
Cemetery	21	8	13	0.915	3.136
Littleton Playing Field	12	2	10	0.883	3.236
Little Wood	9	4	5	0.914	2.417
Hampstead Golf Club	5	2	3	0.718	1.79
Tea House	5	2	3	0.824	2.14
Synagogue	4	1	3	0.966	3.561
Friend's Meeting	3	1	2	0.733	1.959

Table 6.2 The correlation coefficients between the frequency and syntactic variables

Pearson Product-Moment Correlation

	total	subarea A	subarea B	global	local
total	1.000				
subarea A	0.983	1.000			
subarea B	0.979	0.926	1.000		
global	-0.321	-0.377	-0.247	1.000	
local	-0.000	-0.087	0.096	0.657	1.000

(global: global integration; local: local integration)



(a) Sub sample A (p=0.6976)

(b) Sub sample B (p=0.1811)

Figure 6.1 Scattergram between global integration and frequency of appearance of elements in sketch maps consider their neighbourhood to be larger. They also might be able to recall a larger number of spatial elements in the sketch maps than those who live in more segregated locations because they are more strategically placed to acquire spatial knowledge.

This hypothesis is tested by a series of correlation analyses between the cognitive map variables and the syntactic attributes of residential location of a subject. Appendix-C shows these two cognitive variables and the syntactic attributes of the subjects taken from the pedestrian map and the vehicular map respectively. Depth is calculated from three different 'attractors' in the Suburb: Central Square, the perceived centre of the Suburb; Finchley Road and the A1, its boundaries; and Finchley Road alone, the main shopping street. Table 6.3 shows the correlation coefficients between the size of the perceived neighbourhood and the syntactic attributes of the subject (i.e., global integration, local integration, depth). A weak positive relationship is found between neighbourhood size and depth from the boundary spaces of the Suburb (the A1 and Finchley Road) at $r = 0.234$ ($p=0.3639$), and the most integrated space (Meadway) at $r = 0.228$ ($p=0.3472$). The two peripheral streets are the most integrated spaces globally, and the Meadway is the most integrated space locally within the Suburb. From this results, it seems that the greater the depth from the integrated spaces the bigger the neighbourhood. In other words, if a subject resides close to the integrated space, his or her perceived neighbourhood may be smaller. This seems to suggest that the integrated spaces are considered as part of the neighbourhood boundary. However, the association is very weak, and further investigation is needed to generalise this finding,

Table 6.4 shows the relationship between the total number of comprehensible elements on subjects' sketch maps and the syntactic attributes of their residential location. The correlation analysis does not show any relationship between the two. This suggests that the number of comprehensible elements described on sketches is not related to the syntactic attributes of subjects' residential location.

Table 6.3 Correlation between perceived neighbourhood size and syntactic attributes of residential location

Pearson Product-Moment

	Neigh-	INT	CON	CT R	INT(3)	INT-veh	Int(3)-v...	DEP-most	Depth-	Depth-	Depth-FR
Neigh-	1 000										
INT	-0 094	1 000									
CON	-0 163	0 480	1 000								
CT R	-0 096	0 379	0 881	1 000							
INT(3)	-0 100	0 586	0 945	0 790	1 000						
INT-veh	0 037	0 966	0 485	0 375	0 593	1 000					
Int(3)-veh	-0 106	0 582	0 881	0 724	09 3	0 641	1 000				
DEP-most	0 228	0 825	-0 294	-0 222	0 392	-0 745	-0 340	1 000			
Depth-	-0 075	0 144	-0 268	-0 161	-0 321	0 057	-0 329	-0 359	1 000		
Depth-peri	0 234	0 846	-0 307	-0 235	-0 404	-0 770	-0 349	0 996	-0 334	1 000	
Depth-FR	0 216	0 470	-0 317	-0 260	0 364	-0 403	0 251	0 647	-0 044	0 667	1 000

(Neigh: perceived neighbourhood size; INT: global integration; INT(3): local integration INT-veh: global integration of vehicular axial map; INT(3)-veh: local integration of vehicular axial map; DEP-most: *depth from the most integrated space*; Depth-: *depth from the Central Square*; Depth-peri: depth from the peripheries; Depth-FR: depth from the Finchley Road)

Table 6.4 Correlation between number of comprehensible elements and syntactic attributes of residential location

Pearson Product-Moment

	Compre	INT	CON	CT R	INT(3)	INT-veh	Int(3)-v...	DEP-most	Depth-	Depth-	Depth-FR
Comprehe	1 000										
INT	-0 153	1 000									
CON	-0 065	0 480	1 000								
CT R	-0 038	0 379	0 881	1 000							
INT(3)	-0 126	0 586	0 945	0 790	1 000						
INT-veh	-0 081	0 966	0 485	0 375	0 593	1 000					
Int(3)-veh	-0 038	0 582	0 881	0 724	0 913	0 641	1 000				
DEP-most	0 123	0 825	-0 294	-0 222	-0 392	-0 745	-0 340	1 000			
Depth-	-0 105	0 144	-0 268	-0 161	0 321	0 057	-0 329	-0 359	1 000		
Depth-peri	0 135	-0 846	-0 307	-0 235	0 404	-0 770	-0 349	0 996	-0 334	1 000	
Depth-FR	0 141	-0 470	0 317	-0 260	0 364	-0 403	0 251	0 647	0 044	0 667	1 000

Table 6.5 Correlation between sketch map measures and syntactic variables

(a) Sub sample A

Pearson Product-Moment Correlation

No Selector

	Neigh-A...	Compre...	INT	INT(3)	INT-veh	Int(3)-v...	DEP-most	Depth-CS	Depth-p...	Depth-FR
Neigh-Area	1 000									
Comprehen	0 224	1 000								
INT	0 223	0 045	1 000							
INT(3)	0 099	-0 012	0 658	1 000						
INT-veh	0 194	0 060	0 992	0 654	1 000					
Int(3)-veh	-0.054	-0.003	0.693	0 930	0.718	1.000				
DEP-most	-0.150	-0 074	-0.817	-0 563	-0.801	-0.549	1.000			
Depth-CS	0 068	-0.277	0 147	-0 216	0.131	-0 232	-0 064	1.000		
Depth-peri	-0 150	-0 074	-0 817	-0.563	-0 801	-0.549	1 000	-0 064	1.000	
Depth-FR	0 231	0 040	0 038	-0 458	0 046	-0 383	0 132	0 525	0 132	1 000

(b) Sub sample B

Pearson Product-Moment Correlation

No Selector

	Neigh-A...	Compre...	INT	INT(3)	INT-veh	Int(3)-v...	Depth-CS	Depth-p...	Depth-FR	DEP-most
Neigh-Area	1 000									
Comprehen	0 019	1 000								
INT	-0 222	-0 266	1 000							
INT(3)	-0 302	-0 264	0 593	1 000						
INT-veh	-0 166	-0 184	0 965	0 580	1 000					
Int(3)-veh	-0 264	-0 121	0 590	0 900	0 638	1 000				
Depth-CS	0 017	0 148	0 107	-0 391	0 031	-0 342	1 000			
Depth-peri	0.210	0 189	-0.920	-0 476	-0 858	-0 452	-0 329	1 000		
Depth-FR	0 002	0 119	-0 651	-0 474	-0 600	-0 381	-0 100	0 749	1 000	
DEP-most	0 193	0 167	-0 896	-0 460	-0 830	-0 444	-0 373	0 994	0 715	1 000

This finding fails to support the hypothesis of this section. The syntactic attributes of an individual's residential location appear not to be associated with perceived neighbourhood size and the extent of spatial knowledge in terms of the number of features that are identified on sketch maps. It would seem that the impact of the syntactic attributes of residential location does not associate directly with perception and cognition.

The relationship between the two variables is tested further according to the intelligibility of an area in which a subject resides. Subjects are split into two sub-samples: subjects in the intelligible area (sample B), and subjects in the unintelligible area (sample A). The conjecture is that if people live in the intelligible part of the area, a better association between the syntactic attributes of their location and the cognitive maps might be expected.

Table 6.5(a) and (b) show the correlations between neighbourhood size and the number of comprehensible elements, and the syntactic attributes of residential location. In sample B, it is interesting to see that the coefficient between local integration and neighbourhood size and local integration and the number of comprehensible elements is at -0.302 (p<0.0001) and -0.264 (p<0.0001) respectively. Similarly, the coefficient between global integration and the two cognitive variables are at -0.222 (p= 0.0304) and -0.267 (p<0.0001) respectively. This may suggest that if an individual resides in a globally or locally integrated area and at the same time in an intelligible neighbourhood, he or she tends to perceive a smaller neighbourhood and to depict a smaller number of spatial elements. However, it is difficult to find any association for the subjects in the unintelligible area.

Generally, the tables show no significant difference in the relationship between the two groups. This confirms again that the hypothesis is not supported by the findings. The perceived size of neighbourhood and the number of comprehensible elements is not associated with syntactic attributes of subjects' residential location. Although a negative relationship is detected, it is weak and needs further examination.

In conclusion, the syntactic attributes of an individual's location do not affect the size of the perceived neighbourhood or the number of comprehensible elements on an individual's sketch map. Similarly, the intelligibility of an individual's immediate neighbourhood appear not to affect the relationship.

6.4 Spatial configuration in cognitive maps

This section attempts to describe the characteristics of internalised spatial configuration as represented on sketch maps by applying syntactic analysis to them.

All 73 sketch maps were digitised and axial analysis was carried out to measure their syntactic characteristics as discussed in section 3.2.3. Appendix-D shows the mean syntactic characteristics of subjects's sketch maps, including intelligibility, which is calculated by the correlation between global integration and local integration.

6.4.1 The recognition of spatial configuration

Once the syntactic analysis of the sketch maps was done the syntactic characteristics of the two groups: people living in the intelligible area and in the unintelligible area, were compared, to examine the effect of intelligibility on the internalised spatial configuration. It is hypothesised that an individual who lives in the intelligible part of an area might represent spatial layout of a whole area with higher intelligibility than people in the unintelligible area. In other words, intelligibility may lead to differences in cognitive representation of spatial configuration.

The mean syntactic characteristics of the sketch maps between the two groups are compared. They are calculated from the whole sample in Appendix-C. Table 6.6

compares the syntactic characteristics of the sketch maps between the two groups. The average amount of spaces depicted on the sketch maps is 23.9 and 25.4 in sample A and B respectively. The t-test confirms no significant difference between the two groups (α level = 0.05, p = 0.708). It suggests that there is no significant difference in the number of spatial features drawn on the sketch maps in terms of the intelligibility of people's residential location.

Table 6.6 Comparison of syntactic characteristics between the two samples

Subareas	No. of spaces	Connec-tivity	local Integra-tion	Depth	global Integ-ration	Intelligi-bility (I-C)	Intelligi-bility (I-Int3)
Sub sample A (an unintelligible area)	23.9	2.496	1.489	3.36	0.94	0.74	0.769
Sub sample B (an intelligible area)	25.4	2.587	1.532	3.067	1.093	0.812	0.866
T-test *p* value of two groups	0.708	0.414	0.526	0.063	0.012	0.01	0.0008

* Alpha level of t-test is 0.050
* Depth is measured from the most integrated space

The connectivity of the sketches of sample A and B are 2.496 and 2.587 respectively. The t-test failed to prove any significant difference in the mean connectivity of the two samples' sketch maps (p = 0.414, α level = 0.05). However, sketches by people in the intelligible area are generally better connected than those of people in the unintelligible area. Similarly, local integration shows no statistical difference between the two samples. The average local integration of sketch maps of sample A and B are 1.489 and 1.532 respectively. The t-test shows no difference between the two sub-samples (t-test p = 0.526, α level = 0.05). The configurational elements of sketch maps from the intelligible area are slightly more integrated locally, however, as revealed by the t-test, the difference is not at a significant level.

As for depth from the most integrated space on the sketch maps, sample A is 3.36 and sample B is 3.067. The t-test shows again no statistical difference between the two sub-samples (p = 0.063, α level = 0.05). This suggests that both samples depict a similar depth from the most integrated space in their cognitive maps. However, it appears that the sketch maps of sample B have a shallower depth than those of sample A.

The global integration of sketch maps represents how configurational elements on the sketches are interrelated with each other. The mean global integration of sample A is 0.94, and that of sample B is 1.093, as shown in Table 6.6. The t-test shows a significant difference between the two groups ($p = 0.012$, α level = 0.05). The sketch maps of subjects in the intelligible area are more integrated globally than those of subjects in the unintelligible area. This suggests that the intelligibility of an area in which people reside positively affects their representation of spatial configuration. In other words, the ability to relate the street layout in sketch maps is differentiated by intelligibility even though the amount of sketched elements remains the same.

A subsequent question is how configurational elements are interrelated with each other. In other words, how spatial configuration is represented in sketch maps, and whether it is affected by the morphological intelligibility of an individual's neighbourhood. It is hypothesised that if people live in the intelligible part of an area, then his or her configurational knowledge of the whole area becomes more intelligible.

The intelligibility of the internalised configuration can be measured by the correlation analysis of the syntactic properties of the sketch maps. The intelligibility of the sketch is measured in two ways: firstly, by the correlation between global integration and connectivity; and secondly, by the correlation between global integration and local integration. As can be seen from Table 6.6, the intelligibility of sample A is 0.74 and 0.812, and that of sample B is 0.769 and 0.866 respectively. This suggests that the sketch maps of sample B are more intelligible than those of sample A in terms of both measures. The t-test confirms the significant difference between the two samples at α level 0.05; the t-test p values of the samples are 0.01 and 0.0008 respectively. This result suggests that there is a fundamental difference in the way spatial configuration is understood and represented according to the intelligibility of an individual's immediate environment. An individual who resides in the more intelligible area within the global context, has a more intelligible sketch map of the whole area than those residents in the unintelligible area.

This finding might raise the question of how the two samples have sketched the Suburb, since they might concentrate on their immediate neighbourhood. When conducting the survey, respondents were reminded to draw the whole Suburb, not just their immediate area. However, in order to check whether they carried out the task as instructed, sketched features of the two samples are compared to see if there is any difference between them.

Table 6.7 shows the most often mentioned 25 spaces in the two groups respectively. From the table two points can be outlined. First, most of the spaces, 20 out of 25, are drawn commonly in both samples. The spaces do not appear on both groups' sketch maps are either minor through roads located in deep parts of the area, such as Willifield Way, Asmuns Hill and Temple Fortune Hill, or located in the periphery with low local integration values, such as North End Rd (0.6394). The spaces, which have low frequency of appearance or do not appear in both samples, are often immediate neighbouring spaces of subjects' residential location. Second, the order of appearance of spaces in the two groups is similar, especially for the most often mentioned spaces. For example, Finchley Road, Hoop Lane, Meadway and A1 are most often drawn in both groups' sketch maps. These findings suggest that, although the two groups are situated in different geographical locations they both drew similar spaces in their sketch maps.

This seems to support the main findings of this section that the cognitive maps of people living in the intelligible part of an area are more integrated globally and more intelligible than those of people in the unintelligible part even though they depict statistically a similar number of spatial features. In other words, the amount of information on the sketches is quite similar, but the way of organising them is quite different. This suggests that the way in which and degree to which different parts of the built environment are related in the mind differs according to the intelligibility of an individual's immediate neighbourhood. Given this, it can be concluded that a psychological 'detector' of spatial configuration in the human mind is affected not only by the layout of buildings and open spaces within their global context, but also by the intelligibility of his or her immediate environment. It would seem that global integration and intelligibility could be fundamental factors, relating to legibility.

Table 6.7 The most often depicted spaces in sketch maps

Spaces depicted in both samples	Sample A street	Sample A frequency	Sample B street	Sample B frequency
√	Finchley Road	34	Finchley Road	33
√	Hoop Lane	26	A1	29
√	Meadway	23	Hoop Lane	29
√	Hampstead Way	23	Meadway	28
√	A1	20	Kingsley Way	24
	Willifield Way	19	Northway	21
√	Temple Fortune Lane	18	The Bishops Avenue	18
√	Erskin Hill	18	Hampstead Way	17
√	Northway	16	Central Square	16
√	Hampstead Way-1	15	Heathgate	15
√	Central Square	14	Southway	14
√	N Circular Rd	13	Temple Fortune Lane	13
√	Heathgate	12	Bigwood Road	13
	Oakwood Road	11	Winnington Road	12
√	The Bishops Avenue	9	Litchfield Way	12
√	Addison Way	9	Middle Way	12
	North End Rd	9	South Square	12
√	Kingsley Way	8	Wildwood Road	12
√	South Square	8	Erskin Hill	11
√	Wildwood Road	8	Holne Chase	11
√	North Square	8	Thornton Way	10
	Temple Fortune Hill	8	Hampstead Way-1	9
	Asmuns Hill	8	North Square	9
√	Middleway	6	Ossulton Way	9
√	Southway	5	N Circular Rd	8

6.4.2 The most integrated space on sketch maps

This section describes the relationship between the syntactic characteristics of the most integrated spaces on the sketch maps and the characteristics of these spaces in the real map and in cognitive maps. The most integrated spaces in cognitive maps are identified by syntactic analyses of the 73 sketch maps. The number of times each space appears as the most integrated space is counted. This frequency is compared with their syntactic characteristics in the real map.

Table 6.8 shows the frequency distribution of most integrated spaces in each sketch map and their syntactic values. It can be seen from the table that Meadway is described as the most integrated 39 times, out of 73 sketches. Finchley Road and the A1 follow at 17 and 15 times respectively. Hoop Lane is next at 12, and others are counted less than 3 times.

Figure 6.2 shows the syntactic characteristics of these top 4 spaces and their frequency of appearance. The scatters illustrate all the spaces in the Suburb with global integration on the horizontal axis and local integration on the vertical axis. Meadway is represented as 'o' , and the others are marked as 'x'. The scatter shows that all marked spaces are highly integrated globally and locally. This suggests that if a space is integrated both globally and locally in reality it tends to be the most integrated space in respondents' cognitive maps as well.

Figure 6.3 shows the relationship of frequency with global integration and local integration. The figure confirms again the positive relationship between the variables. For local integration, all the spaces are highly integrated, but in their global integration, the boundaries of the Suburb, which are marked as 'x', have the highest value. However, they are segregated from the rest of the group. By excluding them, Meadway is the highest in local integration, and this becomes the most integrated space in cognitive maps as well. It can be inferred that local integration may be a more influential factor in cognitive representation.

Table 6.8 The most integrated space in sketch maps

Spaces	Frequency	global integration of real map	local integration of real map
Meadway	39 (41)	0.863	3.674
Finchley Rd	17 (18)	1.058	4.425
A1	15 (16)	1.048	4.26
Hoop Lane	12 (13)	0.953	2.6
Addison	2 (2)	0.944	2.621
Erskin Hill	2 (2)	0.803	2.466
Hampstead Way	2 (2)	0.83	2.653
Kingsley Way	2 (2)	0.889	2.948
Willifield Way	2 (2)	0.812	2.377
Heathgate	1 (1)	0.821	2.406
Litchfieldway	1 (1)	0.825	2.845

* ( ) is the percentage of frequency which is drawn as the most integrated space in the area by respondents.

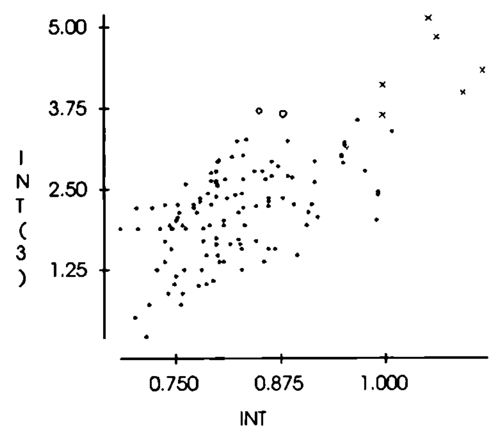


Figure 6.2 The most integrated spaces in human mind and syntactic property in reality (Meadway (o): 2 segments; Finchley Road (x): 3 segments; A1 (x): 3 segments; Hoop Lane (x): 1 segments)

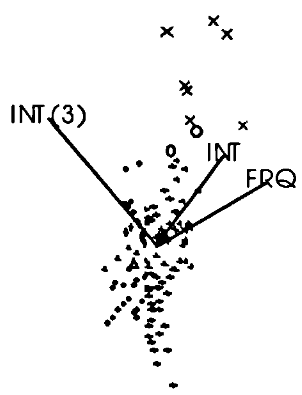


Figure 6.3 The relationship between global integration in reality, local integration (3) in reality and the frequency in sketch maps

Figure 6.4 shows the top 4 most integrated spaces by the dotplot, which illustrates the number of times each element is depicted on the sketches. The plot shows that these 4 spaces are also at the highest level in the frequency of all elements. This means that frequency of appearance is another good indicator of the most integrated space in the cognitive map.

From these findings it is tempting to suggest that local integration is a good indicator of the most integrated space in the cognitive map. In other words, the most locally integrated space is likely to be the most integrated in the sketch map. The number of times a space is depicted on sketch map is another indicator of the degree of integration in the sketch maps. These findings suggest a strong relationship between spatial configuration in the physical world and the internalised representation of spatial configuration depicted in sketch maps. This is explored in the next section.

6.5 Spatial configuration in reality and in the human mind

This section attempts to understand how people recognise spatial configuration by comparing syntactic characteristics of the Suburb with those of the image in the cognitive map.

For the sake of the argument, the syntactic properties of the Suburb were calculated in three different ways: firstly, the Suburb within its global context; secondly, the Suburb only without surroundings; and thirdly, only the 25 spaces, which are depicted most often on the sketch maps. The sketches consist of an average of 25 spaces, hence the top 25 spaces in the sketch maps were picked out in the real world for the comparison. These are then subjected to axial analysis.

Table 6.9 shows the syntactic characteristics of the Suburb in the real world and in the sketch maps. As can be seen from the table, the connectivity and local integration of the real world is generally higher than the sketch maps, but local integration has a similar value. This suggests that people can not recall all the

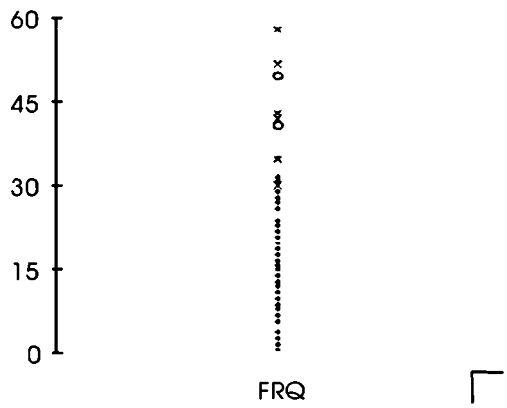


Figure 6.4 The frequency of the most integrated spaces on sketch maps

Table 6.9 Syntactic characteristics in the physical world and in the human mind

Spatial configuration	Connectiv- -ity	Integrat- -ion(3)	Intelig- -ibility	Integrat- -ion
Spatial configuration in reality				
- global context	3.045	1.849	0.366	0.788
- The Suburb only	3.105	1.842	0.693	0.899
- top 25 frequency spaces	2.462	1.478	0.864	0.908
Spatial configuration in human mind	2.541	1.51	0.775	1.016

spatial elements in the same priority, but as already revealed in section 6.4, they recognise a space according to its local integration. As a result, some minor spaces with low local integrations are not drawn on the sketches, thus connectivity and local integration have a lower value than in reality. However, configuration in the sketch maps is locally more integrated than that of the top 25 spaces in the map.

The table shows that the sketch maps are generally more intelligible than reality, excluding the map of the only 25 spaces. The average intelligibility of the sketch maps is 0.775, and those of the Suburb, the Suburb calculated without surrounding areas and the 25 spaces are 0.366, 0.693 and 0.864 respectively.

For global integration, the sketch maps are more integrated than any other system at 1.016 compared to those of the various real systems at 0.788, 0.899 and 0.908 respectively. Configurational elements in the sketch maps are well integrated globally compared to reality. This suggests that people acquire and represent configurational knowledge in a more integrated way than in terms of spatial configurations in the physical world.

6.6 The relationship between frequency in sketch maps and syntactic properties in the real map

What configurational characteristics enable us to recognise spaces easily is largely unknown. The possible relationship between spatial configuration and its cognitive representation has not been studied empirically. In order to explore the possible association between spatial configuration and spatial cognition, this section investigates the relationship between information on the sketch maps and the syntactic characteristics of spaces in the real world.

Two kinds of information from the sketch maps are identified. One refers to the frequency, which is a conventional way of analysing sketch maps by counting the total number of times each spatial element is depicted. The other are the syntactic characteristics of configurational knowledge in the sketches. Subjects' sketches consist of streets and landmarks. For analysis, they are analysed separately, since they are not the same kind of entity.

6.6.1 Frequency of appearance of features in sketches and syntactic variables in reality

Appendix-E shows all the spaces identified on the sketch maps, with the information on their frequency of appearance and their syntactic values. Table 6.10 shows the correlation analysis between frequency and the syntactic variables from both the pedestrian and vehicular axial analyses. The table shows that frequency is generally well associated with the syntactic characteristics. The pedestrian model shows a slightly better relationship with the frequency than the vehicle model.

Table 6.10 Comparison of correlation between two axial maps

		Frequency
Pedestrian model		
	global integration	0.456
	local integration(radius-3)	0.708
Vehicular model		
	global integration	0.456
	local integration(radius-3)	0.703

Figure 6.5 is a scattergram of the relationship between local integration and frequency. Scattergram shows that there is a strong association ($r= 0.707$, $p\leq 0.0001$, *df*: 119). Most spaces that appear with lower frequencies are cul-de-sacs and footpaths, which are represented as 'x' in the scatter. This suggests that they are not referenced by many people. These spaces become outliers that behave differently compared to the main body of the data. The scatter is messy at the bottom, but generally the positive relationship between the two variables can be clearly seen.

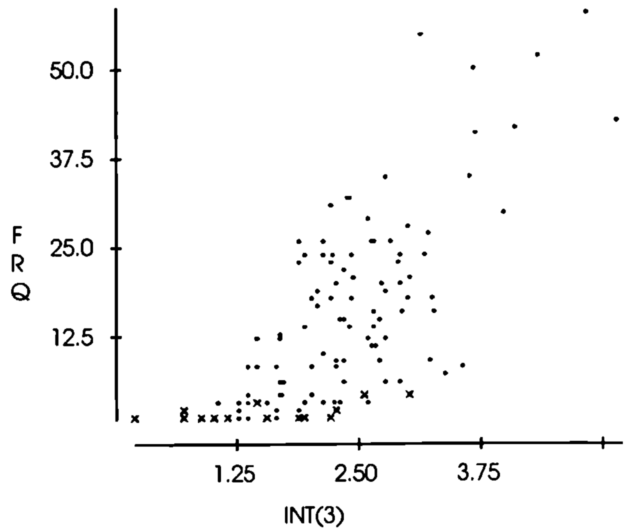


Figure 6.5 Frequency and local integration

Figure 6.6 illustrates the frequency of each space on the axial map coloured from red for the highest, through orange, yellow, blue and purple for the lowest. The figure picks up the A1 and Finchley Road as red and Meadway as orange and several blue and purple groups. The pattern of colour distribution is similar to the local integration map of the Suburb, shown in Figure 4.19(a). This suggests that the frequency of appearance is highly associated with local integration. It confirms that the more a space is locally integrated the more often it is depicted on sketch maps.

Table 6.11 shows the correlation analysis between the frequency and the syntactic variables in the pedestrian axial map. As can be seen from the table all syntactic variables are well correlated with frequency. Among them, local integration shows the best correlation with frequency at $r = 0.707$. The regression analysis has an r-squared value of 0.50 ($p<0.0001$) as shown in Figure 6.6. This suggests that if a space is locally integrated it tends to be depicted in sketches more often.

In conclusion, local integration appears to be a good indicator in explaining the relationship between spatial configuration in reality and in the mind.

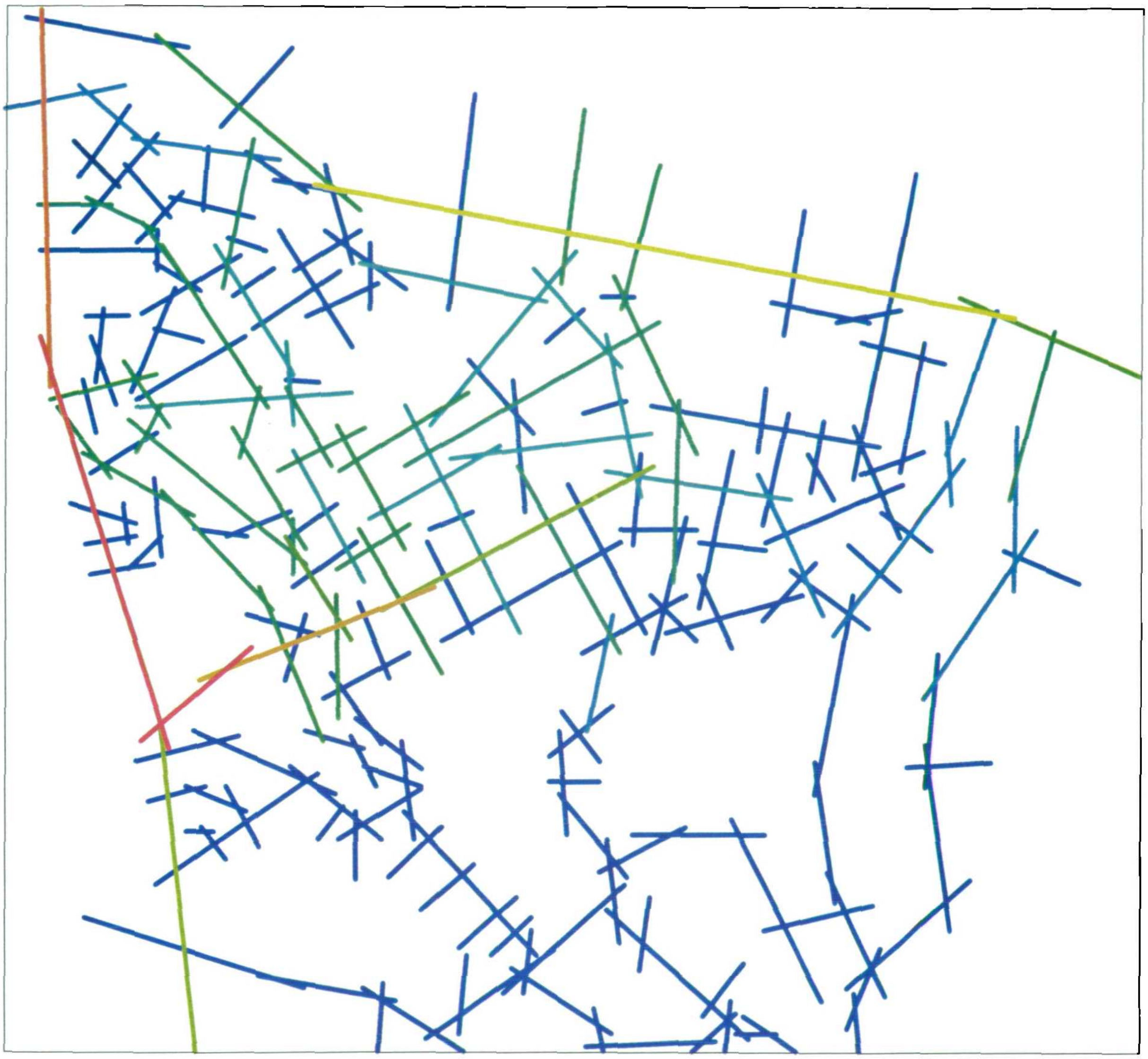


Figure 6.6 The frequency of appearance of each space on sketch maps

Table 6.11 The correlation between frequency and syntactic characteristics of the pedestrian axial map

Pearson Product-Moment	FRQ	INT	CON	CTR	INT(3)	DEP-CS	Dep-peri	Depth-F...	Depth-
FRQ	1.000								
INT	0.450	1.000							
CON	0.652	0.604	1.000						
CTR	0.596	0.539	0.924	1.000					
INT(3)	0.707	0.693	0.892	0.773	1.000				
DEP-CS	-0.344	0.213	-0.134	-0.046	-0.225	1.000			
Dep-peri	-0.380	-0.844	-0.480	-0.444	-0.496	-0.339	1.000		
Depth-Finchley	-0.477	-0.501	-0.382	-0.331	-0.439	-0.056	0.612	1.000	
Depth-	-0.467	-0.486	-0.444	-0.411	-0.433	-0.073	0.700	0.894	1.000

(FRQ: frequency; INT: global integration; INT(3): local integration; DEP-CS: depth from the Central Square; Dep-peri: depth from peripheries; Depth-: depth from the most integrated space)

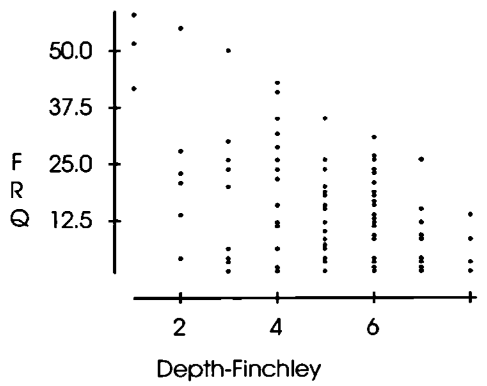


Figure 6.7 Frequency and depth

Depth is calculated from these three main movement generators in the pedestrian model: firstly, from the Finchley Road, the most integrated space where the main local shopping area is; secondly, from the two peripheral carrier spaces of the Suburb, the A1 and Finchley Road; and thirdly, from Golders Green Station. There is a negative relationship between frequency and depth (Table 6.11). The depth from Finchley Road has the best correlation at $r = -0.48$ ($p<0.001$). Figure 6.7 shows the scatter plot of depth horizontally and frequency vertically. The scatter confirms the negative relationship. It is interesting to see that the maximum frequency at each level of depth is limited by the increment of depth from the carrier space. It can be concluded that the greater the depth from main streets in the area, the lower the frequency. This suggests that if a space is located at a greater depth from a main local space, it is less likely to be cognised by the human mind.

In conclusion, it can be said that the frequency with which a space is identified on the sketch maps is highly associated with all syntactic values - global integration, connectivity, control, local integration and depth from the main spaces in an area. Local integration is the best indicator of the association between spatial configuration and cognitive representations. This suggests that spatial configuration positively affects the acquisition of configurational knowledge.

6.6.2 The impact of intelligibility on the association

The next step is to investigate whether intelligibility positively or negatively affects the revealed association between the frequency of sketched elements and their syntactic properties in the real map. Considering the findings of the previous section, it is hypothesised that a positive relationship between the intelligibility of an area and the acquisition of spatial knowledge exists.

Table 6.12 Comparison of the association of frequency with syntactic variables between the two groups

		sub sample A (an unintelligible area)	sub sample B (an intelligible area)
global integration			
	r	0.331	0.501
	r squared	0.11	0.251
	p	0.0008	≤0.0001
local integration			
	r	0.61	0.696
	r squared	0.372	0.484
	p	≤0.0001	≤0.0001

The frequency of each space on the sketch maps is counted separately for the two samples, and these are subjected to correlation and regression analysis on the syntactic variables. Table 6.12 shows the results. For global integration, sample B in the intelligible part of the area shows a stronger correlation at r = 0.501 than sample A at 0.331. This is same in the relationship with local integration as well. Sample B shows a better relationship at r = 0.696 than the other's at r = 0.61. It can be concluded that sample B, who live in an intelligible part of the area, show a stronger association between the frequency and the syntactic variables than sample A who reside in the unintelligible area.

It can be inferred from these findings that if an individual lives in an intelligible area, he or she can acquire and represent configurational knowledge much more easily than an individual in an unintelligible area. The intelligibility of spatial configuration appears to be a salient intervening variable in acquiring spatial knowledge.

6.7 Syntactic characteristics in the mind and in reality

The question addressed in this part of the study is whether there is an association between the spatial configuration in reality and in cognitive maps, and if so, how intelligibility influences the association.

6.7.1 The relationship between syntactic properties in reality and in sketch maps

The relationship is investigated by a series of correlation and regression analyses between the two kinds of spatial configuration in reality and in the sketch maps. In order to perform this investigation, the translation of syntactic variables in sketch maps to axial map of the real world has been done by calculating mean syntactic values from 73 sketch maps as described in section 3.3.

Appendix-E shows the mean syntactic variables of all the spaces drawn on the sketch maps, and these are further split into two sub-samples, A and B. Table 6.13 shows the correlation coefficients and regression analyses between global integration and global integration, global integration and local integration, and local integration and local integration, of the real world and the sketch maps respectively.

Table 6.13 The association between spatial configuration in reality and in sketch maps

	r	r -squared	*p*
global integration of sketch maps : global integration of real map	0.486	0.236	≤0.0001
global integration of sketch maps : local integration of real map	0.648	0.42	≤0.0001
local integration of sketch maps : global integration of real map	0.7	0.49	≤0.0001
local integration of sketch maps: local integration of real map	0.728	0.53	≤0.0001

*df: 118

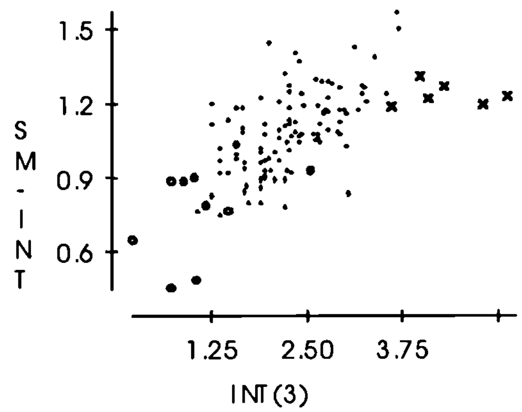


Figure 6.8 Scattergram between local integration of reality and global integration of sketches (**x**: periphery; **o**: cul-de-sac)

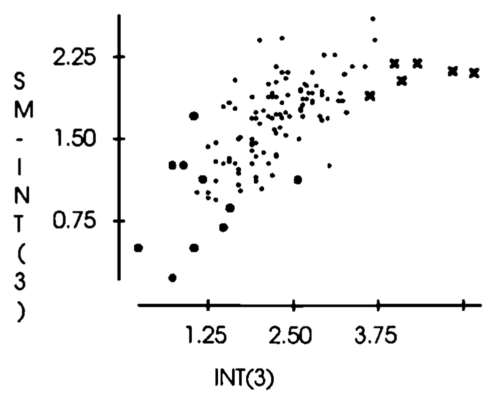


Figure 6.9 Scattergram between local integration of reality and local integration of sketches (**x**: periphery; **o**: cul-de-sac)

As can be seen from the table, global integration in the sketch map and local integration in reality are well correlated at r = 0.648. Similarly, the coefficient between local integration in the sketch map and local integration in reality is also high at r = 0.7. This suggests that there exists a positive relationship between spatial configuration in reality and its cognitive representation. The local integration of reality shows a slightly better correlation with local integration of sketches than global integration. It is, once again, the best predictor in the relationship between spatial configuration in the real world and the internalised configuration in sketch maps, confirming the finding in section 6.6 that local integration is most closely related to the frequency of features drawn on the sketches. This suggests that local integration is strongly related not only with simple information referring to appearance in sketch maps, but with the complex information referring to configurational knowledge.

This relationship is further examined by the regression analysis. Figure 6.8 and 6.9 show the scatterplot of spatial configuration in reality horizontally and of that in sketch maps vertically. Figure 6.8 shows the association between the local integration of reality and the global integration of the sketch maps. The regression gives an r-squared of 0.42 ($p \leq 0.0001$). Figure 6.9 illustrates the scatter of local integration in reality to local integration in the sketch maps, showing a tighter and better relationship than Figure 6.8 (r-squared of 0.49, $p \leq 0.0001$). From the two figures it can be concluded that there is a clear pattern of the association between syntactic values in reality, and those of cognitive maps, confirming local integration as a good predictor of cognitive representations of spatial configuration.

A close examination of the scatters reveals two outlier groups, one in the upper right part represented as an 'x', and another in the lower left marked as 'o'. The first outlier group is the boundary of the Suburb, and the second group is the cul-de-sacs. These spaces are removed from the main body of the scatters. These outliers are seen again in the scatter between local integration of the real world and local integration of the sketches in Figure 6.9. As can be seen from the two figures, the boundaries have a high local integration value, but these spaces are not recognised that much on the sketch maps. Conversely, cul-de-sacs are characterised not only by low local integration in reality but also by their low frequency of appearance on the sketches. Without these outliers we have a slightly tighter and better scatter. Table 6.14 shows the correlation coefficient and r-squared value without the boundaries of the area. The table shows that the r-squared values are increased from 0.49 to 0.51 without these spaces.

Table 6.14 Regression analysis in terms of the characteristics of spaces
(local integration: local integration in mind)

	r	r squared	*p*
All spaces	0.7	0.49	≤0.0001
Spaces without periphery	0.714	0.51	≤0.0001

Several points can be drawn from the relationship between the spatial configuration of the real world and its cognitive representation. Firstly, a positive relationship exists between the spatial configuration of reality and its cognitive representation. Secondly, local integration, the syntactic property that comes from the immediate environment, shows the best relationship with the sketch map variables. Finally, boundaries and cul-de-sacs form outlier groups in these relationships.

6.7.2 The impact of intelligibility on the association

The next question is on to the role of intelligibility on the associations identified. By answering this question, we can understand what spatial arrangements positively or negatively affect the acquisition of spatial knowledge, and how they characterise the spatial configuration of cognitive maps.

It is hypothesised that the intelligibility of subjects' neighbourhoods may have a positive effect on the association. In this context, the hypothesis also proposes that the internalised configurations of people living in the intelligible area will be better associated with reality than that of people in the unintelligible area.

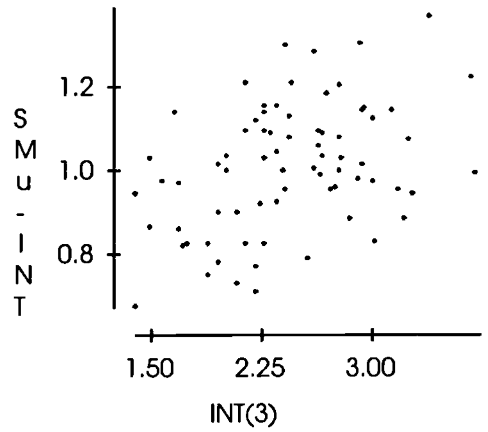
This hypothesis is tested by comparison of the association between two groups. Based on Appendix-D, the syntactic characteristics of the two groups were computed separately. Then correlation and regression analyses were carried out for the two samples independently, between global integration and local integration, and local integration and local integration, of the real map and of the sketch maps.

Table 6.15 The effect of intelligibility on the association of spatial configuration in reality and in sketch maps

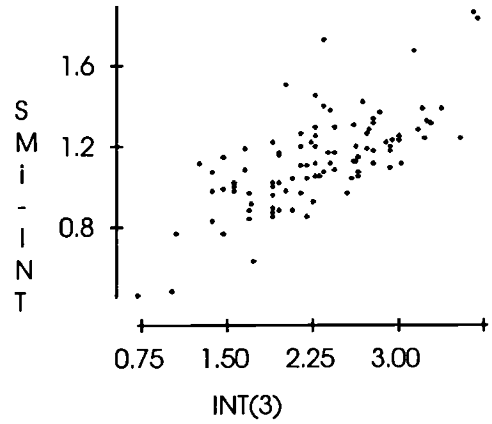
	sub sample A (unintelligible area)	sub sample B (intelligible area)
global integration of sketch maps : local integration of real map		
r	0.407	0.706
r squared	0.165	0.498
p	≤0.0001	≤0.0001
local integration of sketch maps : local integration of real map		
r	0.516	0.689
r squared	0.267	0.475
p	≤0.0001	≤0.0001

Table 6.15 shows correlation coefficients and r-squared values of the two samples. In the relationship between global integration of the sketches and the local integration of reality, there is a big difference between the two samples. The correlation coefficient is 0.706 ($p \leq 0.0001$) in sample B, whilst the correlation is relatively weak at 0.407 ($p \leq 0.0001$) in sample A. The scattergrams show this difference more clearly (Figure 6.10 (a)(b)). The figures show that there is a tighter, more linear relationship in the scatter of sample B, which is even stronger than all other samples' scatters, as shown in Figure 6.8 and 6.9. On the other hand, the regression is not as successful in the scatter of sample A, which does not show any particular pattern in the relationship.

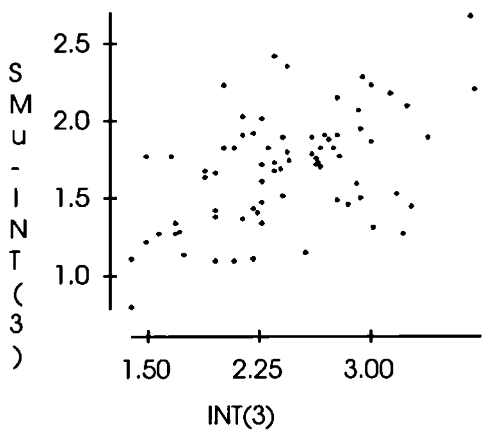
In the case of the relationship between local integration in the real map and local integration in the cognitive maps, the comparison of the association between the two samples reveals that sample B is higher at r-squared = 0.475 ($p \leq 0.0001$) than sample A of r-squared = 0.267 ($p \leq 0.0001$). Figure 6.10(c),(d) shows the scatters



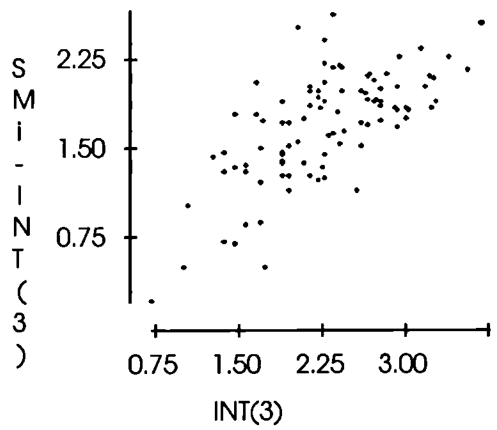
(a) global integration of sketch maps vs. local integration of reality - an unintelligible area



(b) global integration of sketch maps vs. local integration of reality - an intelligible area



(c) local integration of sketch maps vs. local integration of reality - an unintelligible area



(d) local integration of sketch maps vs. local integration of reality - an intelligible area

Figure 6.10 The effect of intelligibility on the association between spatial configuration in reality and in the human mind between the two samples. The figures confirm the difference of associations between the two samples by showing that sample B has a much tighter and more linear scatter than sample A, which indicates a better relationship between spatial configuration and spatial cognition for the people living in the intelligible area.

All the findings suggest that there is a positive impact of intelligibility on the relationship between spatial configuration in the real world and in the human mind. This means that intelligibility enables people to exploit the information present in spatial configuration in order to acquire configurational knowledge. Thus cognition can derive much more information from the built environment if an area is intelligible.

6.8 Conclusion and implications

This chapter has aimed to investigate the relationship between spatial configuration and spatial cognition. The findings show statistically significant effects of spatial arrangement on spatial cognition. The configurational knowledge in sketch maps is associated with spatial configuration in the physical world. Of all the syntactic variables, local integration is the best predictor of relationships between them. The intelligibility of people's neighbourhood is an intervening variable that promotes this association. Thus the relationship gets stronger in intelligible areas compared to unintelligible areas.

With respect to configurational characteristics, a strong correlation is found between sketch maps in human mind and spatial patterns in the real world. No account has been taken of the location of attractors or landmarks in constructing this relationship. The cognition of spatial configuration appears to result naturally from the way that the spatial configuration of the physical world is ordered.

Based on these findings it is tempting to suggest that if the mind has difficulty in figuring out the spatial layout of an area, it may be due to a broken relationship between global integration and local integration in the real world. In other words, if the relationship between global integration and local integration has broken down, as in an unintelligible area, then the acquisition of spatial knowledge of global and local information of an area might also be difficult due to this broken relationship.

In conclusion, these findings are of theoretical importance in the understanding of the relationship between spatial configuration and spatial cognition These seems to be important findings for the design and planning of spatial patterns practically. They also provide strong empirical support for hypotheses, referring to the impact of spatial configuration at a human psychological level, as raised by the syntactic approach in built environment studies.

Chapter Seven

SPATIAL CONFIGURATION AND SPATIAL BEHAVIOUR

7.1 Introduction

Movement usually takes place over paths in the environment. Obvious questions arise: which paths are chosen for action within the existing street layout; why some paths become more frequently used than others; what is the relationship between the spatial characteristics of an area and the patterns of movement within it. This chapter attempts to answer these questions by investigating the relationship of spatial configuration described in chapter four with the observed movement distribution.

Thus this chapter aims at: firstly, determining whether or not there exist any consistent patterns of movement related to the spatial layout in this purely residential neighbourhood; and secondly, if so, how far the relationship is characterised by the intelligibility of an area.

Observation was carried out to gather empirical data on the patterns of space usage. These data were then analysed to see whether movement and configuration were related. This task was accomplished by a series of correlation and regression analyses between the syntactic properties of spatial configuration and the observed movement density. The sample was analysed as a whole, and then as two sub-samples: the intelligible part of the Suburb and the unintelligible part were analysed separately. The pattern of the relationship is compared between the two samples to reveal any differences. On this basis, we can determine whether intelligibility has a consistent and predictable impact on the degree of association between spatial configuration and movement patterns. This chapter tests the hypothesis that intelligibility may be an intervening variable at a psychological level in this relationship.

7.2 Patterns of space usage

7.2.1 The distribution of movement flow

The distribution of movement density in relation to the time of day is shown in Appendix-E, which includes the syntactic properties of all the gates. Figures 7.1 and 7.2 illustrate the mean all-day flow rates in pedestrian and vehicles per hour in all observed street segments in the Suburb. The all day mean hourly flow is noted on each segment of an axial map. The figure above the dot indicates pedestrian/vehicular movements along that line through an imaginary 'gate'. Figures 7.3 and 7.4 illustrate mean pedestrian and vehicular hourly movement segment by segment, in descending order from red for the highest rates to purple for the lowest rates.

The figures show that Temple Fortune Lane, Northway, Hampstead Way and Kingsley Way are the main focus of pedestrian movement, and Meadway, Kingsley and Hoop Lane are the main spaces for vehicular flows. There is, however, a remarkable contrast in the distribution of average pedestrian and vehicle movements. For pedestrian movement, the spaces mentioned above are connecting spaces to the periphery where local shopping facilities are; Temple Fortune Lane and Hampstead Way to Finchley Road, and Northway and Kingsley Way to the Market Place (A1). Most of the spaces with dense pedestrian movements are distributed around secondary spaces which are immediately adjacent to the periphery. In comparison, the highest vehicular movement is in Meadway, Kingsley Way and Hoop lane, which are the major through streets, linking west to east, Finchley Road to the A1 as shown in Figure 7.4. Vehicular movement clearly picks out the spinal spaces of the Suburb, which is concentrated in the centre of the area independent of its periphery.

Table 7.1 shows the distribution of pedestrian and vehicular movement. The mean pedestrian movement rate is very low at 1.7 people per hour, and vehicular movement rate at 11.3 per hour. The total movement is 13 per hour. The variations in vehicular movement through time are much greater than those of pedestrian movement in the table.

Figure 7.1 Average number of pedestrians per hour for all periods

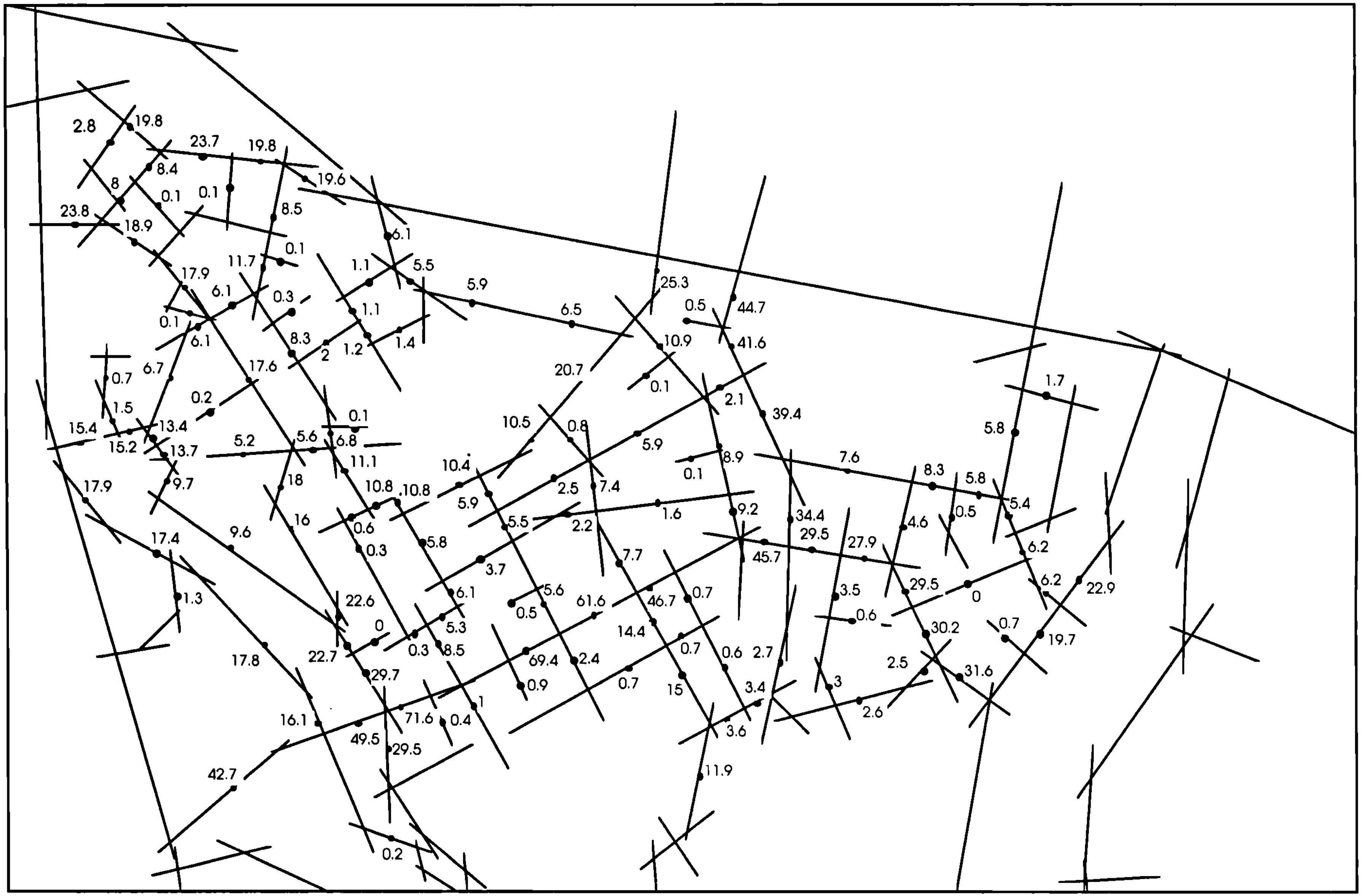


Figure 7.2 Average number of vehicles per hour for all periods

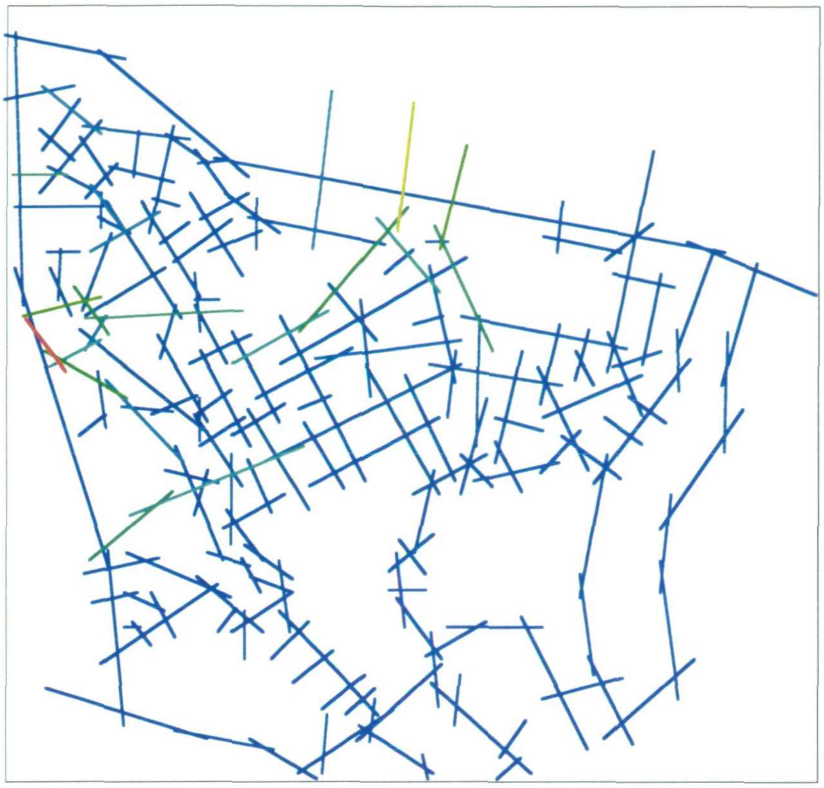


Figure 7.3
Pedestrian
movement

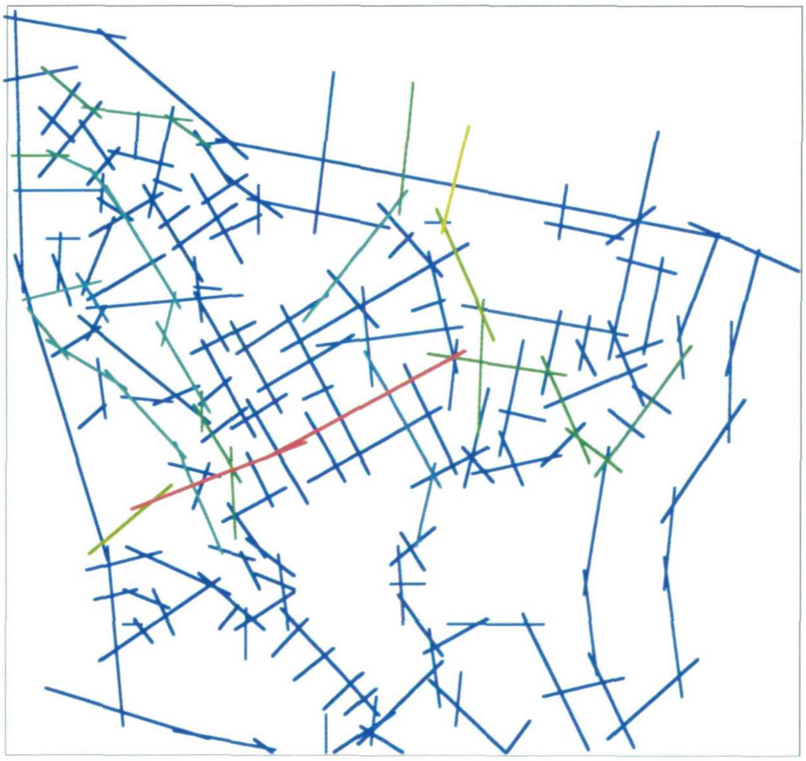


Figure 7.4
Vehicular
movement

Table 7.1 The distribution of pedestrian and vehicular movement

	8:00 - 10:00	10:00 - 12:00	12:00 - 14:00	14:00 - 16:00	16:00 - 18:00	Total	hourly flow
Pedestrian	482	464	494	444	585	2469	1.7
Vehicle	3840	2844	2765	3175	4053	16777	11.3
Total	4322	3308	3259	3619	4638	19246	13
vehicle:pedestrian ratio	7.4:1	6.1:1	5.6:1	7.2:1	6.9:1	6.8:1	6.8:1

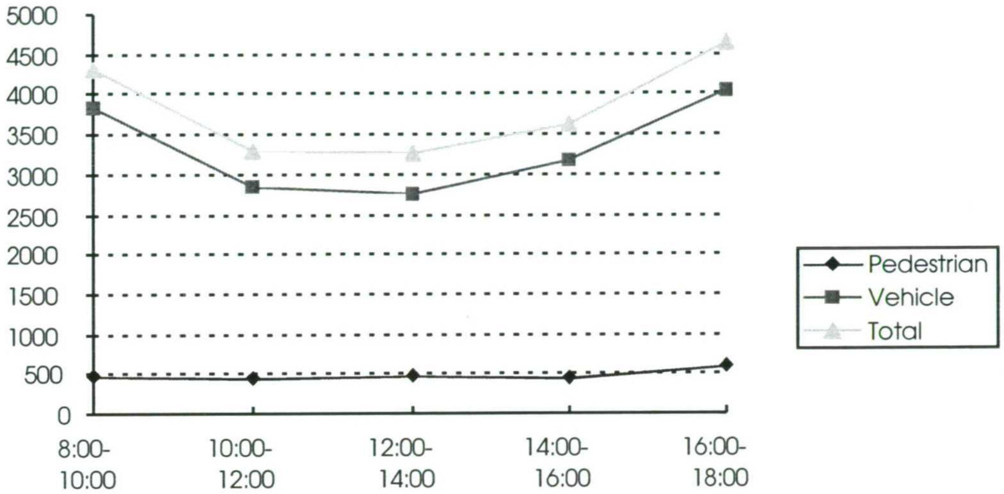


Figure 7.5 The distribution of movement through the day

Figure 7.5 shows the distribution of the movement through the day. The first thing to be noted about the flow is its consistency. Although there are wide variations in levels of movement in different spaces and at different times, the basic time pattern remains constant. The distribution of pedestrian movement throughout the day takes the form of a flattened 'w'; higher levels of occupancy during the morning rush hour (8:00-10:00), fall in the morning period (10:00-12:00), it then peaks above the morning rush hour level during the midday period (12:00-2:00), after this it falls again by about 10 per cent from the midday period in the afternoon (2:00-4:00). In the evening rush hour (4:00-6:00), it reaches the peak of the day at 28 per cent above that of non-peak hours (10:00-4:00), and 20 percent above that of the morning rush hour.

The distribution of vehicular movement throughout the day follows a "U" shape. Unlike the distribution of pedestrian flow, there is no midday peak, On the contrary, midday has the lowest flows, and the morning and afternoon periods show an increase over the midday period. The morning rush hour has 38 percent higher flow than the lowest midday period, and the evening rush hour is the peak of the day about 50 percent above the midday.

These characteristic time profiles, as shown in Figure 7.5, suggest that the Suburb behaves in a similar way to other urban residential neighbourhoods (Penn & Dalton, 1994). It has the general shape of the curve, showing peaks in the morning and the evening rush hour indicating commuting journeys to and from work. Unlike an urban neighbourhood in a city, the Suburb has its peak flows in the early evening period (4:00-6:00).

In spite of these variations in pedestrian movement it is possible to establish statistically that the evening period pattern forms a characteristic pattern of the Suburb. This is supported by correlating whole day movement figures with the midday movement, and then, with the evening figure, which is higher than at any other period. The correlation coefficient between whole day movement and the midday period pattern of movement is $r = 0.817$, and between the whole day and the evening hour movement is $r = 0.909$, which indicates strong agreement between the proportion of people moving in various spaces at different times.

As for vehicular movement in the area, statistical exploration also points to the importance of the evening period. Unlike the distribution of pedestrian movement, the vehicular flow does not have a midday peak. In fact, the midday period has the lowest movement level throughout the day. This is confirmed by a high correlation of 0.983 between whole day figures and the evening period and the high proportion of all cars observed during this period at 24%.

The higher correlation coefficients of evening movement coupled with the peak in the movement figures in both pedestrian and vehicular flows, may suggest that evening movement is the most characteristic of the spatial culture of the Suburb. This finding is interesting in comparison with the work of Hillier (1996) who states that the spatial culture of the City of London finds its fullest expression during the middle of the day. In this residential area, not surprisingly, the finding is different from the City in that the culture embedded in the space is fully exerted in the early evening period of peak usage.

7.2.2 The relationship between pedestrian and vehicular movement

Vehicular movement exceeds pedestrian flow by a factor of 6.9 (Table 7.1). This ratio is similar to the finding that on routes with residential land uses, vehicular traffic out numbers pedestrians at a rate of 8 to 1 (Penn and Dalton, 1994). This ratio is not expected considering that the Suburb is purely residential and the 'retail multiplier effect', noted by Hillier et al (1993) in their studies of city centre area, is not expected at all.

We now examine further the relative rates of pedestrian and vehicular movement. Figure 7.6 shows a scattergram of the relationship between pedestrian and vehicular movement. The distribution shows no clear relation at the low end, with low movement of pedestrians and vehicles, but is tighter in the upper section. The low points belong exclusively to cul-de-sacs, and show the broken relationship between pedestrian and vehicular flows.

The vehicular pedestrian ratio is further examined by relating the ratio to depth from the carrier boundaries, Finchley Road and the A1. Figure 7.7 is a scattergram between depth and the vehicular pedestrian ratio. The lack of a relationship between the two suggests that the depth does not affect the relationship. The vehicular pedestrian ratio remains the same at increased depth. The greater depth generally belongs to cul-de-sacs. These reduce both vehicular flow and pedestrian movement. It seems clear from this analysis that depth is not an influential factor in the vehicular pedestrian ratio in this residential neighbourhood.

7.2.3 Movement at peak-hours and non peak-hours

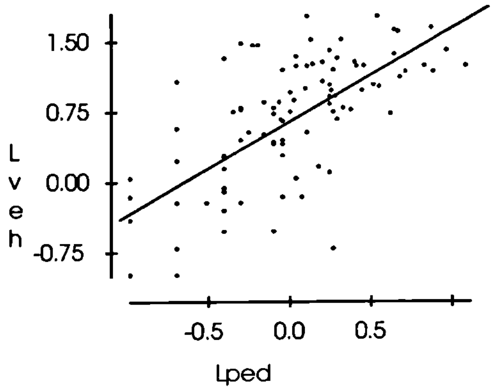


Figure 7.6 The relationship between logged pedestrian movements and logged vehicular flows (r=0.675, r squared 0.459,$p \leq 0.0001$)

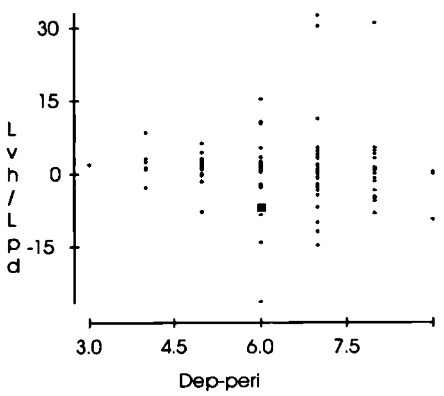


Figure 7.7 The vehicular pedestrian ratio against depth from the peripheries

Table 7.2 Correlation between local integration (3) and movement rates in terms of time period (the peaks *vs* non-peaks)

	the peaks (8:00-10:00; 16:00-18:00)	non-peaks (10:00-16:00)
pedestrian movement rate		
r	0.461	0.492
r squared	0.212	0.242
p	≤0.0001	≤0.0001
df	93	91
vehicle movement rate		
r	0.743	0.766
r squared	0.552	0.587
p	≤0.0001	≤0.0001
df	91	92
total movement rate		
r	0.719	0.745
r squared	0.517	0.555
p	≤0.0001	≤0.0001
df	101	103

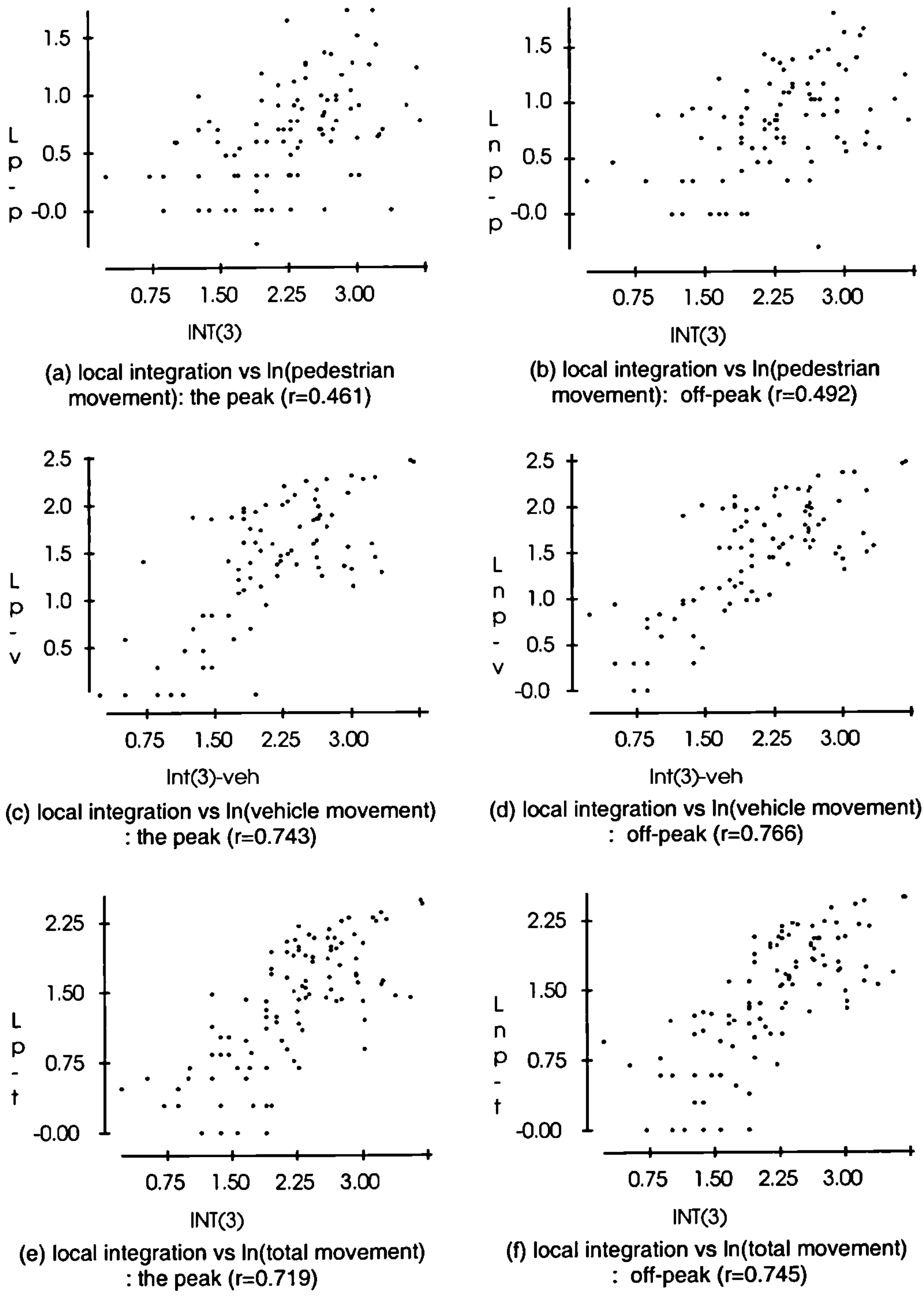
In order to find out the impact of time on the predictability of the movement with configurational variables, the correlation and regression analysis are carried out at two periods in the day. In this purely residential area, the pedestrian-vehicle movement ratio between the peak-hours and the non peak-hours is significantly higher in the ratio of pedestrians to vehicles. The ratio at the peaks (8:00-10:00 and 16:00-18:00) is 7.4:1, and that at the non-peaks (12:00-16:00) is 6.3:1 (Table 7.1).

The investigation of the correlation between spatial configuration and movement rates reveals that the spatial measures are better correlated with all three movement rates - pedestrian, vehicular and total movement rates - at off-peak times than at peak times, as shown in Table 7.2. The correlation coefficients between local integration and all three movements at off-peak times are higher at 0.492, 0.766, 0.745, than at peak times at 0.461, 0.743, 0.719 respectively. Figure 7.8 (a)-(f) shows the scattergrams of local integration against logged movement rates. It confirms again a better association at off-peak hours by slightly tighter and denser scatters. This finding suggests that space use patterns during normal hours are much more dependent on the syntactic properties of spatial configuration than during peak hours.

7.3 The effect of depth on movement

We pay particular attention to the impact of landmarks and movement generators in this part of the study. In order to explore the association, the movement rate is correlated with depth from four different movement generators: Central square, the perceived centre of the Suburb; Golders Green Station; Finchley Road, where the main shopping and public facilities are; and the boundaries of the Suburb, Finchley Road and the A1, which are the top two most integrated spaces in the global context.

Table 7.3 shows the association of the movement rates with depth from the four attractors. As for pedestrian movement, the depth from Finchley Road shows the best correlation at -0.461, and it is followed by the depth from the



(a) local integration vs ln(pedestrian movement): the peak (r=0.461)

(b) local integration vs ln(pedestrian movement): off-peak (r=0.492)

(c) local integration vs ln(vehicle movement) : the peak (r=0.743)

(d) local integration vs ln(vehicle movement) : off-peak (r=0.766)

(e) local integration vs ln(total movement) : the peak (r=0.719)

(f) local integration vs ln(total movement) : off-peak (r=0.745)

Figure 7.8 Regression analyses between spatial configuration and the space use pattern

Table 7.3 Regression between normalised movement rates and depth from four landmarks and attractors

	Central Square	tube station	Finchley Road	boundaries
<u>pedestrian movement</u>				
r	-0.168	-0.458	-0.461	-0.458
r squared	0.028	0.209	0.212	0.21
p	0.0918	≤0.0001	≤0.0001	≤0.0001
df	100	100	99	100
<u>vehicle movement</u>				
r	-0.168	-0.235	-0.273	-0.344
r squared	0.028	0.055	0.075	0.118
p	≤0.0001	0.0185	0.0063	0.0005
df	98	98	97	98
<u>total movement</u>				
r	-0.139	-0.27	-0.307	-0.375
r squared	0.019	0.073	0.094	0.141
p	0.1561	0.0054	0.0015	≤0.0001
df	103	103	102	103

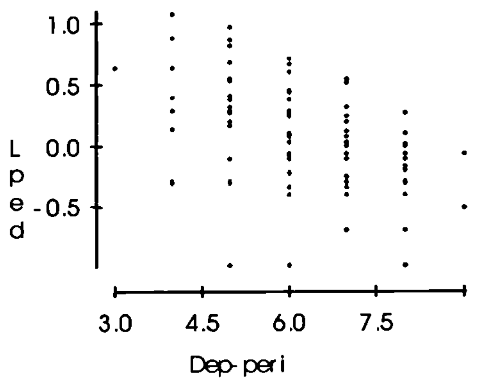
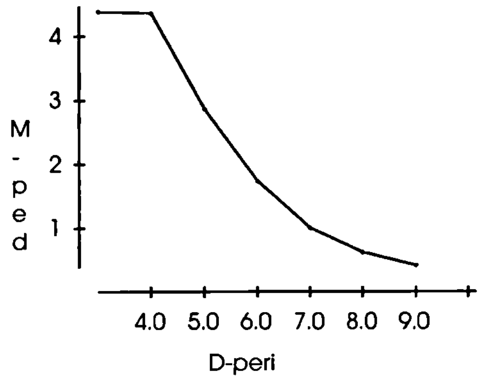


Figure 7.9 The association between normalised pedestrian movement and depth from the periphery

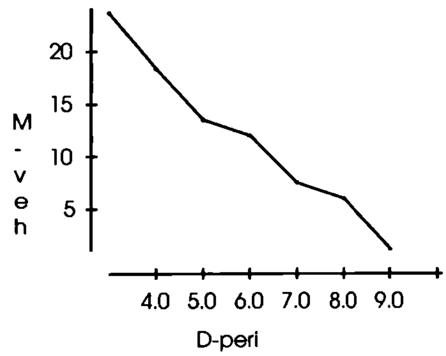
boundaries and the tube station at the same coefficient of -0.458. Figure 7.9 illustrates the scattergram of depth from the boundaries on the pedestrian movement rate. It shows that the amount of the movement is limited with the increase of depth from the boundaries. In vehicular movement, the depth from the periphery of the area shows the highest correlation at r = -0.344. Total movement is correlated best with depth from the periphery at r = -0.375.

The perceived centre of the area, Central Square, has the least association with movements. The correlation coefficient is very weak at -0.168 for both pedestrian and vehicular movements, as shown in Table 7.3. The regression analysis confirms low regression at r-squared of -0.139 (p = 0.156). It seems that the landmark, which is not located in the syntactic centre of the area, does not work as a movement generator at all. The table also shows that vehicular flow is less associated with the depth from all four movement generators than pedestrian movement. For example, the coefficient between the depth from the main shopping street and movement rate is -0.461 for pedestrians and -0.273 for vehicles.

The amount of pedestrian and vehicle movement diminishes dramatically with the increase in depth from the periphery, Finchley Road and the A1. Figure 7.10(a) shows the number of people observed through the Suburb against the depth. The figure shows that as depth from Finchley Road into the Suburb increases, the levels of movement decrease sharply. The vehicular volume also shows the same phenomenon. There is less movement when deeper from the most syntactically integrated movement generator, as shown in Figure 7.10(b). This suggests that Finchley Road and the A1 are the main carrier spaces and sources of large scale movement for the Suburb. It is clear from both figures that as a space is further away from the main carrier spaces, i.e., towards locally and globally less integrated places, the movement volume falls off dramatically. In the Suburb, as you move into the centre from its peripheral of movement carrier spaces, each change of direction towards the centre adds one step of depth and accompanies poor visibility due to the relatively small scale of the interior spaces. This brings about the sharp fall-off in the movement density.



(a) pedestrian movement and depth from periphery



(b) vehicular movement and depth from periphery

Figure 7.10 The relationship between depth from the boundaries and the amount of movement

Table 7.4 Regression analyses of movement on spatial configuration

	global choice	global integration	local integration
pedestrian movement rate			
r	0.586	0.48	0.585
r squared	0.343	0.231	0.342
p	≤0.0001	≤0.0001	≤0.0001
vehicle movement rate			
r	0.709	0.48	0.779
r squared	0.502	0.230	0.607
p	≤0.0001	≤0.0001	≤0.0001
total movement rate (with vehicle model)			
r	0.685	0.448	0.76
r squared	0.469	0.20	0.578
p	≤0.0001	≤0.0001	≤0.0001
total movement rate (with pedestrian model)			
r	0.695	0.49	0.746
r squared	0.483	0.24	0.556
p	≤0.0001	≤0.0001	≤0.0001

* regression analyses of normalised all movements on global and local integration (df135,139,145)

7.4 Spatial configuration and spatial behaviour

A series of statistical analyses provides empirical evidence for a direct relationship between movement patterns and spatial configuration. This investigation is aimed at finding out not only the relationship between the two variables, but the characteristics of the revealed association.

Mean hourly movement was correlated to three spatial variables of the neighbourhood; global integration, choice value, and local integration, to see the extent to which they are related. Table 7.4 shows the resulting correlation. All three spatial measures are correlated with movement rates positively. However, the degree to which the syntactic variable is correlated with the movement rates is different. Generally, local integration correlates best with movement rates, yielding a high correlation coefficient with pedestrian and vehicular movement rates, at 0.585 and 0.779, respectively. The correlation between choice value and movement rates also shows a good relationship at 0.586 with pedestrian movement and 0.709 with vehicular flow. The weakest correlation, though not insignificant, is that between global integration and the total movement rate at 0.49.

As for pedestrian movement, local integration and choice value are correlated to a similar degree: $r = 0.585$ and 0.586, respectively. The scattergrams reveal the difference in the characteristics of these two associations. Figures 7.11 and 7.12 show the relationship of both local integration and logged global choice value to logged pedestrian movement rates. Each gate is one point on the scatter. The number of people per hour passing through the gate is logged since it is skewed to the left as can be seen in Figure 7.13. In the scatter between choice value and pedestrian movement rate (Figure 7.12), some outliers are quite far away from the main clusters, negatively affecting the regression. Conversely, in the case of local integration and pedestrian movement, most of the outliers are not as isolated as in the above scatter. The r-squared value between local integration and movement is 0.342 indicating that we can predict about 34% of the movement in the Suburb based upon the pattern of space alone.

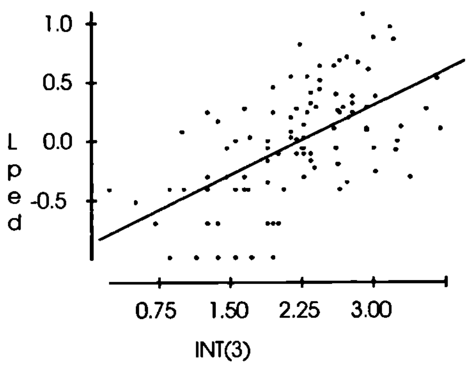


Figure 7.11 Scattergram between local integration and normalised pedestrian movement

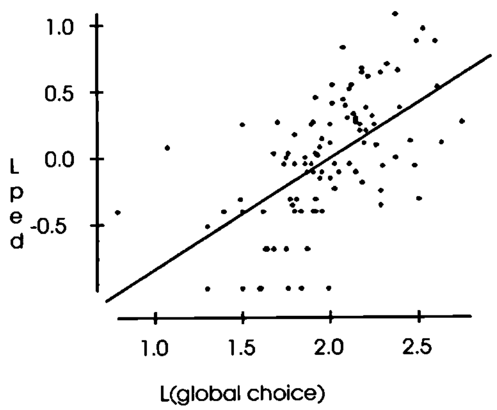


Figure 7.12 Scattergram between normalised global choice and normalised pedestrian movement

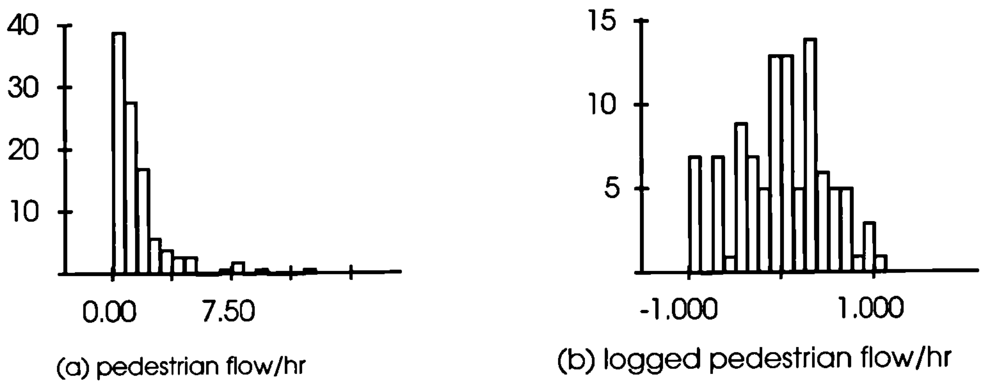


Figure 7.13 Distribution of hourly pedestrian flow (a) and its logarithmic transformation (b)

In the relationship of vehicular movement with spatial variables, the best correlation is with the local integration of the vehicle axial map at r = 0.779, $p<0.0001$ (Figure 7.14). The r-squared of 0.607 indicates a very strong relationship and more than 60% of flows can be explained by the regression. Choice value also shows a strong correlation at 0.709 ($p<0.001$) in Figure 7.15. The overall r-squared value for vehicular movement is much higher than for pedestrian movement.

In the case of total movement, local integration of the pedestrian map which includes all the footpaths, has the best correlation coefficient at 0.746 (Table 7.4). Again, the relation of movement to choice value shows a powerful regression at r = 0.709, however, comparison of the two scatters (Figure 7.16 and 7.17) confirms that the local integration shows a better relationship with movement overall. Examination of the far outliers reveals that these spaces, such as Asmuns Place, Carlyle Close, Temple Grove, are the cul-de-sacs which are located near the major integrators. These spaces have extremely low movement even though they are relatively well integrated.

A close examination of the scattergrams reveals the existence of outliers in each scatter. A cul-de-sac is represented as 'x' and a footpath is marked as 'o'. These spaces are characterised by relatively low global or local integration or low choice values with extremely low movement rates. Most of the spaces are pedestrian only passages or cul-de-sacs. Table 7.5 exemplifies the effect of these spaces on the relation between movement rates and local integration. Not surprisingly, removing footpaths from the scatterplot between total movement rates and local integration, the regression becomes more successful: r improves from 0.745 to 0.767. However, eliminating cul-de-sacs on the scattergram, causes the relationship to become slightly worse; r drops from 0.644 to 0.632. In the relationship between pedestrian movement and local integration, the regression worsened from 0.585 to 0.509 after excluding cul-de-sacs. As for the relation of vehicular movement rates to local integration, excluding cul-de-sacs makes the regression less powerful from 0.779 to 0.701 as well.

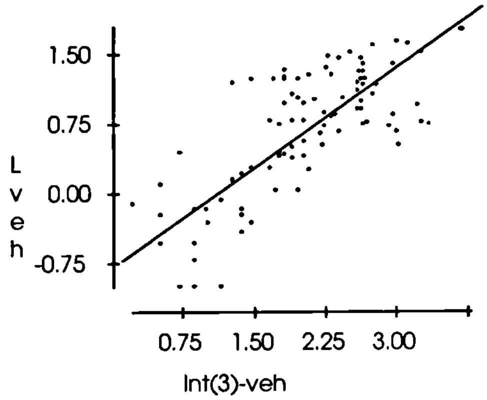


Figure 7.14 Scattergram between local integration and normalised vehicular movement

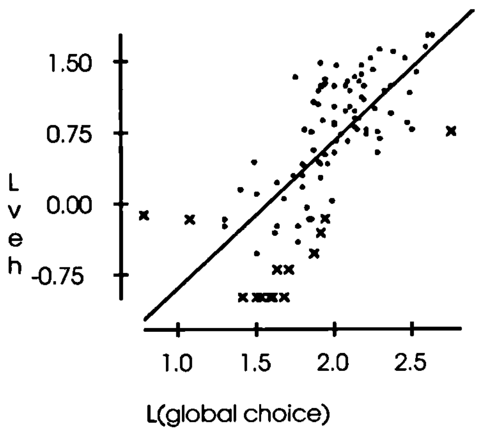


Figure 7.15 Scattergram between normalised choice value and normalised vehicular movement (x: cul-de-sac)

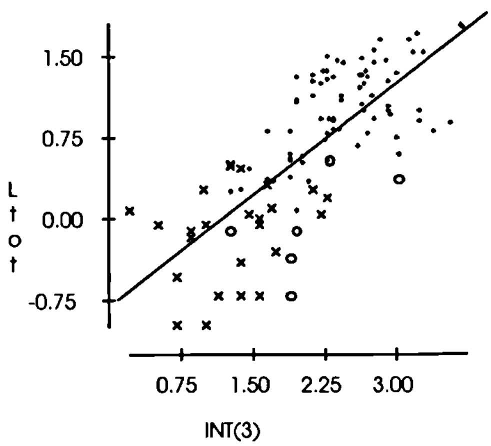


Figure 7.16 Scattergram between local integration and normalised all movement

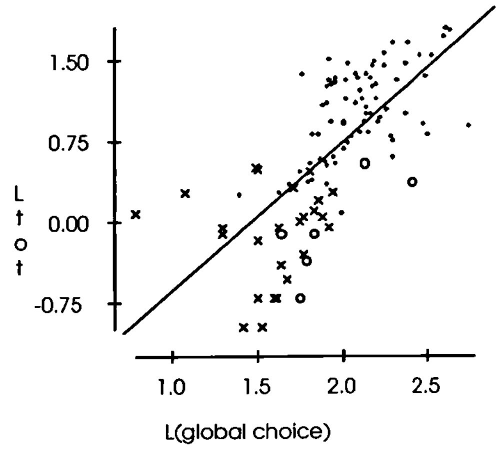


Figure 7.17 Scattergram between normalised choice value and normalised all movement

Table 7.5 The effect of cul-de-sacs and footpaths on the relation of movement rates to local integration

	Total movement	Pedestrian movement	vehicular movement
all scatters including footpaths and cul-de-sacs			
r	0.556	0.342	0.607
r squared	0.745	0.585	0.779
p	<0.0001	<0.0001	<0.0001
scatters without footpaths			
r	0.588	0.33	
r squared	0.767	0.574	
p	<0.0001	<0.0001	
scatters without cul-de-sacs			
r	0.415	0.259	0.491
r squared	0.644	0.509	0.701
p	<0.0001	<0.0001	<0.0001
scatters without both footpaths and cul-de-sacs			
r	0.432	0.228	
r squared	0.657	0.477	
p	<0.0001	<0.0001	

The same is true in the case of the relationship between movement rates and choice value, shown in Table 7.6. The table shows that, by excluding footpaths on the scatterplot, the correlation coefficient improve slightly from 0.695 to 0.712, whilst, by removing cul-de-sacs, the regression is reduced from 0.695 to 0.632. For the vehicular movement, removing cul-de-sacs causes the correlation coefficient to become worse again from 0.709 to 0.628.

Although both cul-de-sacs and footpaths are separated from the main cloud of points in the scattergrams, removing these spaces from the regression does not necessarily secure a better correlation. On the contrary, the coefficients get worse without both of them; decreasing from 0.745 to 0.657 in the analysis of total movement rate with local integration (Table 7.5), and from 0.695 to 0.642 between total movement rate and choice value (Table 7.6). Excluding footpaths from the scattergrams, both integration and choice values correlate better with movement rates, while the correlation gets worse without cul-de-sacs. This suggests that cul-de-sacs are likely to have a negative impact on the association, whilst footpaths work positively.

7.5 The impact of intelligibility on the association between spatial configuration and movement

This part of the study investigates whether 'intelligibility' has any consistent impact on the pattern of the relationship between the spatial configuration of the neighbourhood and its pattern of space usage. The degree of association is compared between two sub-areas. Sub area-A consists of gates in the unintelligible area and sub area-B consists of gates in the intelligible area.

The difference in the pattern of the relationship is compared in terms of three spatial variables: global integration, choice value and local integration. Table 7.7(a) shows the degree of difference in the relationship of movement rates to global integration between the two samples. There is a big difference in the

Table 7.6 The effect of cul-de-sacs and footpaths on the relation of movement rates to global choice

		Total movement	Pedestrian movement	vehicular movement
all scatters with footpaths and cul-de-sacs				
	r	0.483	0.344	0.502
	r squared	0.695	0.587	0.709
	p	<0.0001	<0.0001	<0.0001
scatters without footpaths				
	r	0.507	0.334	
	r squared	0.712	0.578	
	p	<0.0001	<0.0001	
scatters without cul-de-sacs				
	r	0.4	0.314	0.394
	r squared	0.632	0.56	0.628
	p	<0.0001	<0.0001	<0.0001
scatters without both footpaths and cul-de-sacs				
	r	0.409	0.294	
	r squared	0.64	0.542	
	p	<0.0001	<0.0001	

Table 7.7 Correlation of spatial configuration on movement in terms of intelligibility

(a) Association between global integration and movement

		subarea A (unintelligible) observation gates: 1-47,49-52, 62-68, 83	subarea B (intelligible) observation gates: 48, 53-61, 69-82, 84-105
pedestrian movement rate			
	r	0.38	0.649
	r squared	0.144	0.421
	p	0.0036	≤0.0001
	df	55	43
vehicle movement rate			
	r	0.406(0.414)	0.506(0.562)
	r squared	0.165(0.171)	0.256(0.316)
	p	0.0026	≤0.0001
	df	52	44
total movement rate (with pedestrian model)			
	r	0.452	0.589
	r squared	0.204	0.347
	p	≤0.0001	≤0.0001
	df	57	44

( ) with pedestrian model

(b) Association between global choice and movement

	subarea A (unintelligible) observation gates: 1-47,49-52, 62-68, 83	subarea B (intelligible) observation gates: 48, 53-61, 69-82, 84-105
pedestrian movement rate		
r	0.532	0.744
r squared	0.282	0.553
p	≤0.0001	≤0.0001
df	55	43
vehicle movement rate		
r	0.664	0.744
r squared	0.44	0.553
p	≤0.0001	≤0.0001
df	52	44
total movement rate (with pedestrian model)		
r	0.627	0.773
r squared	0.394	0.63
p	≤0.0001	≤0.0001
df	57	44

(c) Correlation between local integration and movement

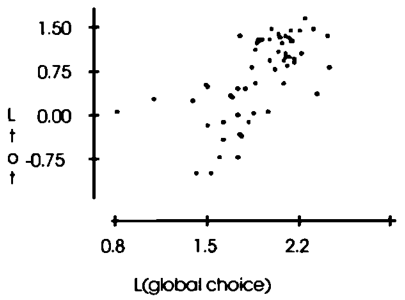
	subarea A (unintelligible) observation gates: 1-47,49-52, 62-68, 83	subarea B (intelligible) observation gates: 48, 53-61, 69-82, 84-105
pedestrian movement rate		
r	0.544	0.692
r squared	0.296	0.478
p	≤0.0001	≤0.0001
df	55	43
vehicle movement rate		
r	0.754(0.746)	0.839(0.796)
r squared	0.568(0.556)	0.703(0.634)
p	≤0.0001	≤0.0001
df	50(52)	44
total movement rate (with pedestrian model)		
r	0.704	0.812
r squared	0.496	0.66
p	≤0.0001	≤0.0001
df	57	44

( ) value with pedestrian model

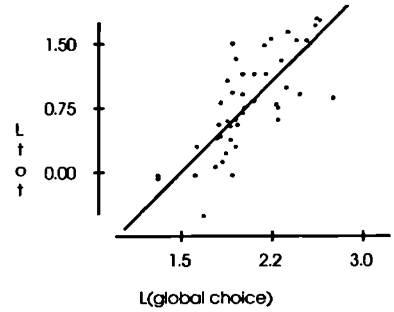
association between the two areas. For pedestrian movement, the correlation coefficient of area-B at r = 0.649, is almost double that of area-A at 0.38. For vehicular flow, the coefficient of area-B is also bigger than that of area-A. The coefficients for the vehicular axial map are r = 0.406 in sample-A and 0.506 in sample-B, and those with the pedestrian axial map are 0.414 and 0.562 respectively. Not surprisingly, the relationship of total movement with global integration also indicates the difference between the two samples at 0.452 and 0.589 in subarea-A and subarea-B respectively. All the coefficients show a stronger relationship in area-B than area-A.

Table 7.7(b) shows the correlation between choice value and movement rates in the two areas. Once again it can be seen that the correlation coefficients of area-B are much higher than those of area-A in all three cases of pedestrian, vehicular and total movement. Pedestrian movement shows a bigger difference in the coefficient than vehicle movement between the two areas. The coefficients of area A and B are 0.532 and 0.744. They are 0.644 and 0.744 for vehicular movement and 0.627 and 0.733 for total movement in subarea-A and B respectively. The scattergrams illustrate clearly the difference in the pattern of the association between the two samples, shown in Figure 7.18. This shows the choice value in a larger model of the Suburb against logged movement rates. As can be seen from the figure, the scatters of area-B; with gates in the intelligible area, are much tighter and more linear, indicating a better relationship between variables than those of area-A.

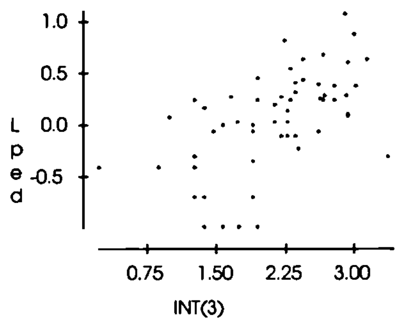
Finally, the effect of intelligibility on the relationship between movement rates and local integration is examined. Table 7.7(c) shows again the very different correlations between them. The correlation coefficients of pedestrian, vehicular and total movement of area-B, are 0.692, 0.839 and 0.812, respectively, and those of the unintelligible area are, 0.544, 0.754 and 0.704. This shows again the stronger association at gates in area-B than area-A. The difference between the two areas is bigger for pedestrian movement than for vehicular flows.



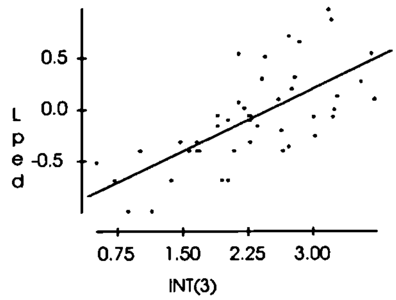
(a) global choice vs ln(total movement) - the unintelligible area



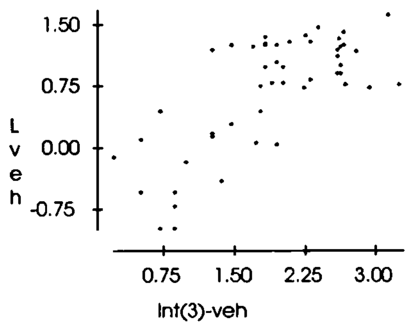
(b)) global choice vs ln(total movement) - the intelligible area



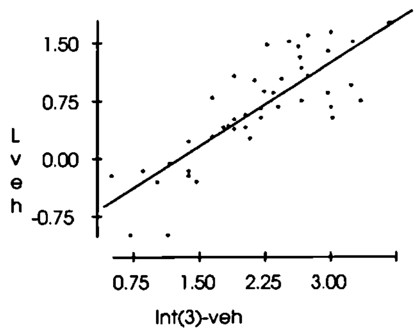
(c) local integration vs ln(pedestrian movement) - the unintelligible area



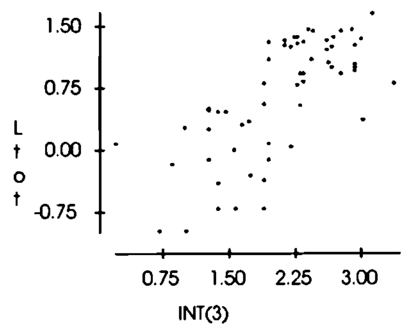
(d) local integration vs ln(pedestrian movement) - the intelligible area



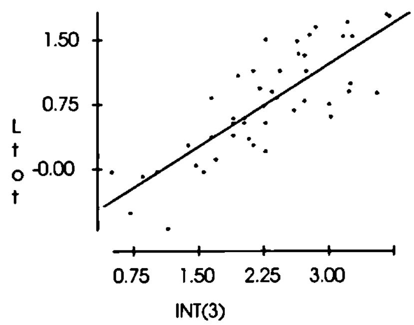
(e) local integration vs ln(vehicle movement) - the unintelligible area



(f) local integration vs ln(vehicle movement) - the intelligible area



(g) local integration vs ln(total movement) - the unintelligible area



(h) local integration vs ln(total movement) - the intelligible area

Figure 7.18 The effect of intelligibility on the association between spatial configuration and the space use pattern

Figures 7.18(a)-(h) show the scattergrams of global and local integration against logged movement rates while maintaining the overall scale of movement between the two areas in each movement. These show that the scatters vary in their degree of correlation in each relationship, but there is a big difference in patterns of their association. The scattergrams of gates located in the intelligible area (Figure 7.18 (b)(d)(f)(h)) show a stronger relationship, showing denser scatters and a more steeply angled regression line than those of the gates in the unintelligible area (Figure 7.18 (a)(c)(e)(g)).

Two facts can be concluded from the comparison of these relationships. Firstly, regarding the association of space usage with the configuration of neighbourhood spatial layout, the correlation is much more powerful and tighter in the intelligible area than in the unintelligible area. This suggests that spatial variables contribute more strongly to the association in the intelligible area. Secondly, pedestrian movement shows a bigger difference between the two areas in the pattern of the relationship with all three spatial dimensions than does vehicular movement. This suggests that the effect of intelligibility on their relationship is greater for pedestrians than for vehicles.

In conclusion, these findings indicate how strongly the movement pattern is influenced by the purely spatial structure of the street layout. In addition, we can predict movement more precisely in the intelligible area than in the unintelligible area. This difference implies the importance of intelligibility in movement patterns. It can be concluded that the intelligibility of an area promotes an association between spatial configuration and spatial behaviour.

7.6 Conclusions and implications

Reviewing these findings, several points can be identified. Firstly, regarding the spatial culture of the residential area, the early evening appears to be most characteristic in terms the intensity of space usage. The culture embedded in the space is fully expressed in this period, unlike a city area. Secondly, local integration is found to have the best association with total movement. As for pedestrian movement, the choice value performs slightly better than local integration in the correlation. However, the comparison of the scatters between them seem to show that local integration is slightly well associated than that of the choice value. In vehicular flows and total movement, local integration is again the best predictor, showing much higher correlation coefficients than choice value. Thirdly, both cul-de-sacs and footpaths are outliers in the relationship between spatial measures and movement rates. By removing footpaths, a slightly better correlation is detected, conversely, eliminating cul-de-sacs does not necessarily secure a better regression. Not all cul-de-sacs are outliers from the trend, since some conform to it. The far outlier cul-de-sacs are close to highly integrated streets, and are characterised by a relatively high integration value but with low movement. Fourth, no clear connection is found between depth from landmarks, which are not located in the globally or locally integrated spaces. However, depth from the street where shopping and public facilities are located, shows a strong negative relationship to movement. Pedestrian movement is more dependent upon depth from these attractors than vehicular movement. Finally, syntactic intelligibility influences these associations positively, enabling a stronger relationship between spatial configuration and spatial behaviour. Conversely, patterns of space use are less predictable in a place where there is a lack of intelligibility.

Among all these findings, the role of intelligibility in the pattern of association is the main concern in this research, since it is hypothesised that space usage patterns are differentiated based on the amount of spatial knowledge acquired. A clear difference in the average strength of correlation of spatial variables with movement rates is detected between the intelligible and unintelligible area.

This difference may result from two effects: firstly, the broken relationship between the two types of spatial knowledge, secondly the characteristics of cognitive maps. As for the former, from Golledge and Stimson's (1997) discussion of spatial knowledge as discussed in chapter two, movement may be based on two types of spatial knowledge. One results from long term exposure to the built environment, and is an understanding of the global structure at a cognitive level. The other is an intuitive knowledge, which is knowledge about the more immediate spatial environment at a perceptual level. From Hillier's (1996) definition of intelligibility, in an unintelligible area, the relationship between local integration and global integration is broken. From this perspective, in an unintelligible area the relationship between the two types of spatial knowledge in the human mind may also be broken. Thus spatial knowledge may be limited due to a weaker relationship between these spatial properties which would hinder the easy acquisition of spatial knowledge.

Supporting evidence for this idea is that cognitive maps are well established in the intelligible area compared to the unintelligible area as revealed in chapter six. Thus wayfinding behaviours are relatively invariant and frequently follow paths of less effort minimising the arbitrariness and uncertainty of movement in an unintelligible area.

Despite the revealed empirical evidence on the relationship between spatial configuration and spatial behaviour, why syntactic intelligibility affects the pattern of the relationship remains unanswered. It seems unexplainable by reference to these two variables alone. This issue will be addressed in the next chapter, which tackles the association of spatial behaviour and spatial cognition.

Chapter Eight

SPATIAL COGNITION AND SPATIAL BEHAVIOUR

8.1 Introduction

This chapter investigates the relationship between the cognitive representation of spatial configuration and the pattern of space usage. Then it extends the argument to examine the role of morphological intelligibility in this relationship. Thus spatial cognition is incorporated into an analysis of spatial behaviour. This chapter thus aims to answer the question of how far and in what way can cognitive representations be related to spatial behaviour; and what kind of movement pattern develops based on cognitive representations. To answer these questions, two things are prerequisite: one is to find out the spatial properties of the configurational elements in sketch maps, and another is to obtain objective data of space use patterns.

By considering the surveyed subjects' sketch maps in chapter five, and the outcome of observed movement patterns in chapter six, a systematic exploration of the likely interdependence between these two variables is carried out. As in the previous two analytical chapters, two cognitive map variables are correlated with movement rates of the pedestrians and vehicles.

Two hypotheses are proposed on the basis of the outcomes in chapter six and seven, which revealed the positive association between spatial configuration and spatial behaviour. Cognitive maps of spatial configuration may be associated with patterns of space usage; and intelligibility may have a positive impact on their association as an intervening variable.

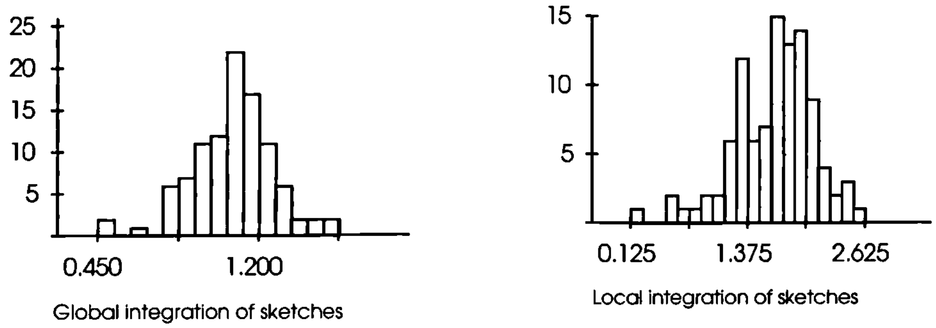
8.2 Internalised configuration in sketch maps and space use patterns

In order to investigate the relationship between internalised spatial configuration and the pattern of space usage, a series of correlation and regression analyses are performed.

Two cognitive variables are used from the sketch maps, representing the characteristics of internalised spatial configuration. One is the frequency of appearance of comprehensible elements in the sketch maps. The other is the mean syntactic properties of each space computed by axial analysis of the 73 sketch maps (Appendix-E). These two cognitive variables are different in their characteristics. The frequency may reflects simple quantitative spatial knowledge by regarding the number of times a feature is recalled and presented on the sketches. On the other hand, the syntactic properties of the sketch maps indicate more complex configurational knowledge by describing the relations of the spatial elements in the mind. Space use pattern variables are mean hourly movement flows for pedestrians, vehicles and their sum (see section 7.2).

The two cognitive variables are correlated to observed movement flows. In order to secure a normal distribution, the frequency and movement variables are logged, since they are highly skewed. These transformations are used in the remainder of the investigation in this chapter. The configurational measures of the sketch maps are more normally distributed and are used without transformation, as seen in Figure 8.1(a) and 8.1(b).

Table 8.1 shows the relationship between sketch maps' variables and movement rates. As can be seen from the table frequency displays the highest correlation with the three movements. The local integration of the sketches and the three movements are correlated at 0.439, 0.675 and 0.655 respectively. The correlations between frequency and the three movements are 0.563, 0.793 and 0.805 respectively. The best correlation is between the frequency and the sum of the movement rates, giving a correlation coefficient of 0.805 ($p<0.0001$).



(a) (b)
Figure 8.1 The distribution of global and local integration of sketch maps

Table 8.1 Regression analysis of movement on sketch map variables

	global integration of sketch map	local integration of sketch map	frequency
pedestrian movement rate (df: 97)			
r	0.382	0.439	0.563
r squared	0.146	0.193	0.317
p	≤0.0001	≤0.0001	≤0.0001
vehicle movement rate (df: 94)			
r	0.633	0.675	0.793
r squared	0.401	0.455	0.629
p	≤0.0001	≤0.0001	≤0.0001
total movement rate (df: 99)			
r	0.616	0.655	0.805
r squared	0.379	0.43	0.648
p	≤0.0001	≤0.0001	≤0.0001

* regression analyses of normalised all movements on global integration, local integration and normalised frequency of sketch maps
* total movement correlate best with local integration of sketches at 0.679

Figures 8.2 - 8.4 are scattergrams between frequency and pedestrian, vehicular and total movement rates. All these three scattergrams indicate very successful regression of r-squared values at 0.317, 0.629 and 0.648, respectively. Using these regression analyses, we can predict 32% of the pedestrian movement, 63% of the vehicular flow, and up to 65% of the total movement.

The syntactic properties of spatial configuration on the sketch maps are correlated with mean hourly movement. All the syntactic variables are strongly correlated with movement rates (Table 8.1). Local integration correlated best with pedestrian movement and vehicular flows. For pedestrian movement, the local integration of the sketches correlated best at 0.439 ($p<0.0001$). Figure 8.5 shows the scattergram of local integration of the sketches horizontally and the logged pedestrian movement vertically, showing an r-squared value of 0.193. Figure 8.6 shows the scatters of the local integration and logged vehicular movement rate. The regression is much more powerful at r-squared = 0.455 ($p<0.0001$), indicating about 45% of the vehicular movement can be predicted. In the case of total movement against local integration, we have a strong r-squared of 0.43 ($p<0.0001$) in Figure 8.7. Considering that we are dealing with sketch maps that are much subject to variation in terms of accuracy and details, these correlation coefficients with rates of movement are remarkably strong. The best correlation is with the frequency of appearance of configurational features.

Table 8.2 shows the comparison of the association between spatial configuration in the physical world and in the sketch maps. The local integration of reality shows a slightly higher correlation at r = 0.585 in the pedestrian movement, than that of the frequency of 0.563, however, the latter becomes the best predictor with all the movement at 0.805. This is higher than that of the local integration of reality at 0.746. This shows that the sketch maps perform better in predicting observed spatial behaviour.

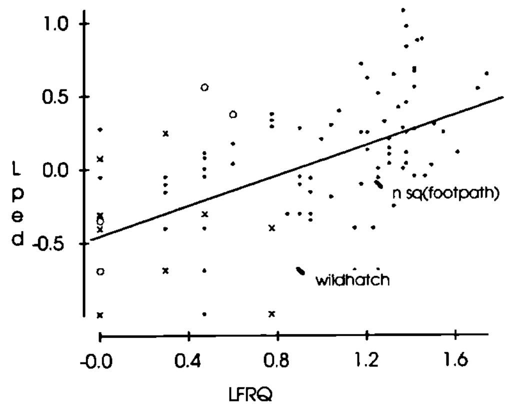


Figure 8.2 Scattergram between the logged pedestrian movement rate and the logged frequency

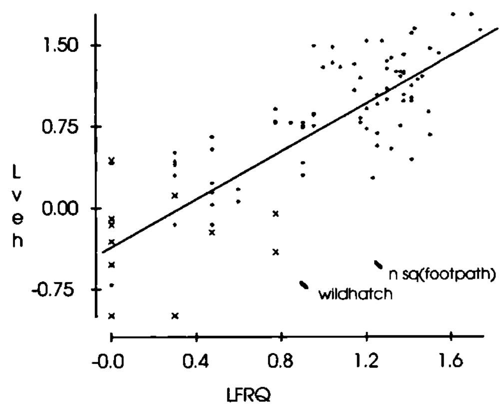


Figure 8.3 Scattergram between the logged vehicular movement rate and the logged frequency

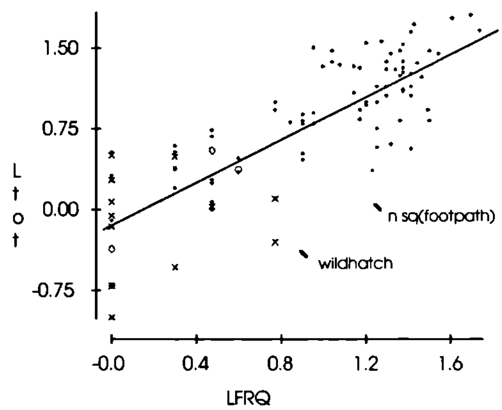


Figure 8.4 Scattergram between the logged all movement rate and the logged frequency

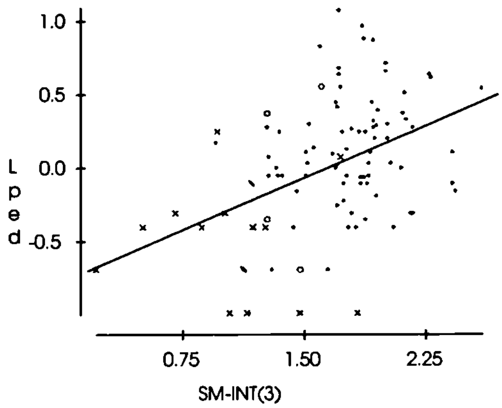


Figure 8.5 Scattergram of logged pedestrian movement rate against the local integration of sketch maps

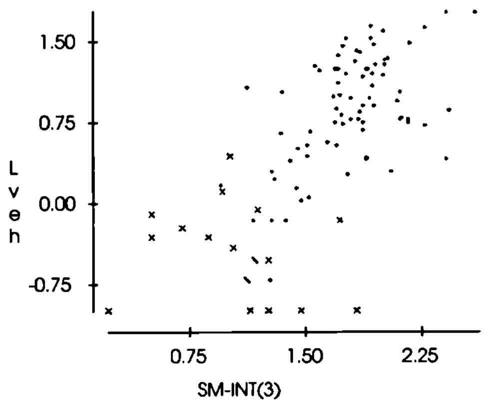


Figure 8.6 Scattergram of logged vehicular movement rate against the local integration of sketch maps

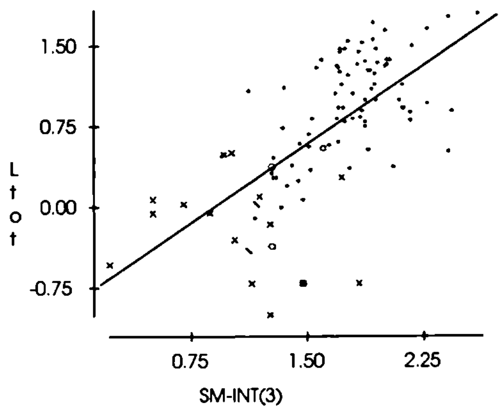


Figure 8.7 Scattergram of logged all movement rate against the local integration of sketch maps

Table 8.2 Comparison of association between movement and spatial configuration on the sketch maps and in reality

	ln(total movement)	ln(pedestrian)	ln(vehicle)
ln(frequency)	0.805	0.563	0.793
local integration of sketch map	0.655	0.439	0.675
local integration of real map	0.746	0.585	0.764

8.3 The effect of cul-de-sacs and footpaths on the relationship between sketch maps and movement rates

A closer examination of the scattergrams reveals the existence of outliers in each scatter (see Figure 8.2-8.7), represented by 'x' (cul-de-sacs) and 'o'(footpath) on all the plots. These spaces are characterised by relatively low local integration, coupled with extremely low movement rates. Most of the spaces are pedestrian footpaths or cul-de-sacs.

In the scattergrams with pedestrian movement rates (see figures 8.2 and 8.5), cul-de-sacs and footpaths are separated from the rest of the group, forming an outlier group. However, they do not necessarily deviate from the general trend of the scatters, on the contrary, they are agreeable with the regression line. The scatters of footpaths are less isolated from the main cluster than those of cul-de-sacs. In the scattergrams for vehicular movement with two sketch map variables, Figure 8.3 and 8.6 show more isolated outliers, but less diffused among themselves than the scattergrams of pedestrians. It suggests that the impact of cul-de-sacs is much clearer in relation to vehicular than pedestrian movement. This is identified again in the outlier group from Figure 8.4 and 8.7. The scatters are diffused at the bottom, but they follow the tendency of the regression line.

Table 8.3 shows the effect of cul-de-sacs and footpaths on the association between movement rates and frequency. When removing footpaths from the scatterplot between total movement rates and the frequency, the regression becomes less powerful: r decreases from 0.805 to 0.783. Again, when

Table 8.3 The effect of cul-de-sacs and footpaths on the relation of movement rates to the frequency

	Total movement	Pedestrian movement	Vehicular movement
all scatters including footpaths and cul-de-sacs			
r	0.805	0.563	0.793
r squared	0.648	0.317	0.629
p	<0.0001	<0.0001	<0.0001
scatters without footpaths			
r	0.783	0.554	
r squared	0.613	0.307	
p	<0.0001	<0.0001	
scatters without cul-de-sacs			
r	0.736	0.43	0.726
r squared	0.541	0.185	0.527
p	<0.0001	<0.0001	<0.0001
scatters without both footpaths and cul-de-sacs			
r	0.699	0.431	
r squared	0.489	0.186	
p	<0.0001	<0.0001	

Table 8.4 The effect of cul-de-sacs and footpaths on the relation of movement rates to the local integration of sketch maps

	Total movement	Pedestrian movement	vehicular movement
all scatters with footpaths and cul-de-sacs			
r	0.655	0.439	0.675
r squared	0.43	0.193	0.455
p	<0.0001	<0.0001	<0.0001
scatters without footpaths			
r	0.67	0.376	
r squared	0.448	0.141	
p	<0.0001	<0.0001	
scatters without cul-de-sacs			
r	0.634	0.353	0.639
r squared	0.402	0.125	0.409
p	<0.0001	<0.0001	<0.0001
scatters without both footpaths and cul-de-sacs			
r	0.633	0.359	
r squared	0.401	0.129	
p	<0.0001	<0.0001	

eliminating cul-de-sacs on the scattergram, the relationship becomes slightly worse: *r* drops from 0.805 to 0.736. The regression between pedestrian movement rate and the frequency worsened from 0.563 to 0.554, when footpaths were removed from the scatters. As for the relation of vehicular movement rates to the frequency, by excluding cul-de-sacs the regression again becomes less successful, falling from 0.793 to 0.726.

Table 8.4 shows the impact of footpaths and cul-de-sacs on the relationship between movement rates and the local integration of the internalised configuration. By removing footpaths from the scatterplot between total movement rates and the local integration, the regression becomes stronger; *r* improves from 0.655 to 0.67. On the contrary, without cul-de-sacs the correlation becomes slightly worse; *r* drops from 0.655 to 0.634. In the relationship between pedestrian movement rate and local integration, the regression decreases from 0.439 to 0.376 without footpaths. The coefficient also decreases from 0.439 to 0.353 when cul-de-sacs are removed. As for the scatters of vehicular movement rates against local integration, by excluding cul-de-sacs the regression falls from 0.675 to 0.639.

All these findings show that, although both cul-de-sacs and footpaths are separated from the main cloud of scatters, removing these spaces from the regression does not necessarily secure a better correlation. In fact, the coefficients get even worse without either or both of them. It can thus be concluded that the cul-de-sacs and footpaths have characteristics which fit well with the general trend of these relationship.

8.4 The effect of intelligibility on the association between spatial cognition and spatial behaviour

This section examines the role of intelligibility in the pattern of revealed association between spatial cognition and spatial behaviour. Subjects' sketch maps are grouped into two sub-samples: sample-A consists of residents in the unintelligible area, while sample-B are those in the intelligible area. These two groups are analysed separately and compared systematically to detect any difference in the strength of association between sketch map variables and patterns of space usage.

Tables 8.5 shows the degree of difference in the relationship between frequency of sketch map variables and movement rates in the two samples. It is evident from the table that there is a consistent difference in their relationship. For the relation of the frequency with movement rates, the correlation coefficient of total movement with frequency is 0.677 in sample-B and is 0.573 in sample-A. In the vehicular flow, the coefficient of sample-B, 0.648, is also stronger than that of sample-A at 0.554. However, the relation between the two is reversed for pedestrian movement where the correlation is 0.49 in sample-A, the unintelligible area, and 0.466 in sample-B.

Table 8.6 shows the impact of intelligibility on the association between local integration of sketch maps and movement rates. For pedestrian movement, the correlation coefficient of sample-A is 0.325, which is much less than that of sample-B at 0.474. In the vehicular flow, the coefficient of sample-B is 0.512, which is weaker than sample A at 0.696. Not surprisingly, the coefficient between the total movement rate and the local integration of the sketch in sample-A is 0.509, which is much less convincing than sample B at 0.67. From these relationship we can see clearly a consistent difference in the degree of association between the two samples.

Figures 8.8 and 8.9 show the impact of syntactic intelligibility on these relationships between the two sketch variables and the logged total movement rates while maintaining the overall scale of the scattergrams within them. These

Table 8.5 The effect of intelligibility on the association of frequency with movement rates

	total samples	sample A (unintelligible)	sample B (intelligible)
pedestrian movement rate			
r	0.563	0.49	0.466
r squared	0.317	0.24	0.217
p	≤0.0001	≤0.0001	≤0.0001
vehicle movement rate			
r	0.793	0.554	0.648
r squared	0.629	0.307	0.42
p	≤0.0001	≤0.0001	≤0.0001
total movement rate			
r	0.805	0.573	0.677
r squared	0.648	0.328	0.458
p	≤0.0001	≤0.0001	≤0.0001

* regression analyses of normalised all movements on global and local integration of sketch maps (df = intelligible area 85, unintelligible area 80)

Table 8.6 The effect of intelligibility on the association of local integration of sketch maps with movement rates

	total samples	sample A (unintelligible)	sample B (intelligible)
pedestrian movement rate			
r	0.439	0.325	0.474
r squared	0.193	0.106	0.225
p	≤0.0001	≤0.0001	≤0.0001
vehicle movement rate			
r	0.675	0.512	0.696
r squared	0.455	0.262	0.485
p	≤0.0001	≤0.0001	≤0.0001
total movement rate			
r	0.655	0.509	0.67
r squared	0.43	0.259	0.453
p	≤0.0001	≤0.0001	≤0.0001

* regression analyses of normalised all movements on global and local integration of sketch maps (df = intelligible area 85, unintelligible area 80)

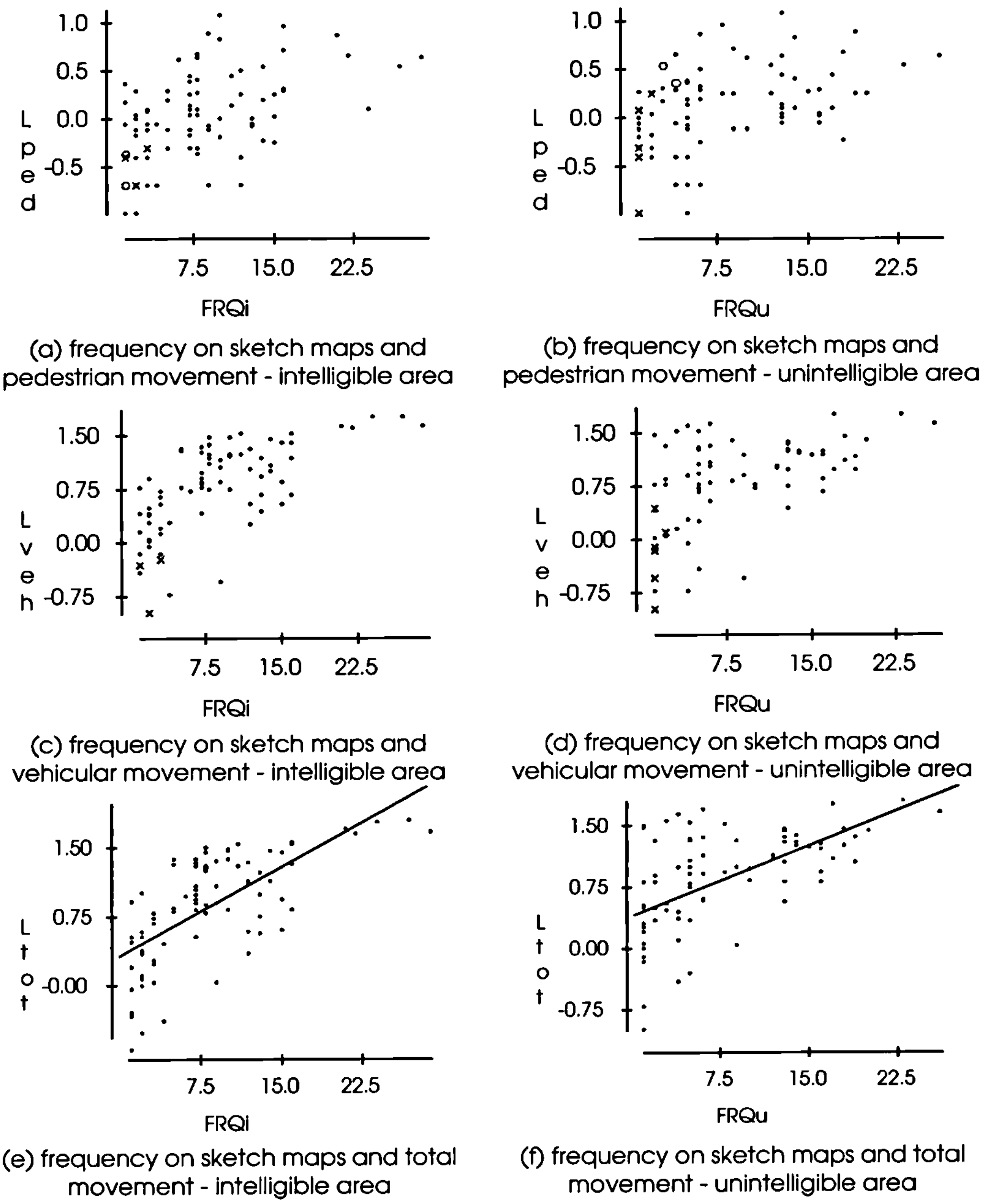
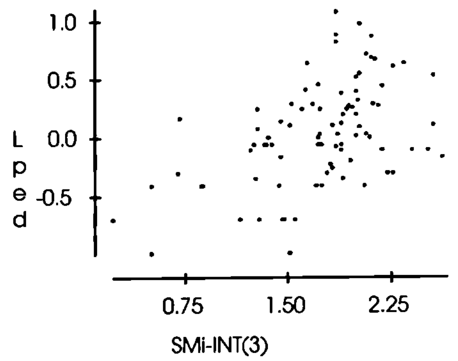
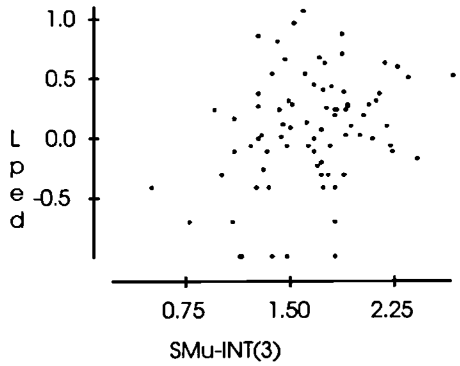


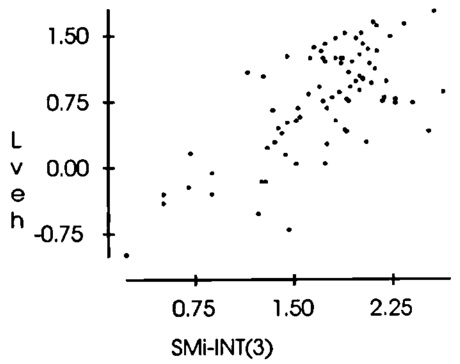
Figure 8.8 The effect of intelligibility on the association between the frequency and movement rates



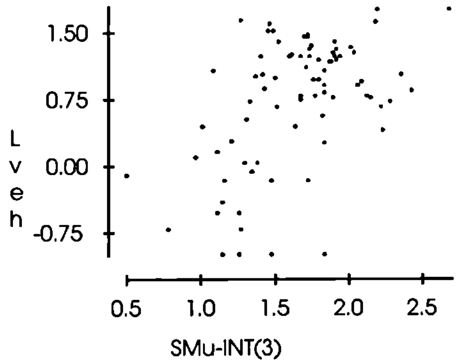
(a) local integration from sketch maps vs pedestrian movement - intelligible area



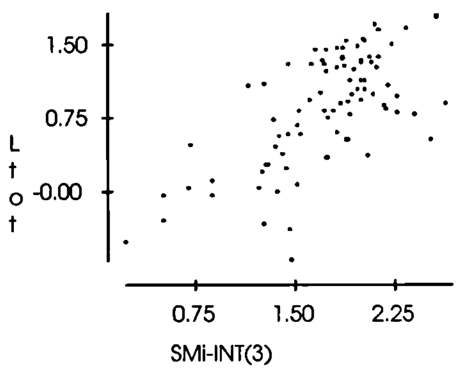
(b) local integration from sketch maps vs pedestrian movement - unintelligible area



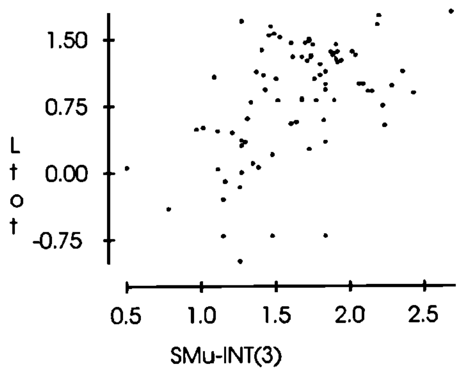
(c) local integration from sketch maps vs vehicular movement - intelligible area



(d) local integration from sketch maps vs vehicular movement - unintelligible area



(e) local integration from sketch maps vs total movement - intelligible area



(f) local integration from sketch maps vs total movement - unintelligible area

Figure 8.9 The effect of intelligibility on the association between the local integration of sketch maps and movement rates show a big difference in the pattern of the plots. The scattergrams of subjects in the intelligible area demonstrate a slightly better relationship with denser scatters and a steeper angle to the regression line than those of subjects in the unintelligible area. The scatters between the frequency and movement rates show that those of sample-B (Figure 8.8 (a)(c)(e)) have a slightly better association than the others (Figure 8.8 (b)(d)(f)). In the scattergrams between local integration and movement rates, despite of a similarity in their general trend, those of sample B (Figure 8.9 (a)(c)(e)) have a stronger association than the scatters of sample-A in the unintelligible area (Figure 8.9 (b)(d)(f)). All the scatterplots confirm the finding that intelligibility is a positive intervening variable between the cognitive map variables and observed movement patterns.

On this basis, two conclusions can be drawn regarding the impact of the intelligibility of respondents' immediate environment on these relationships. First, in the relation between the frequency of occurrence of elements and vehicular and total movement, the correlation is much stronger in the intelligible area than in the unintelligible area. However, for pedestrians, people in the unintelligible area may be more likely rely on recognisable spatial features in their local journeys. Given this, we might infer that if people have difficulty in reasoning about their spatial layout, they tend to depend on the importance of landmarks in building their cognitive image. In other words, they become more reliant on simple spatial knowledge in reasoning about in an unintelligible area.

Second, with regard to the association between the syntactic properties of the sketch maps and movement rates, there is a consistent pattern in these relationships for all modes of movement. The association is much stronger in the intelligible area than the unintelligible area. Unlike the frequency of appearance, intelligibility has a consistent and positive impact on the association. Within this context, it can be concluded that intelligibility promotes the association between spatial cognition and spatial behaviour.

8.5 Conclusions and implications

From a review of all these findings, several points can be made. First, we have identified the association between movement patterns and the properties of sketch maps. Two variables from the sketches - the frequency and the local integration of configuration - are strongly related with movement rates. Frequency is the best predictor in explaining all the movement rates. This association is much stronger than that of spatial configuration in the real map. This suggests that the sketch map is a reliable source in accounting for patterns of space usage. Local integration of the sketch map also shows a clear association. Vehicular movement is better explained than pedestrian flows by the sketch map.

The critical discovery here is that all these correlation coefficients suggest a close connection between movement and a purely cognitive measure of spatial configuration in the human mind. No account has been taken of possible 'attractors'. Nevertheless, the result proves spatial behaviour can be well predicted from sketch maps.

Second, cul-de-sacs and footpaths are identified as outliers in the above association. However, neither of these has a negative impact on the relationship, since removing one or both from the scatters weakens the association. These spaces rather conform to the general tendency of the relation.

Finally, intelligibility has a positive influence on all the associations found. The comparison of the scatters between the two samples confirms clear differences in the strength of the connection. Morphological intelligibility thus allows an individual to obtain a more comprehensive spatial knowledge at the psychological level and this provides for confidence in his or her spatial behaviour. Morphological intelligibility provokes an enhanced intelligibility in the mind in reasoning about an area. Indeed, morphological and psychological intelligibility lead to the legibility of a whole area from an individual's own immediate environment, thus people employ their mind map more efficiently in their spatial behaviour.

In conclusion, this investigation confirms sketch maps as a prime generator of movement in explaining human behaviour. These findings provide an empirical link in the relationship between spatial cognition and spatial behaviour. This sheds light, not only on the theoretical and methodological issues associated with natural movement theory, but also more broadly, in studies of the built environment and human behaviour.

Chapter Nine

THE INTEACTION OF SPATIAL CONFIGURATION, SPATIAL COGNITION AND SPATIAL BEHAVIOUR

9.1 Introduction

The principal objective of this chapter is to integrate three domains: spatial configuration, spatial cognition, space use patterns. All the findings are integrated in an attempt to understand how the built environment influences cognition of, and behaviours, in the physical environment, and how spatial cognition interacts with space use pattern. In this context, an attempt is made not only to integrate our understanding in these three domains but also to interpret each one within a single framework. This analysis may be valuable by extending these partial understandings because it enables a more systematic analysis that may reveal points of convergence and divergence among the three domains.

The interrelationships of these three areas are investigated using multiple regression analysis. Firstly, their interaction is examined, focusing on the ways in which configurational elements, cognitive maps and space usage patterns co-vary. Secondly, the impact of intelligibility on this interaction is investigated. Finally, a conceptual framework is proposed for describing the interface between human and the physical built environment through the interaction between and among these three domains.

9.2 Integration of spatial configuration, spatial cognition and spatial behaviour

9.2.1 Understanding spatial cognition

Table 9.1 shows the multiple regression analysis of two cognitive variables on movement rates and configurational variables. Normalised frequency on the appearance of spatial elements and the local integration of the spatial configuration of sketches act as dependent components in two equations.

Table 9.1 Stepwise multiple regression analyses of the sketches' variables on movement and spatial configuration

	r	*r squared*	*df*	*t*	*p*
ln(frequency)	0.841	0.707	97		
ln(total movement)				8.85	≤0.0001
local integration				3.87	0.0002
local integration of sketch maps				-3.65	0.0004
Local integration of the sketches	0.763	0.582	97		
local integration				5.01	≤0.0001
ln(total movement)				2.90	0.0046
ln(choice value)				-2.04	0.0043

Looking at the regression of the normalised frequency on these variables, the greatest factor is total movement rate with a *t*-value of 8.85 ($p<0.0001$). Local integration follows at $t = 3.87$ ($p = 0.0002$). The local integration of the sketches has a t value of -3.65 ($p = 0.0004$). The regression shows a very strong correlation at r = 0.841. The r-squared value suggests that nearly 70% of the frequency can be explained with this regression. It suggests that the frequency of appearance of configurational elements in sketches, which is a measure of spatial cognition in the human mind, is due mostly to spatial behaviour, followed by the local integration of configurational characteristics.

When the local integration value of the internalised configuration on sketches is taken as a dependent variable, the situation reverses. Local integration becomes the primary factor (t = 5.01, $p < 0.0001$) with total movement in second place (t = 2.9, p =0.0046), closely followed by the choice value at t = -2.04 (p = 0.0043). The correlation is powerful at r = 0.763. This suggests that local integration of the sketch maps is influenced primarily by local integration in the real world, and secondly, by total movement. Local integration of syntactic characteristics in the mind are mostly influenced by spatial configuration in the reality, and this is supplemented by spatial behaviour.

The comparison of r-squared values suggests that the frequency of the street segment on the sketches, i.e. simple quantitative knowledge of spatial configuration, is better than the syntactic properties of sketch maps, which reveal complex knowledge of spatial configuration.

Table 9.2 The comparison between simple regression and multiple regression of cognitive variables on spatial configuration and behaviour

Cognitive variables	Spatial configuration (local integration)	Spatial behaviour (total movement rate)	Spatial configuration + spatial behaviour (multiple regression of local integration and total movement rate)
frequency	0.707	0.805	0.841
local integration	0.7	0.746	0.763

Table 9.2 compares correlation coefficients in simple and multiple regressions between the two sketch map variables and local integration and total movement. As can be seen from the table, the frequency is highly correlated at r=0.841 (p<0.001) with multiple regression analysis on local integration and total movement rate, which shows much more predictability than either local integration (r=0.707) or the movement rate (r=0.804) alone.

Using multiple regression of the local integration of the sketch maps on spatial configuration and behaviour we can predict more precisely sketch map of spatial configuration. The coefficient is high at 0.763. Again spatial behaviour is the primary component in the regression. The findings suggest that people cognise their built environment both by daily experience of the space and from the layout pattern of the physical environment. In this process much cognition comes from spatial behaviour and this is complemented by spatial configuration.

9.2.2 Explanation of spatial behaviour

In order to investigate the effect of spatial configuration in reality and in the human mind on movement, a stepwise multiple regression is applied. Three movements; pedestrians, vehicles and all movements, act as dependent variables in three equations.

Table 9.3 Stepwise multiple regression analysis among spatial configuration, spatial cognition and space use pattern

	r	*r squared*	*df*	*t*	*p*
Pedestrian movement	0.625	0.38	95		
ln(frequency)				-4.73	0.0011
ln(choice)				3.36	0.0073
Vehicular movement	0.875	0.766	91		
ln(frequency)				7.8	≤0.0001
global integration of sketch maps				3.9	0.0002
local integration				2.46	0.0160
total movement	0.872	0.76	97		
ln(frequency)				11.8	≤0.0001
global integration of sketch maps				4.87	≤0.0001
global integration				2.08	0.0398

The overall coefficient is r = 0.625. Table 9.3 shows multiple regression analysis of three normalised flows on configurational and cognitive variables. In the equation of the normalised pedestrian movement rates on both spatial configurations, frequency is the major factor with a t-value of -4.73 (p = 0.0011) closely followed by the normalised choice value (t = 3.36, p = 0.0073). One of the more surprising results of this analysis is that the best correlation of pedestrian movement is with the frequency and followed by the normalised choice value as a second best predictor rather than local integration. This analysis suggests that the frequency of the configurational elements on sketches is the most fundamental factor, determining the mean level of pedestrian movement, with configurational factors as an auxiliary predictor.

When the normalised vehicular movement rate is taken as a dependent variable, the normalised frequency from sketches variable becomes the greater factor (t = 7.8, p < 0.0001), global integration of the sketches is second at t = 3.9 (p = 0.0002) followed by local integration (t = 2.46, p = 0.016). The regression is very strong at r = 0.875. This analysis shows that the frequency acts as the most important contributing factor, and global integration of the sketches and the local integration of reality follow as independent components in the equation at a similar level.

As for explaining all movement, frequency is the major factor again with a t-value of 11.8 ($p < 0.0001$), global integration of sketches is second ($t = 4.87$, $p < 0.0001$) followed by global integration ($t = 2.08$, $p < 0.0398$). The correlation is very powerful at $r = 0.872$. This analysis shows frequency as the primary factor and global integration as a contributing one.

From this analysis of the three kinds of movement it is evident that frequency is the major factor in determining patterns of movement, followed by configurational variables. It suggests that spatial configuration in cognitive maps has a better relationship with the level of all movements than the local integration of reality which has been accepted as the best predictor in syntactic approach so far.

Table 9.4 compares the correlation coefficients of space use pattern on spatial configuration and spatial cognition, between simple regression and multiple regression. The local integration of reality is taken as the configurational variable, since it shows the best correlation with movement. As for pedestrian movement, local integration of spatial configuration in reality is the best at 0.587 from the simple regression, but from multiple regression on both local integration of spatial configuration and the frequency of spatial cognition, we obtain a much better correlation at 0.625. Local integration of reality is taken as the primary factor and the frequency of sketch maps as the second in the regression. For vehicular movement frequency from the sketch maps has a correlation at 0.793, and again, with multiple regression the coefficient improves to 0.875. Unlike pedestrian movement frequency is the first factor and the local integration of reality is next in the regression of vehicular movement. As for total movement, predictability improves from 0.805 with the frequency to 0.872 with both local integration and frequency. Again, local integration follows frequency, which is the primary factor in the regression.

Table 9.4 The comparison of correlation coefficients between simple regression and multiple regression of cognitive variables on spatial configuration and behaviour

Spatial behaviour	Spatial configuration (local integration)	Spatial cognition frequency	Spatial cognition local integration	Spatial configuration (local integration + spatial cognition (frequency)
Pedestrian movement	0.587	0.563	0.439	0.625
Vehicular movement	0.779	0.793	0.675	0.875
Total movement	0.746	0.805	0.656	0.872

These findings suggest that space use patterns in the neighbourhood can be explained more precisely by using both syntactic properties of spatial configuration and their cognitive representation. In other words, spatial behaviour is dependent on two maps: the axial map in reality and the cognitive map in the mind. In fact, spatial behaviour seems to be much more dependent on the cognitive map than on the real spatial configuration.

9.2.3 The integration of configuration, cognition and behaviour

Table 9.5 shows the correlation between the main configurational variables, cognitive map variables and all-day mean hourly movement flows. As can be seen from the table, all the coefficients show strong and positive relationships. Among them, the best correlation exists between the normalised frequency from the sketch maps and normalised total movement at r = 0.805. This is followed by the coefficient between local integration and vehicular movement at 0.764. The local integration of the sketches correlates with total movement strongly at r = 0.655 as well. By far the strongest configurational correlation with cognitive variables and movement is local integration with an average of *r* at 0.699 and 0.698 respectively. As for the relation of the cognitive variables with configurational elements and movements, frequency has the highest coefficient at r = 0.679 and 0.805.

Table 9.5 Correlation among spatial configuration, spatial cognition and the movement rate

	Spatial configuration					Spatial cognition			Spatial behaviour		
	global integ.	local integ.	int-veh	int(3)-veh	ln(choice)	ln(frequency)	sketch-int	sketch-int(3)	ln(pedestrian)	ln(vehicle)	ln(total)
global integ.	1.000	0.614	0.971	0.616	0.708	0.315	0.502	0.390	0.480	0.462	0.490
local integ.		1.000	0.622	0.924	0.900	**0.679**	0.691	0.728	0.585	**0.764**	0.746
int-veh			1.000	0.668	0.713	0.317	0.568	0.439	0.430	0.480	0.486
int(3)-veh				1.000	0.850	0.675	0.685	0.739	0.501	0.779	0.760
ln(choice)					1.000	0.636	0.591	0.592	0.590	0.695	0.685
ln(frequency)						1.000	0.403	0.564	0.563	0.793	**0.805**
sketch-int							1.000	0.867	0.382	0.633	0.616
sketch-int(3)								1.000	0.439	0.675	**0.655**
ln(pedestrian)									1.000	0.678	0.744
ln(vehicle)										1.000	0.983
ln(total)											1.000

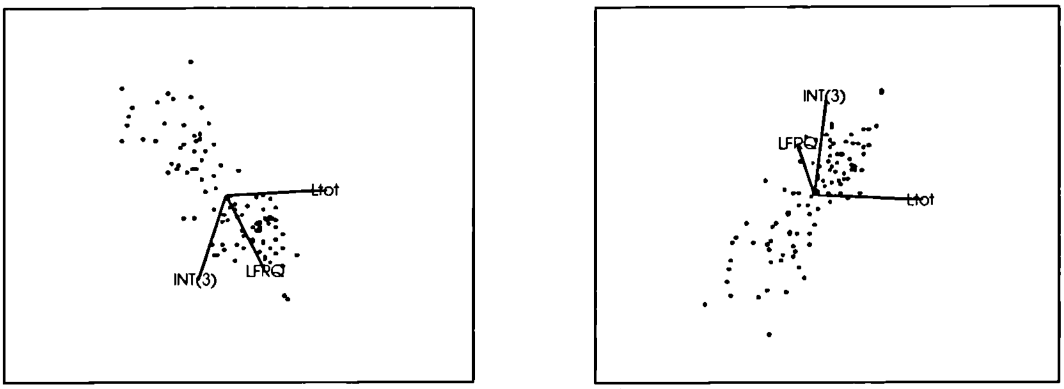
* int-veh: global integration of vehicle map; int(3)-veh: local integration of vehicle map; sketch-int: global integration of sketches; sketch-int(3): local integration of sketches

The table confirms that frequency is somewhat more powerful than local integration. This may be explained by the characteristics of the sketch, which is a representation of a mixture of information influenced by personal, societal and cultural factors in everyday life. Thus, the cognitive map may be a more accurate tool than syntactic modelling of the physical world alone for analysing the relationship between spatial configuration and spatial behaviour.

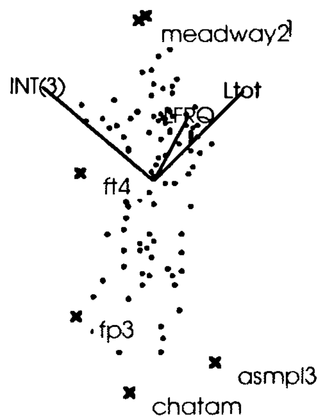
In general, global integration yields weaker relationships with the other variables. Thus it emerges that local integration from the configuration variables, frequency from the cognitive variables, and total movement flows are a representative set of the most influential factors from each of the three domains.

Figures 9.1 and 9.2 illustrate the relations between local integration, logged frequency and logged total movement flows on the x, y and z axis respectively. Locally integrated spaces, such as Meadway, the two segments of Hampstead Way intersected by Meadway, Kingsley Way, North Way adjoining the A1 and Temple Fortune Lane connected to the Finchley Road, have higher values on this plot. Conversely, cul-de-sacs and footpaths, such as Chatam Close, Brunner Close and Woodside, are clustered at the bottom of the scatters, which indicates lower values of local integration, frequency and movement flow. The figures confirm that all three variables are positively related forming a clear pattern of scatters among them. If a space has higher local integration it has a tendency to have higher frequency and movement flow. This indicates clearly how the three factors: spatial configuration, spatial cognition and spatial behaviour, are interrelated with each other.

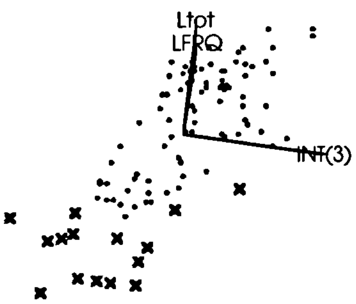
Figure 9.2(a)-(b) also shows the outliers of the scatterplot in the relationship, marked as 'x', from two different angles to examine their characteristics. Figure 9.2(a) illustrates outliers which are located relatively remotely from the main body of data. As can be seen from the figure, all the marked points are identified as cul-de-sacs: Chatam Close (chatam), Asmunse Place 3 (asmpl3) and footpaths (ft3 and ft4). The upper two scatters, Meadway 1 and 2, are the two



(a) (b)
Figure 9.1 The association among local integration, frequency and all movement rates



(a) Scatters far outlied from the main cloud of data



(b) Group of scatters from the main body of data

Figure 9.2 Two different view of outliers from the correlation among the three variables highest points in the system. Figure 9.2(b) illustrates all footpaths and cul-de-sacs in the scatter. These spaces are gathered at the bottom in relation to the others and behave as outliers.

This confirms that both footpaths and cul-de-sacs have a lower value in their local integration, frequency and movement. These spaces are locally segregated, recognised rarely, and produce low movement. However, they do not deviate from the general trend of the relationship. These results confirm the findings of chapters 6,7, and 8, that these spaces are outliers in all the relationships between these three variables.

9.3 The effect of intelligibility on the association

Once the positive relationships among the three variables are revealed we hypothesis further that intelligibility has a role in their association. In this section, the role of intelligibility is investigated and whether it facilitates and/or inhibits the interrelationship among cognition, configuration and behaviour.

Two sets of correlations coefficients among the three variable; one for the intelligible, the other for the unintelligible area, are now compared to investigate the effect of intelligibility on the relationships. Table 9.6(a),(b) shows the correlation for subjects in the intelligible area and in the unintelligible area, respectively. As can be seen from the tables there is a difference in the pattern of the relationship between the two groups. The frequency measure for subjects in the intelligible area shows higher coefficients with local integration and all movement rate at $r = 0.604$ and 0.677, than for subjects in the unintelligible area at $r = 0.463$ and 0.573. This suggests that the spatial cognition of people in the intelligible area is better correlated with local integration of the physical environment and movement patterns than that of people in the unintelligible area.

Table 9.6 Correlation among normalised frequency, movement and the local integration of subjects

(a) Coefficients in the intelligible area

Pearson Product-Moment Correlation

No Selector

	INT(3)	FRQi	Ltot
INT(3)	1.000		
FRQi	0.604	1.000	
Ltot	0.746	0.677	1.000

(b) Coefficients in the unintelligible area

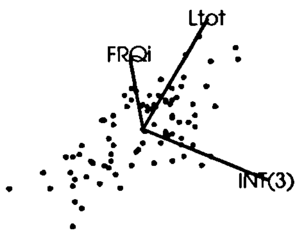
Pearson Product-Moment Correlation

No Selector

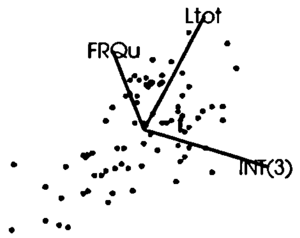
	INT(3)	FRQu	Ltot
INT(3)	1.000		
FRQu	0.463	1.000	
Ltot	0.746	0.573	1.000

The scattergrams (Figure 9.3(a)-(f)) confirm these findings by showing a big difference in the pattern of the association between the two groups. The overall shape of scatters in the intelligible area is much tighter and denser than those of the other group, which are more diffused as a whole. All the scatters for pedestrian, vehicles and total movement flow show the same consistent pattern, which indicates a better relationship in the intelligible area than in the unintelligible area.

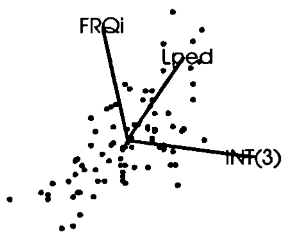
From these findings it can be concluded that there is clearly a positive impact of intelligibility on these association. The association among the variables in the intelligible area are stronger than for people in the unintelligible area. This may imply that intelligibility in a place allows individuals to gain spatial knowledge in more rational ways and to exploit this in their use of the built environment.



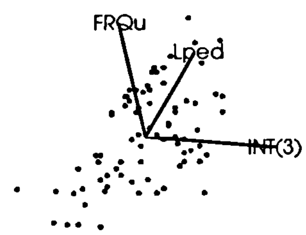
(a) total movement - the intelligible area



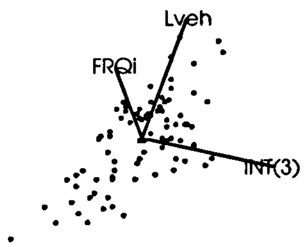
(b) total movement - the unintelligible area



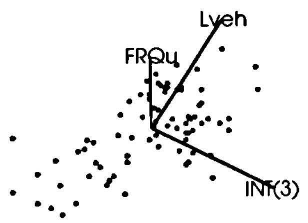
(c) pedestrian movement - the intelligible area



(d) pedestrian movement - the unintelligible area



(e) vehicular movement- the intelligible area



(f) vehicular movement- the unintelligible area

Figure 9.3 The correlation among local integration, normalised frequency and normalised total movement for the intelligible and the unintelligible area

9.4 A conceptual framework for the transmission of configurational knowledge between humans and the built environment

The process of an individual's understanding of the physical environment, and their behaviour within it involves a complex set of variables. A framework is proposed to explain the transmission of configurational knowledge in the interaction between humans and the physical built environment. This includes two mechanisms which correspond with the outer world and inner world of individuals. The former includes physical aspects of the built environment, spatial configuration in this study, the latter covers an individual's psychological and mental ability in cognitive representation.

The current body of knowledge explains the psychological process of cognition and perception as a discrete system, in the human-environment relation. The human mind continuously communicates with the built environment and behaves as an intervening variable between spatial configuration and spatial behaviour. Spatial behaviour is the outcome of this process in the built environment. In investigating the impact of the physical environment, we propose intelligibility as a basis for understanding the system, because it works as an intervening variable within the system. All the findings in the analytic chapters of this study support the contention that intelligibility is a very salient intervening variable between and among these three domains, so that it characterises all interactions in the framework. Intelligibility encourages and/or hinders the psychological and behavioural outcomes.

Based on these research findings, a framework explaining the transmission of configurational knowledge is proposed in Figure 9.4 and 9.5. This explains the association of spatial configuration, spatial cognition, and spatial behaviour, and the role of intelligibility in the system. It proposes that intelligibility acts as an intervening process affecting how spatial configuration influences spatial cognition and spatial behaviour, and how spatial cognition and spatial behaviour interact with each other.

Intelligibility is the factor promoting the association of the variables within the system, and influencing all the processes from spatial configuration to spatial behaviour through both the intervening variable of the cognitive mapping process and the direct impact of spatial configuration on spatial behaviour, as well as the interaction between spatial cognition and spatial behaviour, including the feedback process of spatial behaviour to spatial cognition. All these processes are affected by intelligibility. Thus, spatial configuration itself plays a positive role in the understanding of, and the use of space, quantitatively and qualitatively. In other words, intelligibility characterises the legibility of the built environment, and as a consequence, the pattern of space usage. This issue will be explored further with reference to the conception of intelligibility in architectural design rationales in the final chapter.

This model is useful in understanding how spatial forms enhance and/or deter human understanding of the physical built environment, and subsequent behaviour in the built environment. It shows how the system works in every possible interaction between the objective spatial characteristics and the more subjective characteristics of spatial cognition and behaviour, directly and indirectly. As suggested in earlier chapters, the current definition of intelligibility, which describes objective spatial characteristics purely morphologically, has no proved impact on human psychology. Its definition therefore needs to be expanded to include its implications for the work of the human mind and everyday behaviour.

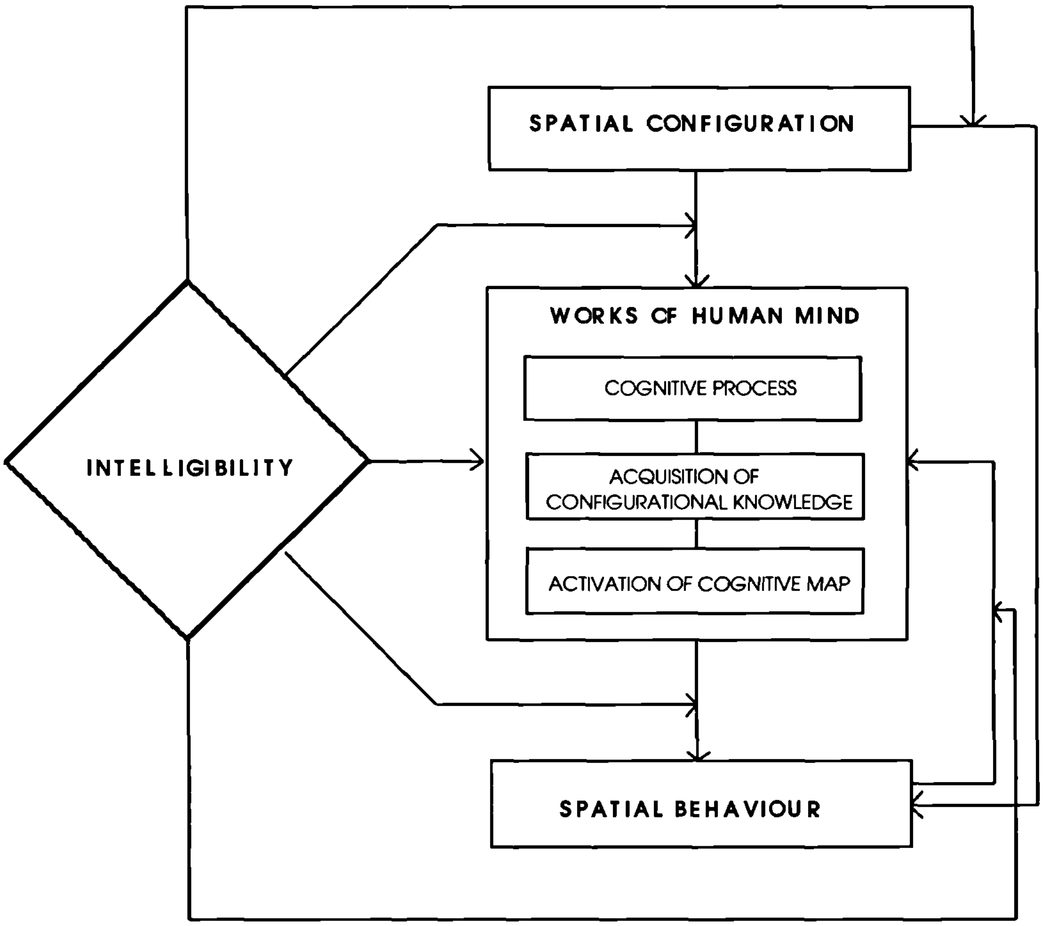


Figure 9.4 A paradigm for the interface between spatial configuration, spatial cognition and spatial behaviour

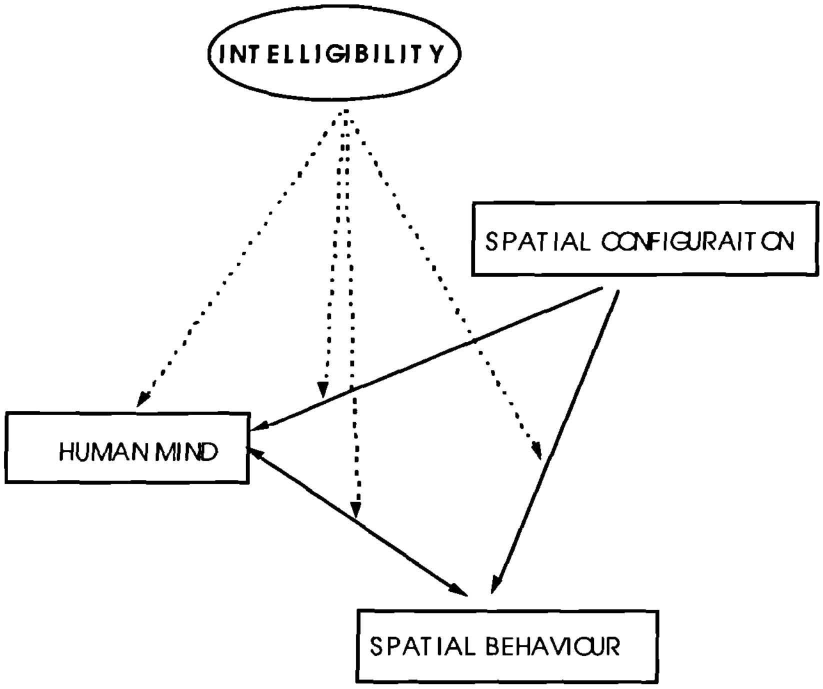


Figure 9.5 The role of intelligibility in the interface

Chapter Ten

CONCLUSIONS: TOWARDS AN INTERFACE BETWEEN MAN AND BUILT ENVIRONMENT

10.1 Introduction

This thesis aimed to investigate the interrelationship of spatial configuration, spatial cognition, and spatial behaviour in a single framework interfacing the human and built environment, and the role of morphological intelligibility within it. This thesis thus is intended as a systematic, theoretical attempt to shed light on studies investigating the relationship between the built environment and spatial behaviour, through the use of detailed empirical evidence.

The aim of this final chapter is to integrate all the findings, and to review them in the wider context of architectural theories, particularly those which focus on the relationship between man and the built environment. First, it attempts to synthesise morphological analysis and residents' cognition of the Suburb. Then it returns to the discussion of social ideals and design concepts of the Suburb to review the way these are realised in space and their consequences for people's spatial experience in cognition and behaviour. Second, it discusses the findings on the relationship among and between spatial configuration, spatial cognition and spatial behaviour, along with the role of intelligibility within it. Third, it proposes an extended notion of Hillier's morphological intelligibility. Fourth, it discusses how the proposed paradigm fits in architectural theory. Finally, it defines a concept of 'architectural intelligibility', and proposes that this is an important basic human need.

10.2 Morphological and cognitive understanding of Hampstead Garden Suburb

Among all the findings of the morphological analyses suggest that the Suburb has 'onion-like' shape in its spatial structure, along with an intelligible half and an unintelligible the other not only in terms of the global context but also in terms of its internal structure. These dissimilar characteristics of neighbourhood spatial structure appears to bring about a sharp contrast in residents' perception and cognition of the Suburb. This intelligibility of people's immediate environment seems to have a positive effect on their understanding of street layout, and experienced ease of wayfinding at the cognitive level.

Third, the size of the perceived neighbourhood is affected by the intelligibility of the residents' neighbourhood. People who live in the intelligible area extend their boundaries across the whole local area, but those in the unintelligible area were concerned mostly with their immediate neighbourhood, so that their perceived neighbourhood is smaller.

Fourth, the image of spatial layout of the whole area is affected by the intelligibility of an individual's immediate neighbourhood. The spatial layout of the immediate neighbourhood, in which an individual's everyday activity is conducted, has the main role in determining a cognitive representation of the whole area. If a subject's neighbourhood's spatial layout is intelligible then his cognitive representation of the whole local area becomes intelligible as well. Conversely, if a neighbourhood is unintelligible, residents' cognitive representations of neighbourhoods are unintelligible too. This suggests that the intelligibility of a person's neighbourhood's spatial structure is, indeed, one of the major intervening variables that brings the spatial and psychological dimensions together.

These findings provide an important input into research on spatial cognition studies which use analytic descriptions of internalised representations of spatial configuration. At the same time, they provide a psychological dimension to research on the role of spatial configuration in spatial behaviour. This enables the exploration of further issues concerning the relationship between human cognition and the built environment, especially understanding the relation between the cognitive representation of configuration and human spatial experience.

On the basis of these findings, the discussion then moves to how Barnett's social ideals and Unwin's design concepts of Hampstead Garden Suburb are realised in space and in its perception and cognition. As reviewed in chapter four, Barnett wanted the Suburb to be an ideal community where people of all social classes and levels of income could live in harmony. In accordance with her dream, Unwin designed the Suburb with a variety of picturesque views in both spatial layout and landscape. However, the consequence of this spatial realisation appears to have crippled their dreams in terms of people's spatial experience. This can be explained with reference to the layout's syntactic characteristics. First, the Suburb is syntactically segregated from surrounding areas. In addition it does not have an intelligible layout within its global context. Second, the Suburb is in two halves. One area is relatively intelligible, the other less so. Finally, the Suburb has an 'onion-like' shape spatial structure that consists of a series of layers. It has hidden footpaths as connections between the layers. This is likely to lead to a difference in the spatial experience of strangers and residents. These morphological characteristics result in more than the physical segregation of the spatial structure.

This conjecture, at the more practical level of the creation of spatial form, leads inevitably to a discussion of how spatial configuration can be consolidated into design rationales, since understanding spatial configuration and the activity of design are closely intertwined. A major cause of the recurrent misdirection of modern residential area design appears to be because of a widespread lack of understanding of spatial configuration, hence the urgent need to clarify this concept. This is comprehensively discussed in the next two sections.

10.3 The relationship among spatial configuration, spatial cognition and spatial behaviour

This section reviews the main findings on the relationship between and among spatial configuration, spatial cognition and spatial behaviour. Then it discuses their implications.

First, the investigation of the relationship between spatial configuration and spatial cognition demonstrates that the effect of spatial arrangement on spatial perception and cognition is statistically significant. Both the frequency of occurrence of elements and their syntactic properties in sketch maps are highly associated with the actual spatial configuration. Frequency is highly correlated with all the syntactic values. The syntactic properties of spatial configuration in residents' sketch maps are also associated with syntactic variables in reality. Local integration shows the best correlation with both the frequency and local integration of sketches. Local integration in the real world is associated best not only with simple spatial knowledge of the frequency, but also with complicated configurational knowledge.

Intelligibility is the intervening variable in this relation. There is a fundamental difference in the way the spatial configuration of an area is internalised and represented according to the intelligibility of the subjects' neighbourhood, even though they are in the same local area. People living in an intelligible area has more integrated spatial layout than that of people in an unintelligible area. The same applies to the intelligibility of spatial configuration in sketch maps. Although both groups in the sample have a similar number of configurational features on their sketch maps, the way of relating these features is quite different. It is found that people in an intelligible area represent them as much more integrated and have an intelligible layout about them. In other words, in spite of similar amounts of spatial elements in sketches, the organisation of these elements is affected by the intelligibility of people's immediate built environment.

Second, the investigation into the relationship between neighbourhood morphologies and patterns of movement confirms Hillier et al's (1993) natural movement in this purely residential area. For pedestrian movement the local integration and choice value are correlated to a similar degree. However, comparison of these data reveals that the former shows slightly better association. For vehicular movement, local integration of the vehicular axial map shows the best correlation. In the case of total movement, local integration of the pedestrian map including all the footpaths has the best correlation coefficient. The higher correlation coefficients of spatial configuration with movement, coupled with the peak in the movement density, may suggest that early evening movement is the most characteristic of the spatial culture of the Suburb.

The major issue in this investigation is whether 'intelligibility' has any consistent impact on these relationships. A positive role for intelligibility is detected. An intelligible area demonstrates better average correlations than an unintelligible area. Intelligibility again is the intervening variable in the relation between spatial configuration and spatial behaviour.

Third, as might be expected from the positive relationship of spatial configuration with both spatial cognition and spatial behaviour, the cognitive map is positively associated with space use patterns. Both the frequency and the syntactic properties of spatial configuration in sketch maps are significantly correlated to pedestrian and vehicular movement rates. Frequency on sketches is correlated best with all the movement rates. Among all the syntactic properties of sketch maps, local integration is found to have the best correlation with movement. Vehicular movement shows a stronger relationship than pedestrian movement. Sketch maps, which are the outcome of spatial cognition, are found to be of considerable importance in characterising the pattern of movement distribution and in predicting it.

It has also been found that, in the intelligible area, there is a stronger association between the syntactic properties of sketch maps and movement patterns than in the unintelligible area. The comparison between the two sample scatters confirms a clear difference of patterns by showing a denser and tighter association in the intelligible area. Thus intelligibility is a salient intervening variable that encourages a positive association between spatial cognition and spatial behaviour.

With this empirical evidence of association between each pair of domains respectively - spatial configuration and spatial cognition; spatial configuration and spatial behaviour; spatial cognition and spatial behaviour - we can now interpret how they interact within a single framework, focusing on the ways in which spatial cognition and behaviour co-vary with the other two variables within the system. As discussed in chapter nine, spatial cognition can be explained by multiple regression analysis on spatial configuration and behaviour, which has better predictability at r=0.841 than either spatial configuration (r=0.707) or behaviour (r=0.804) alone. Among these two, movement that represents spatial behaviour in everyday life, is the dominant factor. As for the regression of spatial behaviour on spatial configuration and spatial cognition, it has much more powerful coefficient at r=0.872, higher than that with only spatial configuration (r=0.746) or with spatial cognition (r=0.805). It seems clear that, with both the cognitive map and the axial map, we can much improve the predictability of space use patterns. The evidence suggests that the sketch map predict observed movement better than a syntactic description of spatial configuration.

These strong correlations suggest that the association among the three variables - spatial configuration, spatial cognition and spatial behaviour - is clearly positive. The three variables are related positively forming a clear pattern of scatters as shown in Figure 9.1. Evidently all three domains interact and are interdependent with each other.

All these findings lead to discussions about their implication within existing knowledge. First, Hillier's morphological intelligibility seems to be a prerequisite for attaining legibility in the built environment. For a long time, Lynch's 'imageability', which is determined by the five elements - paths, edges, districts, nodes and landmarks - has been centred on the analysis of cognitive representation. However, an obvious problem with respect to his analysis is that, since it is based on disaggregation of represented spatial elements, it can not account for the characteristics of their aggregation. Thus Lynch failed to incorporate configurational effects on imageability. Nevertheless, he admitted the importance of patterns of high continuity and of the interrelationship of spatial elements for evoking a strong image.

This research found that people have more difficulty in sketching the spatial layout of an area if they reside in an unintelligible part of an area. This area has broken relations between global and local properties. The investigation in Chapter six to eight provides empirical evidence that intelligibility facilitates the representation of spatial configuration. It is found that, in an intelligible area, people have a better understanding of spatial pattern, and their wayfinding behaviour is relatively invariant. In addition, it has been found that the effect of landmarks on sketch maps and movement patterns is not significant. These findings support a strong conjecture that spatial configuration causes the most fundamental differences when representing spatial layout and using spaces. Imageability appears to be based on spatial configuration at a cognitive level in the mind. In other words, Hillier's intelligibility is likely to be a prerequisite to Lynch's imageability. These findings provide strong empirical support for conjectures, referring to the psychological effects of spatial configuration, raised by the syntactic approach. Now we certainly have theoretical links between spatial configuration and spatial cognition.

Second, the transmission of configurational knowledge from the built environment can be facilitated and/or impeded by spatial configuration in reality. It may be explained by the degree of relationship between the two sets of spatial knowledge, which affect their acquisition. As Golledge and Stimson (1997) point out, configurational knowledge consists of two complementary sets of spatial knowledge acquired in the process of spatial learning: knowledge of global structure at cognitive level, resulting from long term exposure to the built environment: and intuitive knowledge about a more immediate environment at a perceptual level.

According to Hillier's definition of intelligibility, in an unintelligible area, the relationship between global and local integration has collapsed. He conjectures that the generic function of spatial structure is inhibited in this situation. In addition, empirical findings of this thesis confirm that intelligibility brings a big contrast in the relationship between spatial configuration, spatial cognition and spatial behaviour. These provide the strong conjecture that the relationship between the two sets of spatial knowledge is broken as well in the human mind, since spatial learning can be limited by morphological intelligibility. This results in poor cognitive maps and less predictable space use. In other words, the broken relationship between two sets of spatial knowledge is likely to inhibit the transmission of configurational knowledge from the physical environment.

Finally, another important discovery here is that a strong correlation between spatial cognition and spatial behaviour is produced by purely cognitive measures of spatial configuration. No account has been taken of generators of movement, such as spatial configuration or land use, in constructing the association. However, the frequency of configurational features in sketch maps has a better correlation than that of syntactic properties in reality in predicting movement. As Garling et al (1986) pointed out, the purpose of the cognitive map is to aid the planning of movement, which deals with complex sets of information not only from the observable physical environment but also from memories of the environment as experienced in the past, along with other varied social, cultural, political and economic factors. Thus investigation of cognitive maps is likely to generate better prediction of movement than axial maps of spatial configuration.

The finding of this positive association between internalised representations of spatial configuration and movement patterns allows theoretical and methodological progress in investigating the man-environment relation. It provides empirical links between the cognition and behaviour. Particularly, since internalised representation of spatial configuration has not been a research agenda in predicting spatial behaviour quantitatively. The approach adopted here, along with syntactic analysis of spatial layout in sketch maps, could be a useful tool. It allows some general statements to be made about the characteristics of internal representations of configuration and their consequences for behaviour. This will shed light not only on the theory of natural movement, but on more general studies of the built environment and human behaviour.

10.4 Reflections on intelligibility in architectural theory

When morphological intelligibility is considered, it opens up further discussion about the possibility of extending its current definition, and its role in shaping spatial experience.

As revealed by this research, spatial cognition and spatial behaviour are differentiated by the morphological intelligibility of the neighbourhood. People in an intelligible area build better-developed cognitive maps than the people in an unintelligible area. At the same time, their configurational knowledge is more intelligible and more comprehensive, presumably because morphological intelligibility facilitates the acquisition of global understanding from local understanding. In other words, in an intelligible area, on the basis of locally acquired spatial knowledge, it is possible to build up useful global spatial knowledge. In this context, intelligibility does not seem to be only a thing in reality but a thing which exists in the mind as well. These empirical findings suggest that an axial representation of spatial configuration is not just a syntactic view of the physical environment since it reflects our memories of experience as well. It may provide a linkage between the way people perceive their physical environment and the ways in which they communicate about it.

However, Hillier's definition of intelligibility is about the correlation between local and global spatial properties. It is purely morphological. It is only a mathematical way of describing spatial configuration. As shown by this work, morphological intelligibility leads to more intelligible cognitive mapping of an area, through comprehensive configurational knowledge, which further influences spatial behaviour positively as well. Intelligibility thus seems to be not only a static property of systems but also affects the process by which the mind acquires spatial knowledge.

This intelligibility in the mind appears to relate local and global spatial knowledge reasoning about spatial structure. Spatial structure has an obvious structure that can be grasped immediately, and a potential structure, which will allow one gradually to construct a more complex and comprehensive picture. The former is spatial knowledge of the immediate environment (that is, local configurational knowledge) and the latter relates to the more global configurational knowledge, coming from a global context. The relation between these two sets of spatial knowledge result in differences in the degree of spatial learning. This intelligibility of configurational knowledge in the human mind gives an indication of the degree to which it is possible to reason about how the whole structure is likely to be.

This extended notion of intelligibility recognises the importance of spatial reasoning in the human mind - it is not just a topological geometry for representing the physical environment. It also reflects a flexible and complex representation to capture and explain the results of cognitive mapping. On this basis, Hillier's intelligibility needs to consider two complementary sources: the psychological approach at the cognitive level about the way people experience and perceive the physical environment as well as the formal mathematical approach. More-over the axial representation of spatial configuration seems to reflect human cognitive understanding of spatial structure in some degree. It appears to describe a psychological effect upon the human mind and a behavioural impact on the pattern of space use. This perspective to the syntactic description of spatial reality is intuitive to use and would provide powerful reasoning capabilities and methods for examining perception and cognition in understanding configuration.

Architecture and urban design is about the organisation of elements and ultimately controls the intelligibility of the system. This allows the elements to come together to form a global whole in reality. On this basis a building or urban area has great potential to excite the mind by enhancing the degree of spatial control, through promoting confidence in spatial choice. Thus, creating a space seems to define the transmission of configurational knowledge. More importantly, these are what makes architectural form intelligible to us. At the same time, this enables us to behave rationally, which would seem to be a precondition for the social function of the city.

10.5 The interface between spatial configuration and spatial experience

This dissertation has presented a general and systematic investigation concerning the role of spatial configuration within the man-built environment research framework. All the findings can be directly applied to a theory of environment, cognition and action, and a theory of built environment and behaviour. This section discusses the implications of the proposed paradigm and the findings within this study.

The understanding developed through this integrated approach suggests that spatial configuration cannot be considered as a peripheral speciality of little interest to built environment and behaviour study as such. On the contrary, it has an essential contribution to make to the study. However, most research to date has failed to incorporate the role of spatial configuration.

As discussed in chapter two, in spite of making a considerable contribution in investigating the man and built environment relation, cognitive approaches seem to side-step the central problem of the interaction between spatial configuration and human spatial experience. They seem to have failed to incorporate configurational aspects objectively in their research frameworks. This conventional research posits the human mind as an intervening variable between the objective physical environment and subjective human behaviour, without direct reference to spatial configuration. On the other hand, the syntactic approach has not consolidated human agency in its man-environment paradigm. Thus it has also failed to investigate the role of internalised representations of spatial configuration. This is not to suggest that environmental cognition does not include a notion of spatial configuration. It rather implies that the methods should be adopted which understand spatial configuration both in the mind and reality as an analytical and describable phenomenon. In a similar vein, it does not imply that the syntactic approach to the physical environment in understanding spatial behaviour is not enough. This approach needs to take its place in the company of cognitive approach, since spatial experience is a humanistic discipline.

This thesis has shown how the theoretical positions of spatial cognition and the syntactic description of spatial configuration can be combined in an integrated approach to understanding spatial experience. The linkage among the three variables within a single framework enables an in-depth understanding of the role of intelligibility between spatial configuration and spatial experience. This role provides a crucial complementary perspective to existing knowledge. There is certainly a symmetry between the cognitive approach to spatial experience, and at the syntactic approach to spatial behaviour. Such an integration is the beginning of a systematic account of the interrelationship between spatial configuration and its experience. What is needed judging from current gaps in the two fields is a shift in attention, through an integrated approach, to this interactive process.

The conceptual framework proposed in Figure 9.4 has been built upon a theoretical and empirical stance. It has benefited not only from the empirical findings of syntactic description of spatial configuration and natural movement, but also from an analytic inquiry into its cognitive representation. By applying this framework some indication has been provided of what the problems are in the argument presented.

In conclusion, this incorporation of spatial configuration into the built environment and behaviour relationship implies a specific understanding of the role of intelligibility in environmental cognition and behaviour. The conception of extended intelligibility, as a morphological and psychological phenomenon, has been suggested as the intervening variable that interfaces spatial configuration and spatial experience. An important consequence of this conception is that understanding spatial experience must be conceived as a continuous conversation between the objectivity of configuration and the subjectivity of cognition or it will lose its proper object of inquiry. This may provide us with new architectural rationales, since this extended definition of intelligibility appears to be a central problem in describing architectural legibility.

10.6 Architectural intelligibility and the sense of autonomy

The research literature has documented many situations where dysfunction of the built environment has interacted with psychological goals to produce negative outcomes for users or vice versa (e.g., Weisman, 1981; Kaplan and Kaplan, 1983; Garling, 1986). This thesis has also provided empirical evidence that spatial configuration facilitates and/or hinders well-developed cognitive representation and much predictable patterns of space usage.

In the real world, this interaction is bound together, not only by spatial structure but also by the specific way in which those environmental elements are mingled in physical and social networks. It is formulated continuously with respect to the built environment and other human beings, either positively or negatively. Thus this interaction between built environment and spatial experience can be viewed as an ongoing process. I define the basic functioning of this process as 'architectural intelligibility'.

In this perspective, architectural intelligibility generally refers to bringing about desired levels of spatial experience, that is, achieving desired outcomes. It can be described as the fundamental nature of active belief that one has a choice among responses that are differently effective in accomplishing the desired outcomes. The notion of architectural intelligibility depends primarily on the process of achieving those outcomes rather than on the outcomes themselves.

Doyal and Gough (1991) contend that 'autonomy' is essential for human survival, which is defined as being aware of, and having choices or alternatives for meeting basic human needs. They continue that it provides freedom to act and to make choices for desired outcomes. From this point of view, the built environment can affect individuals' sense of autonomy by shaping every day spatial experience. For example, if you are in an unintelligible area, you may lose your sense of spatial control, or your freedom might be confined to only the limited choices that are offered by its spatial structure and vice versa.

In this perspective, securing a sense of autonomy in the built environment, may require awareness of, and the existence of choices or alternatives in spatial experience. Architectural intelligibility may help us to achieve a sense of autonomy by providing choices over space usage. One's spatial choices are greatly influenced by the alternatives that make it more likely that one's needs will be met. It could be a salient factor in facilitating a sense of control over spatial structure through its degree of physical and psychological accessibility. This command of space has strong psychological consequences such as feelings of anxiety, satisfaction, pride, or submission. In this context, architectural intelligibility would be another factor at the core of achieving the sense of autonomy.

Based on these conjectures, it is tempting to suggest that architectural intelligibility meet the basic human need of autonomy in built environment. Architectural intelligibility may serve as a broad frame of reference, an organisation of activity or belief or knowledge. It not only offers security but also heightens the potential depth and intensity of human experience. Just as with one's need for food or for affection, making sense of the built environment is a continuing concern throughout one's lifetime. Architectural intelligibility thus may be crucial one's psychological well being. The need for it is the reason we search the environment for information. It is essential to one's sense of competence and is basic to human functioning, regardless of who the person is, or where he or she may be.

These conjectures need further empirical validation. The question of how or whether architectural intelligibility is directly associated with a sense of autonomy is remains unanswered in this thesis. This is for future studies.

Appendix-A: A letter for an interview survey corporation

1st October, 1996

Research Survey

Dear Sir or Madam,

University College London is carrying out research into the perception and use of space in the Hampstead Garden Suburb. The survey consists of a self completion questionnaire and it will be completed with the aid of a surveyor. It is important for us to obtain a wide range of views in order to achieve a complete cross-section of opinion. The survey would take about half an hour.

Over the next few days you may be visited by the surveyor, Mr Kim, who will ask whether you would be prepared to participate in the survey. He will carry an identification card, and will you arrange a convenient time to conduct the survey. If you do not wish to participate, please tell him then or call on 0171-504-5916, and leave your address, and I shall ensure that the surveyor does not visit you.

All replies will be treated as strictly confidential and will not be shown to any third party. This research complies with the Data Protection Act(1994).

If you have any query, please do not hesitate to contact me on 0171-504-5919.

Thank you very much for your co-operation.

Yours sincerely,

Alan Penn
Senior Lecturer

Appendix-B: Questionnaire

Interviewer:
PLEASE PROVIDE ANSWER SHEETS AND READ OUT EACH QUESTION TO INTERVIEWEE.

QUESTION 1: Sketch-map of Streets and Buildings in Your Local Area

Please sketch your local area on the paper I've handed out. Imagine that the purpose of the sketch is for a visitor as a guide to orienting himself and finding his way or buildings about on your local area. Two well-known places on your local area are placed on the paper for reference. Let's allow 20 minutes in completing the map.

Interviewer: READ OUT FOLLOWING:

- Do not refer to an actual map(including the map of question No.2)
- Figure the scale of map according to the distance between two places marked on the sheet.

QUESTION 2: The Boundary of Your Neighbourhood

This is a map of the Hampstead Garden Suburb area. Your home is placed in the map with red symbol. Please draw a boundary of your neighbourhood on a provided street map (Draw with a dotted line on which sides the boundary is not clear).

QUESTION 3: Space Use Outside Home - Diary of Trips

In this part of the survey, we would like to know about trips you have done within local area for the 24 hours from 4 am yesterday, ____/____/1996, until 4 am this morning. Please include all the trips that you did in that period. Please describe them on the sheets provided, where each of your trips began, stopped, and ended, the exact route that you taken.

Please write down the details of all the trips have done in last 24 hours period, that is all journeys that you went out beyond the house and garden such as public places outside your home, other people's houses, shops, offices, places of work or indoor recreation or shopping areas etc.

Interviewer: READ OUT FOLLOWING IF THEY DO NOT UNDERSTAND THE QUESTION.

Please include all occasions for example when you were:

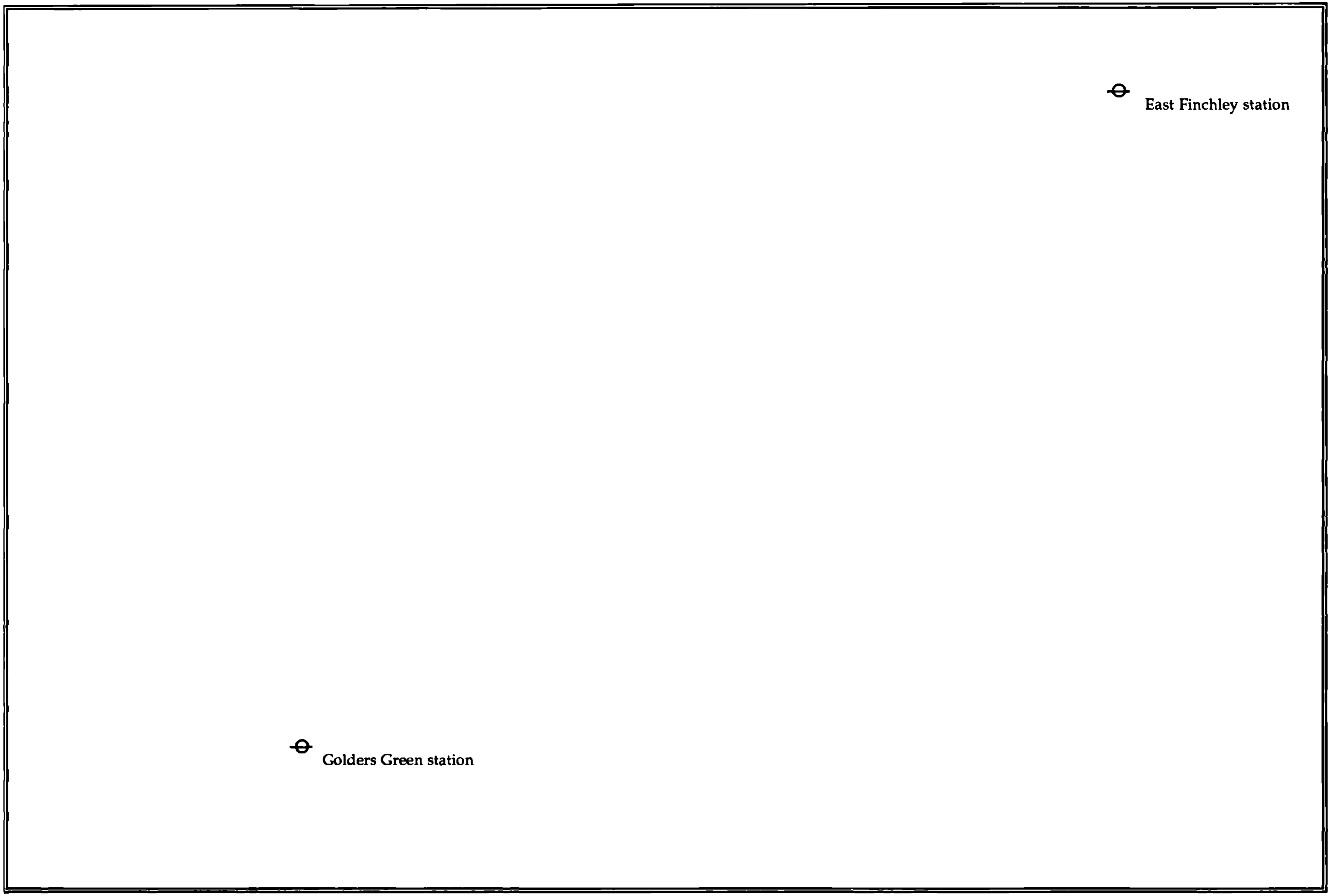
- Outside to talk to someone
- Playing a game in the street
- Posting a letter
- Going to the grocery
- Visiting the corner shop
- Walking to or from a bus stop / tube station etc.

QUESTION 4, 5: Self - completion questionnaire

FOR OFFICIAL USE ONLY			
Questionnaire No	: ____________	Interviewer Initial:	______
Intelligibility Code	: ____________		
Street Code	: ____________	Date	: ________
Building No	: ____________	Time	: ________
Household No	: ____________		

INTRODUCTION

Thank you for agreeing to help us with this project. The first part of the question is about your views of area where you live. And the second part, question 4 and 5, is the self completion questionnaire which will ask you what you feel about your area and for more information about yourself.


East Finchley station
Golders Green station


Fortis Gree
East Finchley
Hampstead Garden Suburb
Golders Green
Golf Course
Reservoir (covered)
Highgate School
Lyttelton Playing Fields
Hampstead Golf Club
Bunkers Hill
Hampstead Heath Extension
Big Wood
Little Wood
St Marylebone Cemetery
Garden of Remembrance
Synagogue
Works
FINCHLEY ROAD

3.DIARY OF TRIPS

Trip No.	Description and main purpose	Time taken (Minutes)	Mode of travel (See reference A)	Route followed (Trace them on the map)	Reference
1	From To Purpose				A. Select appropriate number from examples? 1.Walk 2. Car/Taxi 3. Bus 4. Tube 5. motorcycle 6. Bicycle
2	From To Purpose				
3	From To Purpose				
4	From To Purpose				
5	From To Purpose				

Trip No.	Description and main purpose	Time taken (Minutes)	Mode of travel (See reference A)	Route followed (Trace them on the map)	Reference
6	From To Purpose				A. Select appropriate number from examples? 1.Walk 2.Car/Taxi 3. Bus 4. Tube 5. motorcycle 6. Bicycle
7	From To Purpose				
8	From To Purpose				
9	From To Purpose				
10	From To Purpose				

4. Post-task questions and perception of neighbourhood
This part of questionnaire is asking about the perception of your neighbourhood and some post-task questions.

Q1 How difficult did you find it to draw the boundary of your neighbourhood?
1) Not at all 2) A little 3) Some 4) Much 5)Very much

Q2 How confident you are of the boundary drawing you've just done?
1) Not at all 2) A little 3) Some 4) Much 5)Very much

Q3 How difficult did you find it to sketch your local area?
1) Not at all 2) A little 3) Some 4) Much 5)Very much

Q4 How confident you are of the sketch map you've just drawn?
1) Not at all 2) A little 3) Some 4) Much 5)Very much

Q5 What area do you see as the centre of the Hampstead Garden Suburb area? Is there one building, street or place which you see as the centre of the Suburb?

Q6 Have you ever had trouble finding your way or got lost in Hampstead Garden Suburb? How often has this happened?
1) just about whenever I walk in the area
2) fairly often 3) sometimes
4) just occasionally 5) practically never

IF 'practically never' GO TO QUESTION 8

Q7 What was the most lost you have ever become in Hampstead Garden Suburb? (Please 4 on a five point scale)

1	2	3	4	5
totally lost				**just momentarily lost**

Q8 Do you think that the street layout of Hampstead Garden Suburb is arranged in a clear and obvious pattern?

1	2	3	4	5
fairly well				**not at all**

Q9 Do you think you'd be able to direct a stranger to many places in Hampstead Garden Suburb? (e.g. parks, churches, schools, houses)

1	2	3	4	5
fairly well				**not at all**

Q10 All things considered, do you think Hampstead Garden Suburb is a relatively easy or a relatively difficult place to figure out and in which to find your way?

1	2	3	4	5
difficult				easy

Q11 The access to shops in the neighbourhood

1	2	3	4	5
satisfied				unsatisfied

Q12 The access to open spaces in the neighbourhood

1	2	3	4	5
satisfied				unsatisfied

Q13 In conclusion, your general sense of access to all facilities and places in Hampstead Garden Suburb

1	2	3	4	5
satisfied				unsatisfied

5. Resident Survey
In this part of the questionnaire, we would like to ask you a few details about yourself. This is for use in ensuring that our survey is representative.

Q1 What is your sex?
1)Female 2)Male

Q2 What was your age last birthday?
1)Under 20 2)20-39 3)40-59 4)60 or over

Q3 What is/was your main occupation,--- that is, what sort of work do/did you do?
1)Small businessman 2)Personal services 3)Professionals 4)Students
5)Office workers 6)Housewives 7)Skilled workers
Other(specify) ________________________________

Q4 How long have you been living at this address?
1)less than 1 year 2) 1- less than 3 years 3)3 - less than 5 years
4)more than 5 years (if more than 5 years, how many years: _____)

Q5 How long have you lived in Hampstead Garden Suburb?
1)less than 1 year 2) 1- less than 3 years 3)3- less than 5 years
4)more than 5 years (if more than 5 years, how many years: _____)

Q6 What is your educational background?
1) Secondary school or less 2) College degree(2 years)
3) University or upwards

COMMENTS:

Appendix-C: Cognitive variables of sketch maps and syntactic attributes of residential location

Subjects	neighbourhood area (sq km)	comprehensible elements	global choice	global integration	connectivity	local integration
1	1.571	12	160	0.793	5	2.749
2	2.633	24	32	0.751	1	1.149
3	1.143	29	165.8	0.803	6	2.945
4	1.265	26	75.2	0.749	3	2.021
5	5.388	23	135.7	0.878	4	2.354
6	1.225	13	76	0.721	4	2.212
7	3.49	52	212.8	0.865	5	2.719
8	3.347	8	90	0.892	4	2.273
9	0.978	29	438	0.849	9	3.704
10	2.49	23	148	0.809	5	2.661
11	2.51	19	91.7	0.771	4	2.273
12	3.184	34	100.1	0.78	4	2.354
13	2.306	16	241.8	0.872	5	2.845
14	4.449	17	200	0.818	6	3
15	2.816	23	88	0.762	3	1.896
16		10	235.8	0.822	7	3.25
17	2.837	30	80	0.758	3	1.959
18	1.102	16	49	0.824	3	1.724
19	0.776	16	185	0.865	6	2.933
20	2.653	29	68.8	0.735	2	1.698
21	1.02	21	81.2	0.702	4	2.212
22	1.98	20	161.7	0.853	6	2.781
23	1.327	17	84.8	0.754	3	2.14
24	3.143	18	26	0.716	1	0.704
25	4.082	18	75.2	0.749	3	2.021
26	3.284	19	196.4	0.831	6	3.022
27	0.429	29	12	0.778	2	1.001
28	3.857	25	34	0.786	1	1.019
29	1.612	20	125.7	0.821	3	2.406
30	1.224		100	0.907	3	1.959
31	1.449	37	6	0.714	1	0.211
32		19	116	0.99	2	2.028
33	1.796	16	134	0.861	4	2.312
34	3.489	33	24	0.619	1	1.019
35	0.693	12	152	0.991	3	2.454
36	0.51	34	139	0.916	6	2.929
37	0.918	17	107	0.799	4	2.396
38	1.53	14	139.2	0.793	5	2.636
39	4.244	8	59	0.798	2	1.741
40	1.612	36	413	0.878	9	3.674
41	3	28	73	0.743	3	1.896
42	1	21	320	1.009	6	3.387

Subjects	neighbourhood area (sq km)	comprehensible elements	global choice	global integration	connectivity	local integration
43	0.938	4	142	0.861	4	2.354
44	2	17	312	0.948	5	3.007
45	0.979	22	128	0.798	5	2.615
46	4.897	8	84	0.791	3	1.959
47	3.836	13	120	0.86	4	2.239
48	0.836	31	32	0.782	2	1.274
49	4.775	41	44	0.735	2	1.379
50	3.734	19	32	0.74	1	0.873
51	0.979	7	159.2	0.801	5	2.933
52	1.244	27	40	0.829	2	1.572
53	1	12	139.2	0.793	5	2.636
54	1.02		25	0.76	2	1.274
56	4.673	12	73.4	0.752	4	2.273
57	1.673	12	20	0.7	1	0.5
58	2.693	19	105.9	0.845	3	2.252
59	3.408	16	63.8	0.826	2	1.659
60	1.775	15	43	0.803	2	1.379
61	0.918	12	286.7	0.835	7	3.283
62	3.367	32	84	0.861	2	1.571
63	2.755	39	75.2	0.749	3	2.021
64	3.204	16	48	0.756	1	0.704
65	3.816	23	102.2	0.763	5	2.598
66	3.306	37	196.4	0.831	6	3.022
67	4.163	20	103.2	0.824	3	2.14
68	4.489	17	568	0.966	7	3.56
69	4.489	35	60	0.801	2	1.478
70	1.367	22	42	0.748	1	1.019
71		25	88.5	0.775	3	2.14
72		12	116	0.8	4	2.566
73	5.122	37	88.5	0.775	3	2.14
74	2.918	36	79.8	0.783	3	1.896
75	4.734	26	195	0.884	5	2.719
76	3.816	26	177.1	0.843	5	2.781

Subjects	depth from Central Sq.	depth from periphery.	depth from Finchely Road	depth from the most integrated space.
1	5	7	5	7
2	5	8	6	8
3	4	6	4	6
4	2	8	6	8
5	6	5	3	5
6	3	8	6	8
7	3	6	7	6
8	8	4	3	4
9	4	6	4	6
10	5	7	6	7
11	6	8	7	8
12	4	8	6	8
13	5	6	7	6
14	3	7	5	7
15	6	8	6	8
16	4	7	5	7
17	3	7	5	7
18	7	6	7	6
19	6	6	5	6
20	5	7	5	7
21	5	8	6	8
22	6	6	4	6
23	5	7	5	7
24	5	8	6	8
25	3	8	6	8
26	4	7	6	7
27	8	6	4	6
28	6	7	6	7
29	3	6	4	6
30	6	5	6	5
31	9	7	6	7
32	8	2	2	2
33	5	5	4	5
34	9	8	9	7
35	6	3	2	3
36	6	4	3	4
37	5	6	4	6
38	6	6	4	6
39	5	6	4	6
40	4	5	3	5
41	2	8	6	8
42	6	4	5	4
43	4	6	7	6
44	7	4	2	4

Subjects	depth from Central Sq.	depth from periphery.	depth from Finchley Road	depth from the most integrated space.
45	5	6	4	6
46	6	6	4	6
47	7	5	3	5
48	8	6	4	6
49	6	7	5	7
50	6	8	6	8
51	5	6	5	6
52	8	5	4	5
53	6	6	4	6
54	6	7	8	7
56	4	8	6	8
57	7	9	7	9
58	6	7	6	7
59	7	7	7	7
60	8	7	8	7
61	5	7	5	7
62	6	6	7	6
63	2	8	6	8
64	5	8	7	8
65	6	8	6	8
66	4	7	6	7
67	2	7	6	7
68	6	5	6	5
69	7	7	8	7
70	4	8	6	8
71	5	7	5	7
72	5	5	6	5
73	5	7	5	7
74	2	7	5	7
75	7	6	7	6
76	6	7	6	7

Appendix-D Syntactic characteristics of subjects' sketch maps

subjects	location	global integration	connec-tivity	local integra-tion	depth	no. of depicted spaces	intelligibility (global - local integration)	correlat-ion between Int-Con
1	Wildwood Road	1.106	2.2	1.272	2.4	10	0.979	0.976
2	Brunner Close	0.862	2.267	1.31	2.93	15	0.875	0.863
3	Temple Fortune Hill	0.772	2	1.248	3.14	14	0.873	0.75
4	U Southway	1.373	3.214	1.906	2.893	28	0.863	0.801
5	Asmuns Hill	0.667	2.154	1.16	3.31	13	0.837	0.809
6	North Sq	0.58	1.875	1.024	3.88	16	0.619	0.607
7	Northway	1.507	3.704	2.177	3.222	54	0.922	0.828
8	Willyfieldway	1.139	2.6	1.492	2.5	10	0.845	0.779
9	Meadway	1.228	3.073	1.883	3.659	41	0.849	0.724
10	Erskin Hill	0.846	2.622	1.552	4.53	45	0.874	0.705
11	Kingsley Way	1.603	2.2	1.642	2.1	10	0.991	0.961
12	Thorntonway	1.555	3.217	1.931	2.739	23	0.936	0.928
13	Kingsleyway	0.94	2.692	1.529	3.385	26	0.739	0.681
14	Bigwood Rd	1.266	2	1.28	2	6	0.989	0.95
15	Spencer Dr	1.148	3.688	2.115	3.406	32	0.707	0.602
16	Litchfield Way	1.319	2	1.371	2	6	0.994	0.937
17	N Square	1.004	2.72	1.642	3.44	22	0.644	0.6
18	Denman Dr	0.773	2.222	1.285	3.5	18	0.65	0.571
19	Erskin Hill	0.656	2	1.151	3.31	13	0.594	0.667
20	Ruskin Close	0.828	2.261	1.428	3.522	23	0.75	0.621
21	Willyfield Way	0.869	2.778	1.599	3.5	18	0.748	0.606
22	Asmuns Hill	0.985	2.625	1.517	3	16	0.828	0.769
23	Willifield Way	0.992	2.75	1.541	3.72	32	0.933	0.869
24	Chatam Close	0.554	1.846	1.136	3.69	13	0.396	0.531
25	Southway	1.148	2.25	1.285	2.25	8	0.953	0.936
26	Middleway	0.817	2.118	1.169	3.059	17	0.752	0.788
27	Asmuns Place	1.107	2.963	1.728	3.63	54	0.807	0.716
28	Honsefield	0.958	2.583	1.517	3.5	24	0.88	0.775
29	Heathgate	1.034	2.609	1.605	3.13	23	0.776	0.748
31	Asmun Place	0.806	2.417	1.456	3.58	24	0.677	0.737
32	Childway	0.983	2.154	1.283	2.69	13	0.89	0.874
33	Farm walk	0.841	2.649	1.525	3.89	37	0.795	0.701
34	Heath cl	0.748	2.651	1.533	4.63	43	0.734	0.688
35	Hill Cl2	0.93	2.4	1.429	2.6	10	0.647	0.799
36	Horgarth Hill	1.321	2.64	1.724	2.88	25	0.877	0.826
37	Hampstead Way	1.558	2.909	1.741	2.36	11	0.89	0.926
38	Hampstead Way	1.002	2.6	1.516	3.35	20	0.845	0.758
39	Linnel Close	0.721	2	1.317	2.78	9	0.599	0.623
40	Meadway	0.888	2.906	1.793	4.09	53	0.613	0.535
41	N square	0.883	2.955	1.701	4.18	44	0.81	0.73
42	Oakwood	1.213	2.933	1.757	3.27	45	0.88	0.79

subjects	location	global integration	connec-tivity	local integra-tion(3)	depth	no. of depicted spaces	intelligibility (global - local integration)	correlation between Int-Con
43	Oakwood	0.942	2	1.259	2.33	6	0.811	0.866
44	Queens Ct	0.887	2.8	1.648	3.07	15	0.814	0.786
45	Temple Fortune Lane	0.881	2	1.76	3.13	16	0.469	0.715
46	Temple Fortune Lane	1.208	1.67	1.163	3	6	0.995	0.986
47	Temple Fortune Lane	0.668	2	1.036	2.75	8	0.794	0.724
48	Temple Grove	1.113	2.941	1.758	3.44	34	0.812	0.722
49	WIld Hatch	0.853	2.905	1.711	4.82	81	0.738	0.598
50	Woodside	0.585	2.444	1.411	4.48	27	0.52	0.543
51	Willifieldway	1.603	3.077	1.845	2.46	13	0.894	0.917
52	WordsworthWalk	1.387	3.273	1.907	2.96	22	0.931	0.874
53	Hampsteadway	0.856	2.308	1.242	2.85	13	0.891	0.876
56	Constable Cl	1.607	2	1.598	2	7	0.999	0.954
57	Caryle Cl	1.307	2.6	1.496	2.3	10	0.958	0.971
58	Rowan Walk	1.246	2.5	1.476	2.625	16	0.927	0.921
59	Charton Dr	0.946	1.818	0.97	2.455	11	0.964	0.955
60	Church Mount	0.961	2.789	1.582	3.763	38	0.809	0.731
61	Holne Chase	1.14	2.4	1.366	2.4	10	0.964	0.969
62	Kingsley Cl	1.198	2.846	1.673	2.962	26	0.845	0.822
63	Southway	0.961	2.789	1.582	3.763	38	0.817	0.797
64	Sutcliff	0.68	2	1.067	3.526	19	0.819	0.74
65	Kingsleyway	0.841	1.75	0.875	2.375	8	0.914	0.92
66	Middleway	0.968	3.011	1.766	4.264	85	0.831	0.666
67	Northway	0.69	2.444	1.403	3.667	18	0.827	0.764
68	Norrice Lea	0.924	2.588	1.513	3.941	34	0.792	0.724
69	Lytton Cl	0.782	2.667	1.531	4.625	48	0.728	0.681
70	Hurst Cl	0.746	2.133	1.202	3.467	15	0.759	0.643
71	Cotman Cl	0.996	2.522	1.479	3.087	23	0.865	0.825
72	Grey Cl	0.863	2.167	1.206	2.75	12	0.966	0.918
73	Cotman Cl	1.199	3.259	1.923	3.611	54	0.866	0.734
74	S Square	1.318	3.672	2.155	3.65	60	0.826	0.695
75	Norrice Lea	1.326	2.821	1.708	3	39	0.905	0.844
76	Kingsleyway	0.931	2.857	1.663	3.476	21	0.711	0.608

N.B. INT: integration, CON: connectivity

Appendix-E: Syntactic properties, sketch map variables and movement rates

						A whole area			
Gate No	Street	Int	Int(3)	Int-veh	Int(3)-veh	Frequency	SM-Int	SM-Int(3)	SM-Dep
1	willyfieled 1	0.88	2.45	0.873	2.252	21	1.2	1.717	3.143
2	hogarth	0.85	2.94	0.836	2.598	6	1.27	1.946	3.167
3	Willifield 2	0.82	2.27	0.814	1.833	20	1.12	1.562	3.3
4	wordsworthwalk	0.77	1.57	0.762	0.873	1	1.18	1.833	3
5	addison3	0.84	2.66	0.828	2.615	11	1.3	2.012	2.818
6	addison2	0.85	2.31	0.836	2.312	12	1.3	1.955	2.833
7	creswick	0.77	1.16	0.762	0.704	1	1.2	1.019	2
8	addison4	0.87	2.08	0.851	2.081	10	1.21	2.018	3.2
9	erskin1	0.82	2.93	0.806	2.636	20	1.08	1.682	3.825
10	coleridewalk	0.77	1.38	0.755	0.873	1	1.02	1.478	4
11	oakwood1	0.94	1.9	0.921	3.268	7	1.39	2.163	3.571
12	oakwd2	0.85	2.21	0.837	2.239	8	1.19	1.741	4.25
13	oakwd3	0.81	2.35	0.773	1.896	15	1.09	1.848	4.067
14	den n	0.85	1.38	0.835	1.959	3	1.13	1.476	4
15	den s	0.73	1.27	0.716	1.274	3	1.12	1.441	4
16	erskin2	0.77	2.66	0.754	2.636	16	1.12	1.876	3.625
17	asmun hill2	0.8	2.78	0.791	2.689	6	1.23	2.112	3.5
18	Honsefield	0.75	1.02	0.737	0.873				
19	asmunhill1	0.81	2.31	0.804	2.021	6	1.13	2.127	3.167
20	willyfield3	0.77	2.35	0.746	1.833	22	1.13	1.702	3.545
21	willyfield4	0.76	2.93	0.747	2.636	24	1.13	1.909	3.4
22	ft5	0.77	1.96	0.725		1	0.94	1.163	4
23	hampstead1	0.85	2.84	0.841	2.799	28	1.16	1.87	3.109
24	hamp2	0.79	2.64	0.785	2.601	26	1.05	1.714	3.407
25	hampstead3	0.74	2.44	0.727	2.021	24	1.09	1.914	3.13
26	tfh	0.75	2.95	0.742	2.933	16	1.18	2.28	3.379
27	hamp4	0.73	2.64	0.687	1.833	26	1.08	1.794	3.058
28	orchard	0.75	1.66	0.72	0.873	1	1.11	1.274	3
29	tfl1	0.85	2.91	0.841	2.672	23	1.09	1.713	2.913
30	tfl2	0.78	2.24	0.769	1.698	24	1.05	1.598	2.958
31	farm wk	0.78	2.44			3	0.93	1.606	3
32	tfl3	0.73	1.96	0.72	1.478	24	1.09	1.698	2.778
33	temple grove	0.72	1.27	0.706	0.5	2	0.83	0.964	3
34	ft1	0.67	1.27						
35	willifield6	0.67	2.21	0.661	1.274	23	1.12	1.93	3.391
36	ft2	0.68	1.9			1	0.97	1.274	4
37	ers3	0.74	2.31	0.728	2.312	15	1.07	1.731	3.8
38	chatam	0.68	0.7	0.671	0.704	1	0.89	1.267	3
39	willifield5	0.71	2.14	0.706	1.959	24	1.1	1.899	3.5
40	denman2	0.79	1.7	0.776	1.724	4	0.87	1.521	4.5
41	denman1	0.75	1.48	0.738	1.478	8	0.93	1.284	3.875
42	woodside	0.7	0.87	0.693	0.873	1	0.89	1.267	3

						A whole area			
Gate No	Street	Int	Int(3)	Int-veh	Int(3)-veh	Frequency	SM-Int	SM-Int(3)	SM-Dep
43	asmunspl2	0.71	1	0.703	1	1	0.91	1.724	3
44	asmuns pl1	0.77	1.27	0.766	1.274	4	0.93	0.959	3.75
45	asmpl3		0.21	0.65	0.211	1	0.66	0.5	4
46	hoop la	0.86	2.6	0.85	3.137	55	1.43	2.27	2.536
47	tfl4	0.75	2.62	0.742	2.598	29	1.06	1.768	2.69
48	meadway1	0.82	3.67	0.712	3.674	50	1.57	2.605	2.168
49	wildhatch	0.7	1.38	0.683	0.873	8	0.75	1.127	3.75
50	hamp6	0.76	2.4	0.75	2.396	32	1.08	1.749	2.688
51	hamp5	0.75	2.78	0.744	2.661	35	1.1	1.837	2.493
52	linnel cl	0.75	1.74	0.742	1.375	6	0.8	1.039	3.333
53	meadway2	0.8	3.7	0.795	3.704	41	1.51	2.414	2.494
54	haeathgate	0.78	2.41	0.768	2.406	32	1.05	1.536	2.911
55	turnner cl	0.74	1.66	0.696	1.164	6	0.95	1.192	3.5
56	bigwood	0.78	3	0.773	3	18	1.18	1.871	3.423
57	hurstcl	0.72	1.02	0.71	1.019	1	0.48	0.5	7
58	south w	0.72	2.02	0.711	2.021	18	0.99	1.645	3.529
59	south w2	0.72	2.08	0.715	2.081	17	1.01	1.774	3.667
60	middle way	0.8	3.02	0.785	3.022	21	1.04	1.705	3.576
61	central sq	0.74	2.21	0.729	2.239	31	0.9	1.704	4.298
62	n sq	0.71	1.9	0.7	1.774	23	0.8	1.699	4.683
63	n sq(footpath)	0.69	2.21	0.647	0.5	18	0.78	1.174	4.5
64	ers4	0.72	2.14	0.709	1.959	24	0.91	1.353	4.522
65	ssq	0.75	1.9	0.739	1.774	26	0.86	1.51	3.818
66	hill cl	0.7	1.57	0.685	0.873	3	1	1.336	3.333
67	willifield7	0.7	2.27	0.687	1.833	20	1.14	2.034	3.3
68	fp3	0.67	1.9			1	1.01	1.478	4
69	north w3	0.89	3.15	0.877	2.971	24	1.18	1.857	2.958
70	nw2	0.83	2.72	0.815	2.661	15	1.16	2.003	3.245
71	litchfield1	0.79	2.44	0.783	2.439	18	1.24	2.117	3.5
72	brunner	0.73	1.15	0.717	0.704	2	0.45	0.211	4.5
73	kingsleyw1	0.89	3.19	0.877	3.001	27	1.28	1.928	2.481
74	kingsleyway2	0.83	2.84	0.822	2.749	26	1.28	2.002	2.517
75	kinscl	0.81	1.57	0.799	1.478	1	1.03	0.873	3
76	kingsleyw3	0.81	2.78	0.796	2.524	19	1.29	1.926	2.368
77	litchfield2	0.79	3.25	0.778	3.236	18	1.27	2.099	3.297
78	brunnercl	0.72	1.15	0.714	1.149	1	0.79	1.149	5
79	thornton3,wildwd1	0.76	2.75	0.741	2.749	20	1.18	1.935	3.065
80	thornton2	0.75	2.35	0.736	2.354	9	1.46	2.706	3
81	nw1	0.79	2.14	0.778	2.14	26	1.07	1.723	4
82	thornton1	0.78	2.02	0.763	2.021	8	1.51	2.717	2.875
83	ft4	0.89	3			4	0.84	1.271	3.5
84	holne1	0.8	3.28	0.79	3.266	16	1.21	1.76	2.82
85	spencer dr	0.73	1.9	0.724	1.896	2	1.03	1.458	2.5
86	Caryl Cl	0.68	0.5	0.667	0.5				
87	holne chase2	0.77	2.64	0.757	2.636	11	1.2	1.943	3.182

						A whole area			
Gate No	Street	Int	Int(3)	Int-veh	Int(3)-veh	Frequency	SM-Int	SM-Int(3)	SM-Dep
88	rowanwalk	0.81	2.25	0.799	2.197	3	0.93	1.344	3.333
89	linden lea	0.85	3.24	0.832	2.979	9	1.25	1.853	2.667
90	norrice lea1	0.9	3.54	0.889	3.34	8	1.25	2.169	3
91	Nlea2	0.84	2.72	0.821	2.661	9	1.17	1.877	3.222
92	lyttoncl	0.77	1.48	0.759	1.379	3	0.76	0.693	3.667
93	chmount3	0.76	1.38	0.75	1.379	3	0.98	1.305	3.333
94	winnington3	0.8	2.65	0.788	2.654	14	1.07	1.825	3.45
95	norrice lea3	0.78	1.66	0.762	1.659	8	1.09	1.793	3.375
96	Winnington 4	0.73	1.83	0.722	0.873				
97	holne chase3	0.77	2.27	0.753	2.273	9	1.28	2.173	3.333
98	nervillrdr3	0.72	1.9	0.71	1.896	2	0.9	1.406	3.5
99	chrtondr	0.79	1.66	0.781	1.659	2	1.19	2.057	3.5
100	wildwood2	0.72	1.96	0.694	1.896	14	0.9	1.129	4.267
101	king5	0.73	2.6	0.72	2.212	3	1.08	1.513	3.333
102	nerville1	0.71	1.9	0.694	1.774	1	1.31	2.601	3
103	cotman	0.74	2.14	0.728	1.375	3	0.98	1.283	3.333
104	kings4	0.74	2.27	0.73	1.833	2	1.26	1.894	2.5
105	constablecl	0.72	2.27	0.688	0.873	2	1.02	1.373	4

		Sub-area B: the intelligible area				Movement rates		
Gate No	Street	Frequency	SM-Int	SM-Int(3)	SM-Dep	Ped/hr	Veg/hr	Tot/hr
1	willyfieled 1	13	1.211	1.756	3.15	4.4	23.8	28.2
2	hogarth	4	1.306	2.073	3	1.95	8.2	10.2
3	Willifield 2	13	1.156	1.618	3.23	1.4	18.9	20.3
4	wordsworthwalk	1	1.184	1.833	3	0.1	0.1	0.2
5	addison3	6	1.189	1.915	2.83	2	21.8	23.8
6	addison2	5	1.289	1.893	2.8	2.5	19.6	22.1
7	creswick	1	1.201	1.019	2	0.5	2.8	3.3
8	addison4	5	1.212	2.04	3.2	1.6	19.8	21.4
9	erskin1	13	1.019	1.501	3.58	1.25	10.1	11.4
10	coleridewalk	1	1.023	1.478	4	0.1	0.1	0.2
11	oakwood1	2	1.374	1.895	2.5	0.5	6.1	6.6
12	oakwd2	5	1.031	1.338	4.4	0.8	5.5	6.3
13	oakwd3	10	0.929	1.677	4.2	0.8	6.2	7
14	den n	1	1.02	1.379	4	0.1	1.1	1.2
15	den s					0.4	1.4	1.8
16	erskin2	9	1.095	1.837	2.78	1.8	8.3	10.1
17	asmun hill2	5	1.207	2.155	3.4	2.4	6.1	8.5
18	Honsefield					0	0.1	0.1
19	asmunhill1	6	1.132	2.127	3.17	2.15	6.4	8.55
20	willyfield3	14	1.156	1.74	3.36	2.6	17.9	20.5
21	willyfield4	14	1.147	1.948	3.18	1.3	17.6	18.9
22	ft5	1	0.936	1.163	4	0.1	0.7	0.8
23	hampstead1	19	1.126	1.876	3.08	7.75	15.3	23.1
24	hamp2	18	1.038	1.712	3.37	4.85	13.6	18.4
25	hampstead3	17	1.085	1.798	3	2.8	9.7	12.5
26	tfh	10	1.153	2.287	3.05	4.15	5.4	9.55
27	hamp4	19	1.062	1.759	2.95	1.85	9.65	11.5
28	orchard	1	1.106	1.274	3	1.9	0.2	2.1
29	tfl1	13	0.981	1.603	3.08	12.1	17.9	30
30	tfl2	14	0.924	1.414	3.14	6.8	17.4	24.2
31	farm wk	3	0.929	1.606	3	3.6	0	3.6
32	tfl3	13	1.018	1.673	2.67	2.85	17.8	20.7
33	temple grove	2	0.833	0.964	3	1.8	1.3	3.1
34	ft1					0.2	0.6	0.8
35	willifield6	15	1.121	1.921	3	1.9	16	17.9
36	ft2					0.45	0	0.45
37	ers3	8	1.093	1.832	3.13	1.8	6.8	8.6
38	chatam	1	0.891	1.267	3	0	0.1	0.1
39	willifield5	16	1.098	1.913	3.19	1.1	18	19.1
40	denman2	2	0.822	1.297	4	1.1	1.15	2.25
41	denman1	4	0.869	1.218	3	0.9	2	2.9
42	woodside	1	0.891	1.267	3	0.4	0.3	0.7
43	asmunspl2	1	0.908	1.724	3	1.2	0.7	1.9
44	asmuns pl1	3	0.946	1.112	3.6	1.5	1.5	3

		Sub-area B: the intelligible area				Moveemnt rates		
Gate No	Street	Frequency	SM-Int	SM-Int(3)	SM-Dep	Ped/hr	Veg/hr	Tot/hr
45	asmpl3	1	0.655	0.5	4			
46	hoop la	26	1.149	2.188	2.33	4.4	42.7	47.1
47	tfl4	16	1.006	1.796	2.56	0.9	16.1	17
48	meadway1	23	1.227	2.683	1.96	3.5	60.6	64.1
49	wildhatch	4	0.671	0.784	3.5	0.2	0.2	0.4
50	hamp6	18	1.001	1.698	2.67	0.6	29.5	30.1
51	hamp5	20	1.083	1.908	2.32	1.8	26.2	28
52	linnel cl	5	0.829	1.147	3.2	0.1	0.4	0.5
53	meadway2	17	0.997	2.203	2.94	1.3	59.2	60.5
54	haeathgate	16	0.959	1.514	2.79	2	4.75	6.75
55	turnner cl	4	0.973	1.346	3.25	0.4	0.9	1.3
56	bigwood	5	0.977	2.231	4	0.88	4.85	5.73
57	hurstcl					0.4	0.5	0.9
58	south w	6	1.003	1.826	3.5	0.2	3.7	3.9
59	south w2	5	0.901	1.833	3.89	0.4	1.9	2.3
60	middle way	6	0.832	1.315	4.4	0.57	3.5	4.07
61	central sq	16	0.766	1.439	4.13	1.07	7.57	8.63
62	n sq	13	0.75	1.676	4.39	1	5.7	6.7
63	n sq(footpath)	9	0.71	1.112	4.33	0.8	0.3	1.1
64	ers4	12	0.903	1.424	4	1.8	11.1	12.9
65	ssq	13	0.83	1.638	3.68	0.9	2.8	3.7
66	hill cl	1	0.978	1.274	4	1	0	1
67	willifield7	13	1.143	2.015	3.08	1.1	22.6	23.7
68	fp3					0.2	0	0.2
69	north w3	8	0.959	1.534	3.63	9.4	25.3	34.7
70	nw2	9	0.956	1.879	3.78	5.2	15.6	20.8
71	litchfield1	6	1.131	2.358	3.83	3.3	10.9	14.2
72	brunner					0.2	0.1	0.3
73	kingsleyw1	6	0.889	1.28	3	7.5	44.7	52.2
74	kingsleyway2	4	0.89	1.47	3.13	4.65	40.5	45.2
75	kinscl					0.4	0.5	0.9
76	kingsleyw3	3	1.004	1.498	2.67	2.1	34.4	36.5
77	litchfield2	5	1.077	2.097	3.8	1	9.05	10.1
78	brunnercl	1	0.788	1.149	5	0.1	0.1	0.2
79	thornton3,wildwd1	6	0.961	1.836	3.8	1.6	12.4	14
80	thornton2	2	1.048	2.78	4	0.7	7.4	8.1
81	nw1	12	0.83	1.377	4.75	3.6	10.4	14
82	thornton1	1	1.037	2.945	4	0.8	2.6	3.4
83	ft4	4	0.839	1.271	3.5	2.4	0	2.4
84	holne1	5	0.947	1.454	4	1.37	34.4	35.7
85	spencer dr					0.7	3.25	3.95
86	Caryl Cl					0.3	0.6	0.9
87	holne chase2	1	1.097	1.724	5	0.65	29.9	30.5
88	rowanwalk					0.9	4.6	5.5

		Sub-area B: the intelligible area				Movement rates		
Gate No	Street	Frequency	SM-Int	SM-Int(3)	SM-Dep	Ped/hr	Veh/hr	Tot/hr
89	linden lea					0.87	7.23	8.1
90	norrice lea1					1.9	5.8	7.7
91	Nlea2					0.45	5.8	6.25
92	lyttoncl					0.5	0.6	1.1
93	chmount3					0.2	1.7	1.9
94	winnington3	2	0.993	1.736	4	0.4	21.3	21.7
95	norrice lea3	1	1.144	1.774	3	0.5	6.2	6.7
96	Winnington 4					0.1	0.7	0.8
97	holne chase3	1	1.097	1.724	5	0.5	31.6	32.1
98	nervillrdr3					0	2.5	2.5
99	chrtondr					0.4	2	2.4
100	wildwood2	5	0.78	1.095	5.17	0.2	11.9	12.1
101	king5					1.3	3.5	4.8
102	nerville1					0.9	2.6	3.5
103	cotman					1.2	0.7	1.9
104	kings4					0.8	2.7	3.5
105	constablecl	1	0.83	1.478	5	0.9	0.7	1.6

*Int: global integration; Int(3): local integration; Int-Veh: global integration of vehicular map; INt(3)-Veh: local integration of vehicular map
SM-Int: global integration of sketch maps; SM-Int(3): local integration of sketch maps
SM-Dep: Depth from the most integrated space in sketch maps;
Ped: pedestrian; Veh: vehicular; Tot: total; hr: hour

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