Spatial Design and Reassurance for Unfamiliar Users When Wayfinding in Buildings

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Abstract

Wayfinding tasks comprise decision points and interconnecting paths leading to a destination. Path choice at decision points is critical to the successful completion of wayfinding tasks. Research has found that signage is not the only influence on path choice and that influences vary depending on familiarity with an environment. People familiar with their surroundings have a cognitive map – a prior understanding of the environment – against which they can compare the environment as they experience it in order to orientate themselves. People unfamiliar with their surroundings, and therefore lacking a cognitive map of them, are found instead to rely upon wayfinding strategies to inform their path choice decisions.

This study investigates how aspects of the spatial design of buildings may assist unfamiliar users in finding the destination they are seeking within the building. Observations of people wayfinding in an unfamiliar building suggested that four aspects of spatial design affected route choices made at decision points. Four wayfinding strategies describe the behaviour observed: 1) Maintain a Straight Bearing through the building; 2) Avoid a Change of Level; 3) Walk Towards a Brighter Space; 4) Choose the Wider Corridor. Evidence supporting three of these was found in the literature. For the fourth – Choose the Wider Corridor – only limited evidence was available from the literature and hence further work was carried out to test the predictability of its influence on wayfinding behaviour.

An online experiment was conducted to investigate to what degree corridor width influences path choice and the interaction between the Choose the Wider Corridor and Maintain a Straight Bearing wayfinding strategies. A means of categorisation, comprising two wayfinding principles, was devised for information in the environment and means of undertaking wayfinding tasks: Reassurance Principle – wayfinding strategies reassuring the wayfinder that they are taking the correct route - and Tools Principle - signage, maps, landmarks and other sources of information in and representing the environment, available to aid wayfinding decisions. This thesis looks at strategies for wayfinding reassurance.

It is proposed that unfamiliar users would find buildings more intuitive to wayfind within if they were designed with routes to likely public destinations that conform to the four wayfinding strategies. An applied test was conducted to confirm whether wayfinding ease could be predicted by analysing the routes within that building against the behaviours described by the wayfinding strategies. It was found that ratings of difficulty given by test participants matched predicted ratings based upon an analysis of the building's conformance to the wayfinding strategies. It is suggested that if this analysis was conducted at the design stage it could limit potential wayfinding difficulties. Some possible designs as means of achieving this in new buildings and refurbishments are discussed.

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Introduction

1.1 The need for wayfinding research in buildings

The term wayfinding describes the cognitive processes and consequent actions undertaken when going from one place to another (Passini, 1984; Allen, 1999; Golledge, 1999). All movement involves wayfinding to some degree (Lynch, 1960). Although this study is concerned primarily with the issues encountered by people wayfinding within unfamiliar environments, wayfinding itself is not limited to such circumstances – the term is as relevant describing the actions of people finding rooms in their own house, for instance. However, as discussed in Chapter 2, much research carried out into wayfinding recognises that there is a difference between wayfinding tasks which are undertaken repeatedly and those being undertaken for the first time and that, generally, it is the latter of the two which is the more complex, requires the most focus and cognitive energy and is therefore the more likely to fail. Failures in wayfinding for unfamiliar users are suggested to be causes of stress, which further compound the difficulty of wayfinding tasks (Kaplan et al., 1998). It is this area which is therefore the focus for much of the wayfinding research that has been conducted   (Lovelace et al., 1999; Butler et al., 1993; Raubal & Winter, 2002; Abu-Ghazzeh, 1996; Dogu & Erkip, 2000).

Research into wayfinding has its roots in studies of the city and city legibility. Lynch (1960) argued that the more legible and hence easier to read the city is, the easier it is to collect the information required for wayfinding. Studies of wayfinding within

buildings are more recent and, to an extent, draw on the findings from wayfinding within the city (Passini, 1984; Sterling & Carmody, 1993). Within this thesis, these two areas of study are referred to as city-scale and building-scale wayfinding respectively. The word 'scale' is used in reference to the way architects are taught to study and represent the city and the buildings within it – although it is commonly accepted that everything within buildings and cities has to ultimately relate to the human scale, different scales are used in architectural representations to help understand how the environment works without being overwhelmed with detail (Freundschuh, 2000). This study has been conducted from the point of view of how spatial design of building influences, and may be influenced by, wayfinding behaviour. Possible applications for the findings in this research could include guidance for design of buildings that limit the difficulties encountered when wayfinding. This would be aimed at architects, hence relating wayfinding in architectural terms was deemed appropriate.

Although wayfinding in buildings is neither a particularly new field of research nor one that has been sparsely investigated, wayfinding features in relatively few of the standard references architects have to follow during the building design process (Hawksworth, 2000). Wayfinding design is not, for example, a requirement of the UK Building Regulations, possibly because being difficult to navigate is not considered a significant enough safety risk, nor is it considered a physical obstacle to accessing the building, only an inconvenience. The safety implications of difficulties encountered navigating when escaping from a fire do feature in the Building Regulations, however the requirements are in the relatively simple form of travel distances to a place of safety. There are guides available for wayfinding design, however these documents, such as the recommendations published by the NHS (Stationery Office / NHS Estates, 1999), tend to focus on the needs of people in particular types of environment. By comparison, it is the aim of this study to contribute more generally to the field of wayfinding in spatial design (designing buildings which ease wayfinding tasks) and not target specific applications such as healthcare. However, recommendations in documents such as those produced by NHS Estates are considered in this thesis as some may be relevant to a wider set of

applications. Also, those recommendations which are targeted at a particular application are not ignored as the underlying reason for the recommendation may still be relevant to a wider range of buildings.

Such guidelines are considered important as wayfinding difficulties can have major implications for the efficient operation of buildings and the experience of its users. Peponis et. al. (1990) documented wayfinding problems in a hospital noting the amount of staff time lost due to having to direct (and frequently accompany) lost patients around the hospital and issues of patients missing appointments due to not being able to find particular rooms. This is frustrating for the staff and potentially very stressful for the patients, at a time when they may already be overloaded with stresses due to their illness and its implications. Wayfinding stress should be avoidable by making buildings intuitive to navigate, so that even when distracted from the wayfinding process incorrect wayfinding decisions are unlikely.

Any guidelines would have to be both practical, in suggesting solutions to particular common wayfinding situations, and theoretical, in order that the general wayfinding design of a building can be easily assessed against known wayfinding factors. Guidelines would have to be flexible enough to cover a range of building types as well as covering instances of change of use – any building designed with the flexibility to adapt to the users' requirements should not be hampered in doing so by over-rigid wayfinding design. This flexibility should also allow practical solutions to wayfinding problems to be considered when wayfinding design is vying (and sometimes conflicting) with the demands of budget, space and aesthetics. Lastly, by being flexible, there is also the opportunity to use them at a late stage in the design process if necessary, at the point where architects may resort to signage to make sense of a difficult to wayfind building. This should ensure wayfinding design is not completely ignored as a consequence of the 'design now, justify later' attitude to legislation, as criticised in government publications such as the Design and Access Statement (CABE, 2006), however in common with Design and Access Statements, wayfinding guidelines should explain and demonstrate the benefits of consideration

at the early stages of the design process. This research study was conducted with the requirements of these guidelines in mind.

1.2   Research Aims and Objectives

The aim of this research is to identify how wayfinding stress can be reduced by reassuring unfamiliar users that they are making the correct path choices when wayfinding. Firstly, wayfinding behaviour is studied in order to develop an understanding of the factors of spatial design that are involved in wayfinding within unfamiliar buildings. This takes the form of observations of wayfinding behaviour with comparisons drawn against wayfinding in buildings from research documented in this thesis and by other researchers. The intention of this is to identify how building design influences wayfinding behaviour and how analysis of this behaviour may be used to inform building design. The ultimate outcome of the study is to develop wayfinding information that is suitable to be used in the form of guidelines. Therefore the second aim is to translate the findings from research into wayfinding behaviour into such a form and do so in a manner that could provide architects with guidance at the early stages of design projects and ensure that that guidance is flexible enough to be applicable to a range of building types and uses and the evolution of a building's use over time.

The origin of the idea behind this translation of wayfinding research into building design is the notion that building design may facilitate wayfinding and spatial orientation (Brösamle & Hölscher, 2007). Routes to destinations likely to be visited by people unfamiliar with the building (unfamiliar users) need therefore to be considered and measures taken to ease the progress of wayfinding tasks along these routes. In order to achieve this, it is proposed that the building's circulation spaces be designed such that known wayfinding behaviour (the wayfinding strategies) will lead unfamiliar users to these likely destinations. Conformance to these strategies should lead to predictable interactions between people and the environment and reassurance for the visitor that they are taking the correct route, akin to that

explored by R. Kaplan et al. (1998) in their design guidance for outdoor spaces.

This research is not aimed specifically at any one type of building, rather it is aimed generally at buildings and parts of buildings which may be visited by members of the public, particularly those who are unlikely to visit on a regular basis and thus develop a knowledge of the environment over time (unfamiliar users). A part of a building may, for example, be a space likely to be accessed by unfamiliar users such as a conference room in an office block or a ward in a hospital. In situations where an unfamiliar user is seeking a destination not normally frequented by unfamiliar users (for example, one of the offices in the office block), the primary destination is regarded as the visitor's first point of contact, for example an enquiries office, from which they may be directed to their destination. The research is targeted at unfamiliar users; no further specific targeting is made to particular groups. Although some reference is made to buildings outside the UK, the research was conducted entirely in the UK and was undertaken with the British architectural practice in mind.

1.3   Methodology

The mix of methodologies used reflects the aim of bridging between the theoretical study of wayfinding and the practical application of that knowledge when designing buildings. Much of the research into what influences wayfinding decisions has been focussed on individual factors, and consequent experiments have aimed to limit the number of variables present. However, wayfinding influences rarely, if ever, exist in isolation due to the complexity of environments hence these experiments stop short of explaining how these factors interact with one another. The observation (Chapter 3) was undertaken to see these factors and the wayfinding behaviours they elicited in an environment known to the researcher. There was potentially the opportunity to see how participants reacted when faced with a multitude of variables, particularly in instances which would elicit contradictory responses were the participant to react in the way predicted by the research into each of those variables. The use of a known environment was important as it allowed the possibility of further investigation of the

space during analysis of the observation findings.

A review of research previously undertaken about wayfinding and wayfinding behaviour was conducted. It was determined that four wayfinding strategies could explain much of the wayfinding behaviour observed. These four strategies are the focus of this research. A further test was conducted as a supplement to the literature research to determine the influence of corridor width on path choice when wayfinding by unfamiliar users. This was undertaken as this behaviour was found to explain many of the path choices in the observational study and was given as a primary reason for path choice by participants in another study (Zacharias, 2002), but had however received little research attention elsewhere.

The Corridor Width experiment (Chapter 4) was conducted in a controlled environment in order that the corridor width variable be isolated and its influence on wayfinding decisions reliably measured. The experiment was conducted in an online, virtual environment, with participants asked to choose which route they would take when shown computer generated images of corridor junctions (decision points) with exit corridors of different widths. The methodology of the experiment shared much with that used by Taylor & Socov (1974) to determine the influence of light levels on wayfinding decisions, however it differed slightly in its approach to masking the intent of the experiment. Reducing a wayfinding situation down to one variable risks making the participant aware of the variable being studied. Taylor & Socov dealt with this by telling participants they were to undertake a colour sample test and then placing the experiment on the route to that task. Janzen & Turennout (2004), in their study of subconscious recognition of objects at certain points along a route, distracted participant by requesting that they observe different objects in the test environment. As with Taylor & Socov's experiment, the Corridor Width experiment led participants to believe they were walking towards a space beyond the junction featured in the experiment, however this was elaborated on to account for the multiple images of junctions presented to each participant (participants in Taylor & Socov's experiment only passed through the test environment once – equivalent to

seeing one image in the Corridor Width experiment).

Using the findings from the existing research, Corridor Width experiment and observational study directly to develop architectural guidance would be inappropriate as they describe wayfinding behaviour rather than building design. If such guidelines are to be practical they need to indicate how building design may make use of these known behaviours to encourage particular wayfinding decisions.

An applied study (Chapter 5) was also devised, conducted in a real environment, which aimed to determine whether wayfinding behaviour could be predicted by an understanding of the environment and identification of elements of the environment likely to trigger certain wayfinding responses. It was of value being able to test whether known wayfinding behaviour, found by observing and testing for decisions in environments, could reliably be used in return to predict those behaviours. The applied test compared the perceived difficulty of a series of test routes . These were then compared against predicted difficulty ratings and rankings that were arrived at through an analysis of the routes each wayfinding task required the participants to follow and the occurrences of conformance and confliction with the wayfinding strategies along those routes.

1.4   Outline of the thesis

This research is an investigation into wayfinding within buildings, specifically concentrating on unfamiliar users. The literature review (Chapter 2) explores definitions of wayfinding and how it is undertaken, concentrating on wayfinding strategies used by people within unfamiliar environments when information about their environment and means of getting to their destination is limited. The choice of wayfinding strategies was guided by exploratory studies (documented in Chapter 3) which were carried out to confirm the applicability of these strategies to wayfinding within buildings. From the literature review and exploratory studies it was

determined that four wayfinding strategies are applicable to and have a marked influence on wayfinding within buildings. They are:

- Maintain a Straight Bearing (the visitor avoids making changes of direction)

- Avoid a Change of Level

- Walk Towards a Brighter Space (when the different exits from a decision point have different illumination levels).

- Choose the Wider Corridor (when there is a choice of corridor widths at a decision point)

These strategies appeared to be important in assisting wayfinding decisions, however the literature review highlighted that little research into the influence of corridor width had previously been undertaken hence this was therefore further investigated. An experiment into the effects of varying corridor width was undertaken (Chapter 4) which tested participants' direction choices in a controlled environment in which the width of the corridors was the primary variable. The experiment also presented the opportunity to test whether maintaining a straight bearing (another of the wayfinding strategies) or following the wider corridor was prevalent. Following this, a further validating test of the wayfinding strategies (Chapter 5) took place within a different building to that used in Chapter 3. This compared the difficulty participants found in wayfinding routes against predicted difficulty based upon whether completion of the wayfinding tasks followed or conflicted with the wayfinding strategies. Finally, possible architectural implications of the guidelines were considered, with analysis of potential effects on wayfinding issues in several buildings that have been briefly studied in the course of this research (Chapter 6).

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2

Literature Review

2.1 Chapter overview

This chapter examines previous research conducted into wayfinding. This review was conducted in parallel with the observational study conducted in the University of Sheffield Students' Union Building documented in Chapter 3. As well as a general review of the field of wayfinding, Chapter 2 covers research into three wayfinding strategies in some detail. A fourth (that unfamiliar users choose the wider corridor when a range of corridor widths is available at a decision point) is introduced and investigated in more detail in Chapter 4. Chapter 2 concludes with a categorisation of the wayfinding strategies and other literature findings into two Wayfinding Principles - Reassurance and Tools - intended to provide indication to building designers of the nature of the strategies and how they influence wayfinding behaviour.

2.2 Introduction

Wayfinding is a field that has its roots in disciplines such as psychology, urban planning, computer science and environment studies and design (and hence architecture). Research in this field therefore covers several disciplines and covers a large range of research topics, including the cognitive processes involved in recognition, spatial problem solving, environmental design and the psychological effects of being lost. For the purposes of this review, the extensive areas of research into how people wayfind are considered as a starting point and the factors of this which relate directly to buildings and wayfinding within buildings.

Despite the broad reach of wayfinding and associated research, until recently little of this directly relates wayfinding performance back to the design of the environment (Werner & Schindler, 2004; Conroy-Dalton, 2001). A similar gap to that between wayfinding theory and practical design is also found by Kitchin et al. (1997a) between the fields of theoretical and practical psychology, which may explain why architectural design practice has not benefited more from wayfinding research. Brösamle and Hölscher (2007) also found a lack of research into how architects approach wayfinding design, and discovered a tendency amongst architects to consider spaces within a building independently of each other rather than considering wayfinding tasks as a chronological activity wherein the links between spaces are important. There is also a degree of scepticism about the importance that architects place on wayfinding (Passini, 1999; Hawksworth, 2000) which a broader exposure of the issues of wayfinding may resolve. This is supportive of the intention, introduced in Chapter 1, to produce information aimed for use when writing wayfinding guidelines as these will directly influence the built environment based on an understanding of how people respond to it. This information may also be of use in computer design tools aimed at predicting behavioural responses to environments during the design stage (Bojduj et al., 2008).

2.3 Wayfinding

Spatial behaviour is central to our lives (Kitchin & Freundschuh, 2000), and the idea that the environment has an influence on behaviour has been acknowledged for some time (Donovan & Rossiter, 1982, p.34; Deasy & Lasswell, 1985, p.10). Wayfinding - the process of going from one place to another – is one area that research into spatial behavior has focused on.

The term 'way-finding' was introduced by Lynch in *The Image of the City* (Lynch, 1960). This book is considered one of the cornerstones of wayfinding research, and the word wayfinding derived from it has found widespread usage within and beyond academic study. Possibly due to the term's relative youth and its relatively rapid

adoption, it appears to have earned a wide range of definitions. It is often either used interchangeably with navigation, or as a name for signage and other printed information intended to aid orientation and direct people towards their destination (Carpman & Grant, 2002; Clark, 2007), these alternative uses occurring particularly outside of academic use. The name 'wayfinding systems' (Kray et al., 2005) given to planned and co-ordinated sets of signs has possibly encouraged the use of the word 'wayfinding' to describe signage. Unfortunately, this misuse of the word 'wayfinding' may be responsible for the misuse of the term 'wayfinding design' to mean adding signage to a design once it is complete. This is considered to be an ineffective approach to wayfinding design and one that has led to many of the wayfinding issues encountered in current buildings (Arthur & Passini, 1992; Hawksworth, 2000). Passini (1999) notes that signage is frequently added to a building in response to reports of wayfinding difficulty, and if this does not resolve these difficulties it is the orientational abilities of the building's users that are called into question, not the design of the building. There is also a mention of a dislike of signage amongst architects and what is perceived amongst building users as a consequent under-provision of signage.

A review of the definitions of the word 'wayfinding', in academic writings as opposed to colloquially, has been conducted below in order to arrive at a definition to be used throughout this thesis.

2.3.1 Definitions of wayfinding

Both the terms 'way-finding' and 'way-finding devices' were introduced by Lynch in *The Image of the City* (1960). Although not explicitly defined, the term 'way-finding' is used to describe the act of finding one's way using any available environmental information, and information obtained from 'way-finding devices'. The author gives maps, street numbers and directional signs as examples of these devices, all of which are typical components of modern wayfinding systems.

The focus of *The Image of the City* is on the legibility of city spaces, and on city 'elements' that have a strong influence or serve certain functions when wayfinding. These five elements are paths, edges, districts, nodes and landmarks. When wayfinding, paths are the routes along which the person wayfinding moves, edges are linear elements not considered to be paths (typically obstructions such as railway embankments or buildings), districts are medium to large sections of the city, conceived of two-dimensionally, which are passed into, through and possibly out of during wayfinding and nodes are strategic points within the city, frequently major junctions between paths. Nodes and landmarks are both described as point-references, both playing a significant role in orientation, however the distinction is made that nodes are entered into, whereas landmarks are experienced externally.

Although concerned with the city, the five elements for cities defined by Lynch can be applied to the interior of buildings or complexes of buildings (Passini, 1984; Sterling & Carmody, 1993). Corridors, external walls, floors and atria possess characteristics akin to those of four of the five elements (paths, edges, districts and nodes respectively; their equivalence is explored in greater detail later in this chapter). Districts have a parallel in the 'zones' discussed by Passini et al. (1998). However, an interior equivalent to Lynch's definition of Landmarks is harder to identify as the cellular nature of most buildings means there are rarely opportunities for landmarks to mark the position of distant points. Lynch's definition of landmarks is broad, though, and does include smaller landmarks, such as distinctive shop-fronts which cannot be seen from a distance. Many buildings feature numerous equivalent internal 'features' which may perform the same function. Section 2.4.2 further explores landmarks and their use when wayfinding.

Although identifying the relevance various city elements have on wayfinding, Lynch does not investigate why they are relevant, i.e., the underlying processes that influence wayfinding performance and how wayfinding tasks are undertaken (S. Kaplan, 1976). Subsequent research has been undertaken concentrating on the process of creating cognitive maps (cognitive mapping) rather than the finished

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cognitive map product (Passini et al., 1998). Accordingly, definitions of wayfinding have been refined over time to better demonstrate the cognitive processes involved, particularly when the wayfinder reaches a decision point where they have to decide between alternate routes (Bojduj et al., 2008). Raubal and Winter refer to a definition given by Gluck (1991), Golledge (1992) and Allen (1999a) which describes wayfinding as a purposeful and directed movement from an origin to a specific distant destination which cannot be directly perceived by the traveller. The implication here is that wayfinding is an unconscious activity, that environmental information is processed and that appropriate physical movement undertaken without the person involved needing to think about the wayfinding task. The definition may also imply that the exact destination is also known, not just what the destination is but also where it is. This definition therefore appears to be describing wayfinding tasks that the person doing the wayfinding is very familiar with, such as the commute to a place of work. The term wayfinding is therefore not limited to finding destinations in unknown locations. Furthermore, it appears likely that this definition only applies to very familiar wayfinding tasks as wayfinding tasks that involve destinations in unknown locations require a great deal of conscious thought and therefore can be directly perceived by the traveller. For Blades' investigation of wayfinding theory and research (1991) the definition of wayfinding given is 'the ability to learn and remember a route through the environment'. Although noted by the author that this is deliberately limited for the purposes of that study, it does highlight that there are different ways in which wayfinding tasks may be tackled. Lawton and Kallai (2002) discuss two ways of tackling wayfinding tasks: orientation-based (making path decisions that maintain an orientation towards a known point) and route-based (making path decisions that keep to a known route). Blades' definition fits into the latter category.

Passini (1984) and Peponis et. al. (1990) also include the cognitive aspect in their definitions, describing wayfinding as involving interactions between the traveller and the environment and also the ability, both cognitively and behaviourally, to navigate successfully through the environment and the ability to find a way to a particular location in an expedient manner and to recognize the destination when reached.

Both these definitions apply to wayfinding with destinations in known and unknown locations. Additionally, by describing wayfinding as a process conducted in an 'expedient manner', Peponis and his colleagues suggest a certain focus to wayfinding tasks. For example, a student travelling around Europe may be considered to be undertaking several wayfinding tasks, from one city to the next. However, the whole excursion would not be considered a wayfinding task, as although an ultimate destination is reached, the total journey involved would not have been the most efficient and expedient way of reaching that destination.

Allen (1999b) expands upon the cognitive requirements of wayfinding tasks. He suggests that, during navigation, various spatial, cognitive and behavioural abilities are utilised. These spatial abilities involve mainly four interactive resources: perceptual capabilities, information-processing capabilities, previously acquired knowledge, and motor capabilities. Montello and Sas (2006) go further when considering the cognitive element of wayfinding, and use the term wayfinding purely to describe the cognitive element of the task of finding the way from one place to another. Whereas other research tends to regard navigation as a component of wayfinding (see section 2.3.2), Montello and Sas reverse this, and regard navigation as having two components: wayfinding and locomotion. This does not directly contradict other definitions of the term – navigation in the naval sense, for example, involves a degree of wayfinding in order to avoid transient hazards. Montello and Sas' definition of wayfinding is simply narrower than others here, and in this respect is potentially useful. This fits with the Passini (1984) model of how wayfinding tasks are undertaken, with information between decision points largely ignored (see Section 2.5.1), as it considers the wayfinding act, and the information collection this involves, as only occurring whenever movement stops or pauses at decision points. However, this does not make concessions for information collection that in itself involves locomotion (exploration).

2.3.2 Wayfinding, navigation and orientation

Wayfinding is distinct from navigation, although closely related. Franz and Mallot (2000) define navigation as "The process of determining and maintaining a course or trajectory to a goal location". Their hierarchy of navigation sees a distinction between local navigation and wayfinding, the former based on recognition of a destination in the immediate vicinity and the latter based on using known and immediately available environmental information to plan and execute a route. According to the Passini theory of spatial problem solving (Passini, 1984), local navigation could be considered part of wayfinding. This theory suggests that local navigation is used whenever decision points are reached in order to gather information required that is necessary in order to know how to reach the next decision point.

These uses of the word navigation to mean a small component of a wayfinding task begin to blur the distinction between wayfinding and navigation. In naval terms, navigation is taken to mean the process of basing direction-taking decisions on information from maps, compasses and other tools to successfully reach a destination (Great Britain Ministry of Defence, 1987). By and large, decisions about which direction to take are not made based upon information in the immediate environment, hence 'navigation' implies a certain detachment from the environment. The immediate environment still has to be studied, but this is required to avoid transient hazards rather than for information gathering required to reach the destination. Transient hazards are those hazards that are unmapped due to their impermanent or relocatable nature – in the naval example these may be other boats, icebergs etc. Wayfinding, by comparison, involves the collection and assimilation of environmental information. Any wayfinding task undertaken by someone ignoring their immediate environment is unlikely to be successfully completed (Donovan & Rossiter, 1982). It is therefore important that there is clarity to the use of 'navigation' and 'local navigation', as the two terms appear contradictory.

Darken and Peterson (2001) acknowledge that the concepts of wayfinding and

navigation are often confused. They define wayfinding as purely the cognitive element of navigation and navigation as the aggregate of wayfinding and motion. Their definition of wayfinding is quite different to those discussed in section 2.3.1, however it supports the definition of navigation outlined above, the navigation task relying upon outside information from the wayfinding task. Darken and Peterson also discuss the contradictory requirements that wayfinding places on orientation. Orientation is the act of locating one's self in the habitat (Wallace, 1997). It is our awareness of the space around us, including the location of important objects in the environment (Hunt & Waller, 1999, p.4) and is hence crucial for finding one's way from one location to another. Kaplan et al. (1998) note that when people feel orientated their anxieties are lessened, reducing stress levels and leading to a sense of reassurance that the wayfinding task being conducted can be completed. However, in building up an understanding of our surroundings, Darken and Peterson (2001, p.493) point out that a degree of disorientation is of value as it leads to exploration of spaces that would not be considered for exploration and, in turn, a more complete understanding of the environment. Even if the additional routes explored are not eventually used to complete the wayfinding task, they are still likely to help establish an understanding of how the various spaces within the environment relate to each other. This theory of disorientation would appear to be referring to wayfinding conducted by people unfamiliar with their environment (unfamiliar users), however it is still of value to people when conducting a common wayfinding task. A route such as that taken to commute to a place of work may be familiar and the consequent wayfinding task easy to undertake, however a lack of understanding of the spaces neighbouring this route may make it less than the most expedient to take.

2.3.3 Research into wayfinding within buildings

Although the term wayfinding was first used in a study of the city, it has subsequently been used in studies of environments of a variety of different scales. Correlations between wayfinding strategies used at different scales were found by Lawton (1996, p.137): 'that indoor reliance on directional cues correlated with the outdoor orientation strategy and indoor reliance on route information correlated with the

outdoor route strategy'. Research into wayfinding within buildings may be considered to be relevant from the point that the city scale is exited, in which case it begins with a search for the entrance into the building, or from the point at which a wayfinding task within a building is started, in which case it starts at the first space in the building immediately following the main entrance. For the purposes of this research, the latter situation is considered – it is assumed that the visitor has already found the building and found their way inside.

Weisman (1981) was the first to introduce the concept of wayfinding in buildings, building on research into indoor navigation carried out by Best (1970). Best identified what is, in effect, an indoor equivalent to Lynch's five elements, fulfilling the same purpose of describing the environment in functional terms, comprising aspects of the building's route network such as choice points, directional changes and distances. Navigational difficulty is predicted based upon the complexity of these aspects. Weisman developed four groups of environmental variables which influence wayfinding: (a) visual access to familiar cues or landmarks within or exterior to a building, (b) the degree of architectural differentiation between different areas of a building that can aid recall (c) the use of signage to provide identification or directional information, and (d) building configuration, which can influence the ease with which one can comprehend the overall layout of the building. Of these, (b), (c) and to an extent (a) are references to the building fabric (which may provide navigational clues to the visitor of a building when wayfinding) while (a) and (d) are references to the spaces that the building fabric encloses (which the visitor is navigating within). Peponis et. al. (2003) makes this distinction succinctly:

> *Architectural design implies a threefold spatial construction, of a complex*
> *material object, of an arrangement of space effectuated through the object*
> *and of a spatial experience engendered by these (Peponis et al., 2003,*
> *chap.02.1)*

2.3.4 Definition of wayfinding used throughout this thesis

For the purposes of this thesis, the following definitions have been developed:

- Wayfinding: using information in the environment, in wayfinding devices and in the mind, as the basis of decisions necessary to navigate from one place to another, from (Raubal & Egenhofer, 1998)

- Decision point: place within the environment where several direction options exist, i.e. it is a point where the wayfinder has to decide between alternative routes (Bojduj et al., 2008; Raubal & Egenhofer, 1998). Decision points are connected by routes.

- Wayfinding task: The origin and goal and each of the decisions required to navigate between the two, from Passini (1984)

- Wayfinder: person undertaking a wayfinding task.

- Unfamiliar user: someone who is in a building or other environment which they have not previously had experience of.

2.4   Understanding the environment

In order that wayfinding tasks may be undertaken, it is necessary for the wayfinder to gain an understanding of the environment they are in. Information collected, whether experienced within the environment itself, gained from wayfinding devices or recollected from memory, is central to all of the definitions of wayfinding above. Information may be useful to someone undertaking a wayfinding task, may be irrelevant or may be confusing and lead to disorientation (Zeisel, 1984). It is therefore important in order to study wayfinding to study what information is available and how it is used.

Hart and Moore (1973) suggested that an understanding of a building involves landmark knowledge, route knowledge and survey knowledge. These define the various elements of environmental knowledge (a recognition of landmarks, an understanding of route and a recollection of surroundings). Lee and Tversky (2005)

and Platzer (2005) expand on these concepts of different types of environmental knowledge with, in the case of Platzer, further subsets of knowledge that expand and connect basic landmark, route and survey knowledge. The analysis undertaken by Passini (1984) of how wayfinding decisions are made included not only landmarks but the far broader term 'information in the environment', to describe anything which could be perceived within the environment. Norman (1988) explores how this information (termed in his research 'knowledge in the world') differs from information held in the mind (termed by Norman 'knowledge in the head'). Passini's analysis of wayfinding decisions, covered in more detail in section 2.5.1, has at its centre the recognition of places by comparing this information in the environment against information held in the mind.

2.4.1 Information in the environment

Information in the environment is potentially anything within the environment. It is all the information stored in the generation of a cognitive map. Passini et al. (1998), as well as listing various examples of information in the environment, also discuss the importance of ensuring that information is clearly and efficiently communicated within the building. The example they use is of a sign directing visitors to a staircase. They suggest that the requirement for a sign shows that the architectural expression of the stair is insufficient – the stair lacks architectural legibility (O'Neill, 1991a; Weisman, 1981). In this instance, given the central importance that staircases have in many wayfinding tasks, this has the potential to badly impair wayfinding performance (Vrachliotis et al., 2005). In an experiment studying route choice (covered in more detail in section 2.6.4), Zacharias (2002) reported that participants avoided taking routes where the circulation area was not clear, typically due to clutter or poor demarcation between the circulation area and adjoining non-circulation areas. It appears from these studies that environmental information that is of relevance and value to people when wayfinding should therefore be suitably expressed and distinct from their surroundings. These characteristics of expression and contrast also typically describe landmarks (Lynch, 1960).

In order that that environmental information can be collected visual accessibility to it at some level is important (Appleyard, 1969; Brösamle & Hölscher, 2007; Goodey, 1974). Weisman (1981) reflects this importance with the inclusion of visual accessibility as one of four groups of environmental variables felt to be of importance when wayfinding. Research by Dogu & Erkip (2000) supports this with findings from an experiment undertaken in a shopping mall featuring a central atrium area leading to corridor-type malls. Participants in the test were more successful finding shops located around the atrium than shops located along the malls. This was attributed to the increased visual accessibility that the shops around the atrium afforded, an outcome that mirrored architectural recommendations made by Arthur and Passini (1992).

2.4.2 Landmarks

Many studies try to explain how and what people need to find their way in the physical world, how they communicate directions and how people's verbal and visual abilities influence wayfinding. Methods of describing a route usually involve the provision of sequences of instructions, however, this kind of procedure does not pay attention to human wayfinding behaviour. Research in spatial cognition has shown that people do not only reference to sequences but frequently use landmarks during spatial orientation and communication of routes (Raubal & Winter, 2002). Golledge (1992) states that landmarks usually provide a significant part of cognitive maps, ensuring a commonality of understanding between people if they have placed the same emphasis on the same landmarks. It is found that landmarks are referenced frequently when discussing knowledge of place.

Lynch (1960) defines landmarks as external points of reference - points that are not part of a route like the nodes in a travel network but a feature of the route. He describes their defining physical characteristic as "singularity, some aspect that is unique or memorable in context." (Lynch, 1960, p. 78). Singularity is derived from a clear form, contrast to the background and a prominent location and can be

achieved by the form and volume of the space that define architectural and decorative elements, and by the use of finishes, light, colours, and graphics (Arthur & Passini, 1992). At the city scale which Lynch is concerned with, one of the contrasting features of landmarks is that they are the only three-dimensional element within a cityscape primarily experienced two-dimensionally. Landmarks and nodes may mark the same point as the node contains all the elements that make it distinctive, possibly including the landmark that marks the node's location from vantage points elsewhere in the city. However, as explained above, this aspect of landmarks is rarely practical within the confines of a building – there are rarely 'vantage points' from which it is possible to see from one of a building's hubs (e.g. a reception space) to another (e.g. an internal atrium).

Landmarks may have particular visual characteristics, a unique purpose or meaning or may be in a central or prominent location that makes them effective as a landmark (Sorrows & Hirtle, 1999). Thus an object's or structure's status as a landmark does not depend on its individual attributes but on the distinction to attributes of close features. Being a landmark is therefore a relative property (Raubal & Winter, 2002). Studies show that landmarks are selected primarily as reference points for route directions, preferably at decision points (Passini, 1984; Michon & Miche; Denis, 2001; Janzen & van Turennout, 2004; Raubal & Winter, 2002), and are essentially used as sub-goals along the route: people progress along a route by orientating themselves towards a landmark (Michon & Denis, 2001). In another study by Lovelace et. al., (1999), landmarks were categorised in four different types: landmarks at a choice point, potential landmarks at choice points, on route landmarks and off-route landmarks. Their research showed that for unfamiliar route directions, landmarks at turning points and just on-route points are quite frequently used and the appearance of landmarks correlates significantly with the quality of route directions. Landmarks are also frequently selected at positions where reorientations could occur, and are usually chosen in positions that pre-empt the decision point slightly rather than being at the decision point, so that someone following the route has time to recognise the landmark and decide which direction to take (Michon & Miche; Denis, 2001; Tom & Michel Denis, 2003). These 'local'

landmarks are only experienced when at close range (rather than the landmarks marking a distant destination), and are therefore most relevant to studies of wayfinding within buildings. Both Lynch (1960) and Steck and Mallot (2000) distinguish between local and global landmarks. Steck and Mallot define local landmarks and global landmarks as follows:

- Local landmarks: visible only from short distances, often associated with route decisions, e.g. normally sized houses, signs, small, but striking objects

- Global landmarks: visible from far away, define an external frame of reference and provide direction knowledge, e.g. sunset, stars, mountains, high towers or buildings

The influence of landmarks on wayfinding is as yet unconfirmed. Tlauka and Wilson (1996) found little evidence of the use of landmarks when wayfinding. However, this runs contrary to the majority of research on the subject. Darken and Sibert (1993), although finding that local landmarks seemed not to play a great role in wayfinding did find that global landmarks (in their case the inclusion of a virtual sun in their computer generated environment) did play a significant role in wayfinding. Steck and Mallot (2000) conclude that landmarks are used within wayfinding.

2.4.3 Signage and other graphical / textual information

There is a common misunderstanding that the term "wayfinding" is the same as "signage" (Muhlhausen, 2006). Lynch's definition of signs, street numbers and maps as 'way-finding devices' (Lynch, 1960, p.24) might be identified as a source of such confusion, however the terms "wayfinding" and "signage" are not synonymous (Carpman & Grant, 2002). Signage is discussed throughout this thesis as it can be a valuable source of information when wayfinding, particularly in unfamiliar spaces. People visiting an unfamiliar space do not have previous knowledge to draw on and are therefore reliant on external information (Norman, 1988; Raubal, 2001) of which signage is one kind. However, as this suggests, persons when wayfinding in unfamiliar environments do not rely exclusively on signs (Muhlhausen, 2006).

Signage is a complement to good wayfinding design. Even the most legible and immediately understandable buildings still require textual information to identify destinations (Passini et al., 1998), particularly those that are not clearly identifiable by their form or which are part of a group of largely identical destinations (such as individual offices). Where the destination is not visible from the start point of the route, which is often the case within buildings, signage is also required to inform initial direction choices. O'Neill (1991b) however found that signage is frequently employed to compensate for poor wayfinding design, rather than to support good wayfinding design. Arthur and Passini (1992) provide the example of a Montreal commercial centre initially praised for the quality of its internal spaces but derided by those who had to use it and frequently became lost within it. Even the later addition of a clear, comprehensive and consistent signage system did not alleviate these problems. In a combined study of plan complexity and signage provision, O'Neill found that, while some benefit was gained adding signage to complex plans, it was markedly less than the benefit gained from simplifying the plans. The simpler plans, even without signage, led to fewer wayfinding errors. Good wayfinding design is therefore considered a prerequisite to a useful signage system (Passini, 1999).

Another explanation for the apparent ineffectiveness of signs in many situations could be the lack of recognition of the signs or understanding of the information they provided (Seidel, 1982). The location of signage has been found to be of significance in signage recognition. Placing signs at decision points increased their recognition and in turn wayfinding speed and accuracy (Best, 1970). This fits with Passini's (1984) model of how wayfinding tasks are undertaken, with information between decision points largely ignored (see Section 2.5.1, Figure 2.01). It is also necessary that the mental image conjured by the sign matches the actual image, i.e. the appearance of what the sign is representing (Mollerup, 2005). A sign directing visitors to a reception desk, for example, may be of little use when the reception desk does not match the visitors' expected appearance of a reception desk. This can have the same detrimental effect on wayfinding performance as any mismatch between information in the environment and information in the mind (Passini, 1984). Mollerup also details

a variety of technical issues that may blight signs (e.g., poor contrast between text and background) and issues of misunderstanding the signage content (Ramadier & Moser, 1998), any of which may worsen the wayfinding problems the signage was intended to ease (R. Kaplan et al., 1998).

Carpman et. al. (1984) outline the different types of signage, categorising signs as either identification signage or directional signage. Identification signage is typically room numbers or names or, in an external context, a building name or a sign welcoming visitors to a town. In all cases the sign is located at the anticipated destination point. Directional signs provide information aimed at directing people towards their chosen destination point. This group is considered to include maps (Passini, 1980), specifically 'You-are-here' type maps and again the location of these has a significant impact on their value to the wayfinding process (Levinew et al., 1984). Here, wayfinding performance was also found to be related to the orientation of the map in relation to the surroundings of those viewing it.

2.4.4 Cognitive maps

Central to the Passini wayfinding theory is the ability to compare perceived environmental information (sensory – Is, see Section 2.5.1) to expected environmental information (retrieved from memory – Im, see Section 2.5.1). Wayfinding success therefore relates to the recognition of environmental information and correct execution of associated wayfinding instructions (Raubal & Winter, 2002). There is no definitive explanation of how this environmental information is stored and structured in the mind and accessed when undertaking wayfinding tasks, however the term cognitive map is commonly used to describe in some way how the information is stored and structured.

A cognitive map of an environment is a mental image of that environment (Golledge, 1995). Lovelace et al. (1999, p.77) term it a person's 'spatial representation'. It may be drawn from primary and secondary information (Kitchin & Freundschuh, 2000),

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the former being information observed in the environment (as termed by Passini (1984), Norman (1988, p.54-80) terms this 'knowledge in the head') and the latter being maps, signage etc. The presence and development of cognitive maps, and the term 'cognitive-like map', were derived by Tolman (1948) as an explanation for route behaviour. Tolman suggested that these mental representations indicate routes, paths and environmental relationships and that it is information from the maps, rather than directly from the environment, which determined the path choice responses in the subjects which were being studied.

Although similar in name, cognitive maps are recognised as being quite distinct from drawn maps as conceived of by physicists, geometers and cartographers (P. Lee & Tversky, 2005; Lynch, 1960). The word 'map' is used to emphasise that the term refers to representations of spaces (Kitchin & Blades, 2002, p.2), however it can be misleadingly understood to imply an accurate, scaled two dimensional map held in one's mind. Mental understandings of an environment do not necessarily obey laws about geometric properties and the inferred relationship of spaces. Evidence for this was found by Gärling (1989) in a study which demonstrated clear differences in path choices based purely on information in the mind compared to path choices made with reference to a printed map. Although cognitive maps and printed maps are both means of storing information in the environment and the relationship between elements in the environment, it is not clear exactly how this information is organised in cognitive maps nor how this affects the differences in path choice recorded by Gärling. The non-cartographic nature of cognitive maps only becomes confusing when the cognitive map is thoroughly interrogated, when it is comprehensive and it is found that a new piece of spatial information does not fit, or when the cognitive map is compared with the perceived environment and found not to match.

Lee and Tversky (2005) also suggest that, in reality, remembered information is stored as a cognitive collage, gradually added to as new environmental information is collected but never organised into a true geographic framework. Spatial mental models are employed to store spatial relationship information that would be lost in a

cognitive collage, although even these are crude compared to the degree of accuracy implied by cognitive maps.

Hart and Moore (1973) introduce the issue of time to cognitive maps, suggesting that, as environments change over time, so does the information collected from the environment and hence the cognitive map that this information is stored in. Even though the built fabric of a city does not change quickly, the navigability of it changes minute by minute as a consequence of the actions of others (transient hazards). The transient element of cognitive maps was also a factor in the information Lynch elicited from city residents participating in his studies of the city image. Lee (1976, p.124) notes that his aim was to 'capture the essential character of cities, the structure and identity of meanings formed by constant interaction and serving as a cognitive map to make orientation possible'.

Moeser (1988) found that ability to construct a cognitive map was related to the complexity of the environment, and that beyond a certain level of complexity the information contained in a cognitive map was not in itself adequate when wayfinding. Their experiment, conducted in a large, complex building on two groups of participants, one group unfamiliar with the building but wayfinding once they were familiar with a printed map and one group relying on two years' experience of the building, found the former group navigated the building more efficiently (in a more direct and expedient manner).

Acquiring a cognitive map is a gradual task – cognitive maps are progressively developed and refined during the experience of an environment (Evans et al., 1981). In circumstances where a cognitive map is being relied upon when wayfinding, its completeness is therefore a determining factor in wayfinding performance. A lack of completeness is considered by Bell et al. (1990, p.69) to be one common error amongst cognitive maps. Other errors tend to arise from simplification of information (straightening routes; missing out decision points that are not, at the time they were perceived, considered relevant) and distortions (basing recollections

of size on recollections of importance; errors of angle, particularly leading to an assumption that paths are parallel when they are not). Passini et al. (2000) found a clear relationship between cognitive map accuracy and wayfinding performance.

2.5 Understanding wayfinding tasks

Section 2.5 explores how the information discussed in sections 2.4.1~3 above, once collected and stored in cognitive maps, is used within wayfinding tasks. Decisions as to which direction to take are based on this information, however the information has to be filtered and analysed before it is of any use. Also, it is worth stressing here that not everyone possesses the same quantity or type of information. People who are within an environment that they are not familiar with (unfamiliar users), lacking a complete cognitive map (Lovelace et al., 1999) are reliant entirely on information that is perceived within the environment (including architectural clues) and information that can be gained from wayfinding devices such as signage and guidance systems (Raubal, 2001). Being able to collect this knowledge in the world is an absolute necessity to the successful completion of wayfinding tasks in unfamiliar environments. By comparison, people who are within an environment that they are familiar with can call upon information stored in their cognitive map. This may have a significant influence on wayfinding decisions – for example, knowing in advance of a dead end to a route.

It is also necessary to determine the purpose and nature of the wayfinding tasks being considered. Allen (1999b, p.48) categorises these as 'travel with the goal of reaching a familiar destination; exploratory travel with the goal of returning to a familiar point of origin; and 'travel with the goal of reaching a novel destination'. It is the last of these categories that is most relevant to the focus of this thesis study – people (unfamiliar users) finding their way to a destination whose location is unknown.

2.5.1 Elements of a wayfinding task

When considering the number of variable factors even the most basic of environments have, it quickly becomes apparent that wayfinding tasks and the cognitive processes required to successfully undertake them, can be very complex. Passini (1984) aimed to break these tasks down into smaller, more easily understandable components by developing an analysis of the cognitive processes (information processing and decision making) and consequent actions involved with wayfinding (Figure 2.01). A wayfinding task (T) is broken into a series of smaller, sequential wayfinding problems each of which needing to be resolved into a wayfinding decision (D) based on environmental information (I) and leading to a behavioural action (B). These are considered the basic units and structure of wayfinding and are further broken down. Environmental information can be either sensory information (Is, information directly experienced), information retrieved from memory (Im) or inferred memory (Ii, information deduced from recognition of related sensory information). Decisions follow a certain hierarchical structure. The organisation of a wayfinding task can lead to decisions running sequentially and overlapping each other, while it is also noted that the wayfinder is not receptive to environmental information when in the process of undertaking an action. A distinction between goal decisions (D) and action decisions (D) is made, action decisions being the immediate motor action decided upon to reach the next decision point. When decision points are reached, the experienced image (information from the immediate environment) is compared with the expected image (from memory information) and a decision (action decision) made as to which direction to go next based partly on whether these two images match or not (Figure 2.01).

subsequent
decision for
execution

$Dm+1$

B OVERT
BEHAVIOR ← execution of
behavior

$I^{ex} = I^{pe}$
IF

Dn

I^{ex} EXPECTED
IMAGE

I^{pe} PERCEIVED
IMAGE

perceiving
setting

matching expected and
perceived image

B PLANNED
BAHAVIOR

$I^{ex} \neq I^{pe}$
IF

new alternative
ready for
execution

Dm NEW PLAN
AND
DECISION

Decision
making

T DECISION
BECOMES TASK
AND PROBLEM

no execution
of behavior
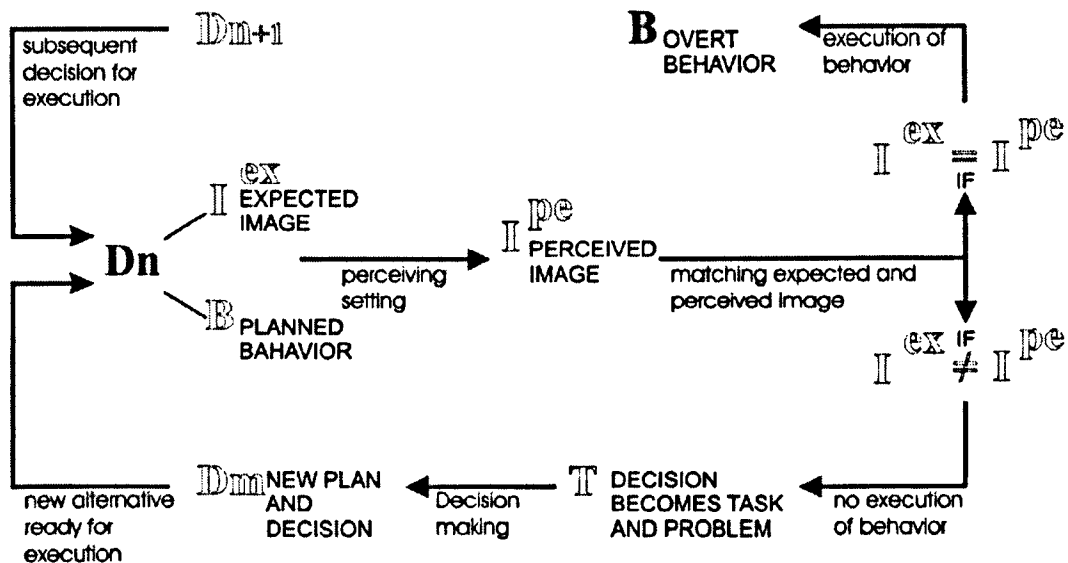
Figure 2.01 Decision execution as a matching feedback process
Source: Passini (1984, p72), re-drawn by author

An essential component of Passini's analysis of wayfinding tasks is the ability to recognise places. The quote below expands on the definition of wayfinding by Peponis et. al. (1990) quoted in section 2.3.1, with its concern about recognising place. It also gives an idea of the broad scope of the information and processes necessary to recognise somewhere or something, one of the main processes and skills utilised in wayfinding.

> In the spatial domain 'recognising' a place means being able to identify its location. In addition to location, occurrences found at particular places have other characteristics, including a name or identity, physical features such as colour, shape, size etc, a temporal life or episodic interval at which an occurrence occupies a location, and a magnitude or measurement of how much of the occurrence is found at that place. Thus, although place is a dimensionless spatial term, conventionally it is interpreted as a multidimensional phenomenon. (Golledge, 1992, p.201)

Collectively, these series of decisions form a route. It has been suggested that the most efficient form of wayfinding (i.e., the most expedient and following the most direct route) involves following an action plan that links in advance a series of these decisions and their related actions (Gärling et al., 1986), however wayfinding performance has been found not to be purely dependent on such 'motor schemes' (Blades, 1991).

2.5.2 Circulation within buildings and wayfinding

Circulation spaces is a term often used within building design. Circulation implies free movement from place to place (Agnes, 1999, p.266), hence circulation spaces which function fully as their name suggests lack obstacles to wayfinding. Within Lynch's study (1960) of wayfinding within cities, spaces within buildings are ignored. Although there are occasions when paths joining two nodes may go through public buildings, this is relatively uncommon. Lynch therefore regards the façades of buildings as edges which cannot be crossed. When considering wayfinding within buildings, rooms have a similar influence. Most buildings, particularly but not exclusively those with cellular organisation of rooms, have distinct circulation spaces that are the focus of wayfinding activity. These circulation spaces include all the decision points, paths and nodes that are encountered during wayfinding tasks therefore it is these spaces that are the focus of this research.

The external form of a building and its circulation spaces are closely linked (Tregenza, 1976). More specifically, a building's form may limit the options available to the architect when designing the circulation system and may be a factor in convoluted and confusing circulation spaces. Also, as circulation spaces are influenced by building form, there is the opportunity to gauge the likely nature of the circulation space before entering the building (Dogu & Erkip, 2000). As circulation spaces are often the organisational structure within buildings (Arthur & Passini, 1992), this has the potential to provide a very beneficial initial piece of environmental information to the wayfinder. It may be drawn upon to structure information in the cognitive map,

especially when being within cellular spaces within a building make it difficult to visualise the building's overall structure. Conversely, if the building's form does not accurately inform the wayfinder of the circulation spaces within the building, which may particularly be the case with larger buildings, the cognitive map may be corrupted by relying on an assumed circulation layout in this manner.

2.6   Wayfinding strategies

The approaches to wayfinding tasks discussed above generally involve the collection, recognition and use of information, either from the immediate environment or from wayfinding devices. However, not all wayfinding behaviour can be explained in terms of response to information. There may be occasions when there is no appropriate or relevant information available to use. There may also be occasions when a great deal of environmental information has to be analysed before wayfinding decisions can be made. Although a glut of information may appear to be beneficial, in reality only so much information can be remembered and processed, as identified by Moeser's study of the reliability of cognitive maps in complex environments (Moeser, 1988). Therefore, decisions may be made based on assumptions or the application of measures intended to reduce the numbers of variables that have to be processed.

Wayfinding strategies form the basis for these decisions. Mollerup (2005, p.43) defines a wayfinding strategy as 'a rational principle for search, decision and motion'. This definition includes intelligent seeking (filtering the wayfinding process based upon already-observed knowledge), rather than random seeking. It is noted that random seeking does not involve logical reasoning and therefore may be resorted to in desperation when the cognitive processes are impaired by feelings of stress (discussed further in section 2.7).

Some wayfinding strategies, discussed below, are explored to find their relevance and application to wayfinding within buildings. They have been identified within the literature as being used by many people in a range of circumstances as partial or

complete responses to wayfinding tasks. Several of the wayfinding trends identified amongst the results of the observational study conducted in the University of Sheffield Students' Union building (documented in Chapter 3) also appear to tally with the wayfinding behaviours that the wayfinding strategies describe. These two factors were instrumental in deciding upon which wayfinding strategies to study in greater detail through the thesis, however the bearing the arrangement of the circulation spaces within buildings has on these strategies was also considered. Design of the circulation spaces is usually the architect's responsibility and is conducted early in the design process. Any use in practice of the findings from this research would also be aimed at the early stages of the design process, hence any wayfinding strategies that need to be considered at that stage are of primary interest.

2.6.1 Strategy 1: Maintain a Straight Bearing

This strategy describes the tendency among wayfinders to avoid making changes of direction along a route. The 'straight bearing' is maintained while it is possible to do so (there are no obstacles present forcing a change of direction) until information explicitly identifies a change of direction to be necessary.

The Least Angle Strategy (LAS) (Hochmair & Frank, 2000; Conroy-Dalton, 2001; Conroy-Dalton, 2003) and Initial Segment Strategy (ISS) (Bailenson et al., 2000) describe wayfinding behaviours which avoid straying from a straight bearing by taking the fewest turns (LAS) or longest leg first (ISS). A wayfinding decision based on LAS would see the user deviating as little as possible from either their current route, or if this has already been deviated from, the direction they originally set out to take. References outside the immediate environment are very helpful when determining a 'running' deviation from the original direction (the amount of deviation at any one point along the route). Without these references, inaccuracies incurred with each LAS-based decision can be compounded due to the complexity of continually considering and calculating angles of deviation at decision points (Hochmair & Karlsson, 2005). A wayfinding decision based on ISS would see the user tackle a

route to their destination that commences with the longest path apparent at the outset. For example if, at the start of the wayfinding task, two paths in roughly the correct ordinal direction are available, the choice of path will be based on which has the longer initial leg.

These studies concentrated on wayfinding tasks undertaken by users unfamiliar with their environment, however LAS and ISS also appear to be favoured strategies for wayfinding amongst those familiar with their environment (and may know shorter, but more complex routes). Golledge (1995) tested the route preferences of 32 familiar users on maps and on a Western United States campus. Two out of the ten criteria were 'fewest turns' and 'longest leg first'. This test demonstrated people's preference for selecting a path which has fewest turns or longest leg first when they were familiar with the route.

Conroy-Dalton (2003) undertook an experiment in a virtual environment in order to determine whether LAS was deliberately adopted when wayfinding or if it was an outcome of random wayfinding decisions. 30 participants were asked to navigate diagonally across a square environment, comprising a series of irregularly shaped polygonal 'buildings' (Figure 2.02). Path choice was noted at each decision point within the environment and compared against randomly generated path choices at the same decision points. Because of this it should be noted that these random path choices did not link together to form a 'random route', but instead represented an alternative possible path choice to the one chosen by the participant. The average deviation across all decisions was calculated for each participant and again for each of the participants' random alternative path choices. Conroy-Dalton argued that, as the participants' decisions led to a smaller deviation than the randomly generated choices, the LAS must be a deliberately followed means of navigation rather than the outcome of randomly exploring the environment. Unfortunately, no provision appears to have been made to prevent the random choice generator from making 'unlikely' choices. There was no means, for example, of stopping it from repeatedly choosing paths that would result in the route almost doubling back. This is a

potential problem as such routes may not be representative of human wayfinding behaviour.
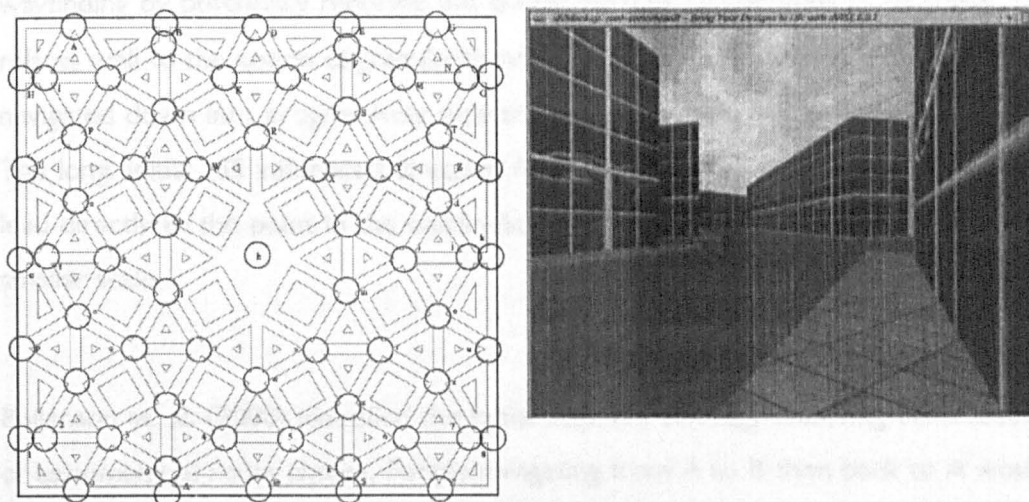
Figure 2.02 Left: Plan for Conroy-Dalton's test environment; Right: Virtual test environment as seen by participants
Source of images: Conroy-Dalton, 2003, p110 (left) and p109 (right)

In introducing the Least Angle Strategy, Hochmair and Frank (2000) describe a scenario where the navigator knows the target direction needed to be followed to reach their destination (target vector) but does not know how to reach that destination. This is not always the case when wayfinding, as a visitor to an unfamiliar building may know neither the location of their destination nor how to reach it. The target vector required in order to utilise LAS is found from being able to see the destination from the point of origin, typically if the destination is a dominant landmark such as a church, or by identifying the destination on a map in relation to the point of origin. When inside a building, it is rarely possible to see the destination from the point of origin. It may however still be possible to determine a target vector, from maps or an understanding of the overall plan structure of the building (for example, knowing which wing the destination is in and having an understanding of how the building's wings are organised in relation to each other).

Initial Segment Strategy is, in essence, a complexity-reducing exercise. It postpones

the point at which decisions based upon environmental information have to be made. A user may base their first wayfinding decision on ISS, choosing the longest path available on the grounds that it is a known quantity. By making the first stage of a wayfinding task as simple as possible, ISS reduces the number of variables in wayfinding by potentially reducing the overall number of decisions to be made. ISS relates well to the notion of granularity when wayfinding, of splitting the areas being navigated down into progressively smaller chunks or districts (Wiener et al., 2004). The long, initial, ISS influenced direction may be chosen to cross many districts and lead directly to the point in the wayfinding task where it is necessary to consider a smaller scale.

Bailenson et. al. (2000) identified the Initial Segment Strategy following observations of asymmetrical route choice. People navigating from A to B then back to A would choose a different route for the return portion of their journey to the route chosen for the outward portion. Christenfeld (1995) noted that people deferred making route decisions for as long as possible at the start of wayfinding tasks as a means of simplifying the task. Within the diagrammatic representation of a path structure shown in Figure 2.03, Route c would be chosen on the outbound portion of a journey as from start point A this route would defer route decisions for the longest period during the wayfinding task. A different route (Route a) is used on the return portion for the same reason, albeit from the environmental information available when at point B. A shorter route may be possible in order to fulfil the wayfinding task, although this would be more complex and require decisions earlier on in the task. Duckham et. al. (2003) found that on average there was only a 16% increase in length due to simplifying routes in this manner, hence this simplification is not considered overly detrimental to the efficient completion of wayfinding tasks.
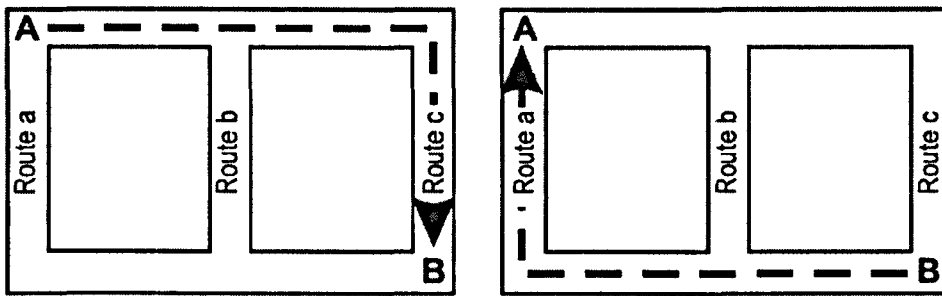
Figure 2.03 Diagram showing route taken from A to B and B to A as described in Christenfeld's study (1995)

Bailenson et. al. (2000) confirmed the validity of ISS through a series of five experiments. The first involved participants choosing between two routes of equal length, one comprising frequent turns, the other comparatively straight. The latter route was preferred. The second experiment featured route choices of equal complexity, but one with a straight segment at the start and another with the straight segment at the end. Participants preferred the former route. Two of the other three experiments arrived at similar conclusions, while the third showed that ISS was more likely to be relied upon during time pressure. It is felt this would be of particular interest to transport interchange designers, who have to cater for visitors unfamiliar with their environment and under time pressure to catch a train or plane. These experiments conducted all comprised of participants identifying preferred routes on maps.

Hockmair and Karlsson (2005) undertook a study of choices of initial direction chosen when wayfinding in order to see whether LAS or ISS was more prevalent. ISS had previously been found to be employed by people when planning routes on maps. Its relevance to un-aided wayfinding was tested by Hockmair & Karlsson and found to be less relevant in this situation than LAS. LAS was considered to be the less risky strategy – an incorrect route chosen on the basis of ISS may lead to a lengthy double-back. Although not tested in that study, it was suggested that regular junctions along a long route may influence ISS-based decisions.

The further relevance of LAS to wayfinding within buildings was explored by Hölscher et. al. (2004; 2006). Their study aimed to determine vertical circulation choice in multi-storey buildings. It was noted that people undertook the same wayfinding task in a multi-storey building in a variety of different ways, the determining factor of their choice appearing to be their familiarity with the building. Three methods were identified:

- The central point strategy of finding one's way by sticking as much as possible to well-known parts of the building, like the main entry hall and main connecting corridors, even if this requires considerable detours.

- The direction strategy of choosing routes that head towards and lead to the horizontal position of the goal as directly as possible, irrespective of level changes.

- The floor strategy of first finding one's way to the floor of the destination, irrespective of the horizontal position of the goal.

It was noted that there was a correlation between these and several known strategies for navigating two-dimensional environments. The direction strategy appeared to relate to the Least Angle Strategy – in both cases a minimum degree of deviation from the direct line to the destination was chosen. This research did not directly study use of Least Angle and Initial Segment Strategies within buildings, although as it was found that the direction strategy was favoured by unfamiliar users it could be inferred that they would also prefer the Least Angle Strategy when wayfinding within one floor.

2.6.2 Strategy 2: Avoid a Change of Level

The concept of districts in wayfinding was developed as one of the five key elements Lynch observed as making up the cognitive image of the city (Lynch, 1960). These elements were derived from drawn and described cognitive information collected from visitors to three US cities, two (Jersey City and Los Angeles) having strict grid pattern city plans and one (Boston) with a more varied plan more typical of those

found in non-US cities. Lynch's interest lay in the information people selected from complex urban environments to organise their cognitive maps. Five key elements comprising landmarks, nodes, paths, edges and districts were defined in the book as described in section 2.3.1, with districts described as 'medium to large sections of the city, conceived of as having two dimensional extent ... which are recognisable as having some common, identifying character' (Lynch, 1960, p.47). Districts were a means of simplifying and organising the city conceptually. The numbers and complexity of the other elements are more manageable within a district-scale area than within a larger city-scale area while the city as a whole is easier to visualise and mentally navigate as a relatively small group of districts rather than a complex mass of the other elements. Districts are typically quite clearly delineated, either by impermeable edge elements, for example a private building or railway embankment, or route-forming path elements such as major thoroughfares. Lynch also found that crossing district boundaries was considered a more significant wayfinding act than navigating within districts.

Lynch's research concentrated on mental representations of cities. Passini (1984), an architect and environmental psychologist, relates the five key elements to mental representations of internal spaces and demonstrates how the concept of districts is still relevant within buildings. His study concentrated on several very large buildings in Montreal and identified the use of districts to discern public shopping zones, office zones and residential zones, homogeneous areas within the buildings studied. Sub-zones were also identified, with the example of a bazaar-like area of market stalls within a larger shopping area given. This brings the relevance of districts to some smaller buildings with fewer uses. By Passini's first definition of building-scale districts a shopping mall of any size would likely to have only one or two districts as the building only has one use (shopping) plus administrative offices (districts based on usage zones). However, by the second definition, the mall may have multiple districts each relating to parts of the mall with distinct characters as well as the office district (districts based on characters).

Because of its roots in city-scale wayfinding, Lynch's concept of district is purely two-dimensional. The vertical dimension is never navigated, except in the rare instances of vertically stacked public 'external' spaces (limited mainly to relationships between public 'surface' space and any subterranean shopping or access spaces). In determining the concept of building-scale districts it has to be decided how different floors are treated. Passini (1984) noted that changes in space function and building floor often coincide, hence by this definition different floors will tend to be considered as different districts by default. Even when there is not a change in use, taking a lift or climbing a staircase is a greater impediment to movement than walking along a corridor, which may reinforce the perception of floors as natural district boundaries. The envelope of a building is a natural 'edge' element and is consequently also a district boundary, particularly on upper floors.

The proposition that floors automatically correlate to districts appears potentially flawed when atria through buildings are considered. An atrium typically has its own distinct character, which would suggest that the atrium itself is a district, however the atrium will typically cut across several floors which may have open spaces bordering the atrium. It is not clear if someone in a space bordering an atrium, but two storeys up, considers themselves within the floor district, the atrium district or both. If districts are always perceived two-dimensionally then this person would consider him / herself within the floor district only. Alternatively, the answer may be dependent on the relative strengths of the floor district character and atrium district character.

Research by Soeda et. al. (1997) potentially undermines the suggestion that floors and districts always correlate. They studied route recollections from 16 participants who, amongst a variety of tasks, navigated between spaces on floors with and without matching plans. They found that participants expected floor plans on different floors to match and became disorientated when they didn't. This could imply a vertical relationship between floors in the mental representation of the building, which would suggest that floors are not automatically perceived as

independent districts. However, an alternative explanation would be re-use of cognitive data of one floor as a means of quickly developing an understanding of other floors. The disorientation is merely the result of being unable to re-use this information, or the affects of attempting to re-use this information in spaces that do not match. There are comparable scenarios in two dimensional wayfinding and this behaviour has been suggested by O'Neill (1991b) in research into symmetrical spaces, where cognitive data collected about one space is re-used when attempting a wayfinding task in the symmetrical companion space. While there is no consensus on the benefits of symmetrical two dimensional space, Montello and Pick (1993) do suggest strong benefits for such repetition in three dimensional space.

In the experiments conducted by Soeda et. al. (1997), a change of level is forced, hence it is not possible to tell if participants would have avoided a change of level if given the choice. However, the findings demonstrate confusion caused by changing levels and it may be that people draw upon past experiences of this nature when faced with a change of level decision. This would suggest a reason, beyond the analogy of districts, why people may avoid a change of level when wayfinding.

Further supporting the suggestion that different floors are regarded as different districts, where there are examples of vertically stacked public spaces in the city scale, their representations do not necessarily match. Underground train maps are based on mental representations of the network, but while there are strong links between stops and surface features, the underground and surface maps differ greatly. Research by Hölscher and his colleagues investigate the practical effects of this perception of floors as independent, stacked districts (Hölscher et al., 2004; 2006). They studied the wayfinding behaviours of 12 participants in a multi-storey conference centre. Six of these participants were already familiar with the building, six were not. The familiar participants typically undertook all the vertical circulation at the point of entry into the building, reaching the required district quickly before tackling the smaller-scale wayfinding to reach the destination. The unfamiliar participants avoided leaving the current floor until it was necessary, preferring to stay

in the known district for as long as possible before tackling changing district. It would not be correct to suggest that they were relating the later floor plan to the current floor plan as, without a prior mental representation of the current floor plan, they had nothing to relate the later floor plan with.

The three vertical wayfinding strategies (see Section 2.6.1) identified by Hölscher et. al.(2004; 2006) each correlate to a horizontal wayfinding strategy. The floor strategy, as used predominantly by the familiar participants, corresponds to the region (or district) strategy observed in two dimensional city scale wayfinding - the participant finds the required district first in a process of gradually making the wayfinding task more fine-grained as it progresses. This responds to Passini's research (1984) which suggesting that all wayfinding tasks are broken down and followed in such a granular hierarchy. The districts provide a means of visualising in a simple way the city as a whole while the destination is some distance away, and in the study by Hölscher et. al., the participants would appear to treat floors in the same manner. All of the three strategies also treat vertical circulation separately to horizontal circulation, regarding the building as a series of stacked two dimensional planes rather than three dimensional volumes. Research in virtual environments by Vidal et. al. (2004) supports this, as it was found that participants quickly became disorientated when wayfinding was conducted in three dimensional space as opposed to remaining on a two dimensional plane.

To summarise, the concept of districts is relevant at the building scale - an area within a building with a defining character is no different to an area within a city with a defining character, and both may be regarded as districts. Furthermore, buildings are generally perceived as consisting of a series of two dimensional planes - the floors. Floors are distinct from each other in mental representations and may consequently be regarded as districts. With the possible exception of atria, mental representations do not link floors together hence departments generally do not span floors, however the re-use of information between floors is more widespread than between districts at a city scale, hence if the layout of floors within a building differs

this can be disorientating.

If floors are considered to be districts, then the act of using a staircase, lift or ramp leads to the visitor crossing district boundaries. This is considered by Lynch to be avoided by wayfinders in preference to remaining within the district. Therefore, anyone without a definite knowledge of a requirement to change level will avoid doing so. This is supported by findings of level change behaviour in unfamiliar users, namely leaving the level change until the last possible time (Hölscher et al., 2004; 2006).

2.6.3 Strategy 3: Walk Towards a Brighter Space

Throughout this discussion, *Brighter space* is considered in terms of relative illuminance levels between neighbouring spaces. A space is considered to be 'brighter lit' if its illuminance level is higher than that of neighbouring spaces. In wayfinding decisions, any direction at a decision point that leads to a neighbouring space with a higher illuminance level than the decision point is considered to lead to a brighter space.

The human eye naturally responds to changes in light levels. Bright light causes strong physiological changes in the eye and attracts the focus sensor within the retina (Michel, 1995). In order that a bright light in the periphery of the field of vision can be seen correctly by both eyes, it is necessary to turn the head, which in turn influences movement of the body. There is therefore a direct link between brightness and orientating oneself in a particular direction. This may be a subconscious reaction to bright lights, however it does stop short of actively leading to movement in a particular direction. The presence of a brighter light in one direction may also limit receptiveness to information from other directions, due to the brighter space attracting the eye's focus and the eye's adaptation to the brighter light resulting in surrounding spaces appearing darker (Bell et al., 1990, p.383).

Evidence that people have a tendency to move toward brighter spaces can be found from the test carried out by Taylor and Socov (1974) and Kang (2004). Both Taylor and Socov's and Kang's research involved participants experiencing a decision point with two route choices, the only difference between them being their illuminance levels. This provides some evidence that brightness can affect wayfinding decisions (Michel, 1995; Ginthner, 2004; Boyce, 2003; Boyce, 2004).

Most interior spaces have artificial lighting, either as the sole source of illumination, as is the case in many corridors and staircases, or to complement available illumination from daylight. Variations in brightness could be achieved by selection of illuminance levels (higher illuminance tend to appear brighter) or by choice of surface reflectance (a surface of higher reflectance will appear brighter for the same surface illuminance). A space which is naturally lit will tend to appear brighter than a space which is purely artificially lit (Binggeli, 2002). A waiting room at the end of an internal corridor in a healthcare premises may be an example of this. In daytime, the corridor will be lit to 200 lux (CIBSE, 2002). The waiting room should have an average daylight factor[1] of 2% to 5% (Tregenza & Loe, 1998). Due to the variable nature of daylight, a diffuse sky can produce 5,000 lux or more for 85% of the day (Phillips & Gardner, 2004, p.xxii), averaged across the working year. Therefore an interior illuminance from daylight alone of between 100 and 250 lux (2% to 5% of 5,000 lux) is exceeded for 85% of the working year. As a result of this, the illuminance level within this room can be expected to exceed the 200 lux illumination level of the corridor for most of the year during daytime. Furthermore, if the daylight is delivered through side windows it is likely to create brighter vertical surfaces than does artificial illumination, further increasing the apparent brightness compared to the corridor. Therefore, 'brighter spaces' will tend to include 'naturally lit' spaces. There are further reasons why people may prefer naturally lit space to artificially lit spaces. The NHS has long had a policy of providing natural light in the belief that it aids patient recovery (Dalke et al., 2006). Here, the quality of the light is considered beneficial. Lighting is a complex subject, and either the level of illuminance or the

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[1]The internal illumination level of the room as a proportion of the available external light – this depends on a wide variety of factors such as time of day and year, room shape and size, orientation, window shape, size, location and orientation and the size and proximity of nearby buildings

quality of light may influence wayfinding decisions.

Taylor and Socov's experiment was conducted in a controlled environment, consisting of a roughly square room entered through an arch in the centre of one wall (Figure 2.04). All sources of daylight were eliminated. A floor to ceiling partition, around 80% the width of the room, faced participants as they entered the room, providing a route choice of going either left or right. With the exception of the illuminance levels at each end of this path, the two route choices were identical and led to the same space, however, the participants were not aware of this at first. Participants undertaking the experiment were also unaware of the purpose of the study, having been asked to take part under the pretence that a product evaluation study was being conducted within the room.

The illuminance level of the perpendicular wall at one end of the path was always set at approximately 11 lux (1 footcandle) and the other was set to either 11 lux, 32 lux (3 fc), 108 lux (10 fc), 323 lux (30 fc) and 1076 lux (100 fc). There were two route options, left and right, and the side chosen to be brighter was partially counterbalanced between the two.

Trials for which both route options were of equal illuminance (11 lux) provided a null condition. If there were no significant bias, 50% would choose right. Of the 21 participants, 14 (67%) chose the right hand route. A similar bias (75%) for choosing the right hand option was also reported by Melton (1933) who observed visitors to a museum. Therefore, the effect of brightness on wayfinding decisions in Taylor and Socov's results must be interpreted with consideration to this apparent right-hand bias.
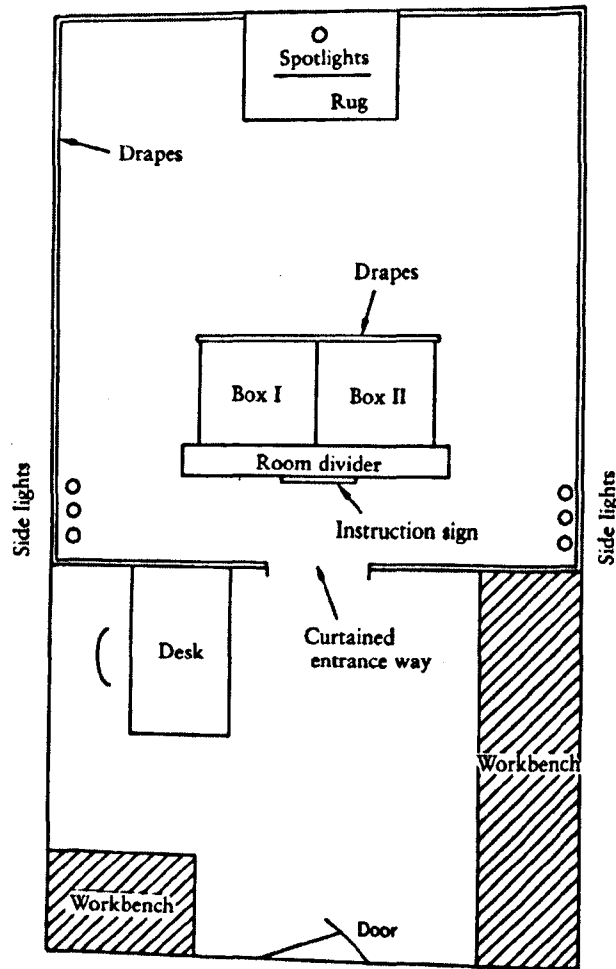
Figure 2.04 Experiment room used by Taylor and Socov to test effect of brightness on path chosen
Source: Image copied from Taylor & Socov, 1974

110 participants undertook the experiment, with around 20 participants undertaking each illuminance ratio (1:1, 1:3, 1:10, 1:30, 1:100). Around 10 experienced the brighter side to the right and 10 to the left. As the experiment relied upon participants not being aware of what they were undertaking (i.e. unfamiliar users), there was no scope to repeat the test with the same person multiple times. In order to gain more results, which may have been beneficial to the outcome of the experiment, more participants would be required.

The percentage of participants who walked towards the brighter side for each illuminance ratio and trend line are shown in Figure 2.05. The trend line shows that

the higher the illuminance ratio, the higher percentage of participants chose the brighter path. The raw data is shown in the left hand part of Table 2.01. The right hand part of the table (the last four columns) is further analysis showing what proportion of the participants would go towards the brighter route were the known Right Hand Side bias (67%) the only factor in route choice. The last column identifies situations where the anticipated results from the RHS bias are overcome by the effects of increased illuminance.

As shown in Table 2.01, if the Right Hand Side (RHS) is brighter than the Left Hand Side (LHS), then choices of RHS are often the same as expected from the RHS bias (67%), i.e. the brightness has not had much effect on the decision chosen. If the LHS is brighter than the RHS, then the number of times when the LHS is chosen are greater than expected from the RHS bias (67%), i.e. the brightness possibly does have an effect on direction chosen. The findings suggest that there was possible evidence between higher light levels and route chosen, particularly as the ratio of the two light levels to each other increased.

Taylor and Socov also recorded the L-R exit choices of their test participants (the direction decision made when exiting the room). These results have been ignored because there may be biases in the decision, e.g. by the desire to explore the route that was previously not experienced. For similar reasons Taylor and Socov also only used these results as part of their discussion rather than as a means of verifying or contributing to the 'entry' results.
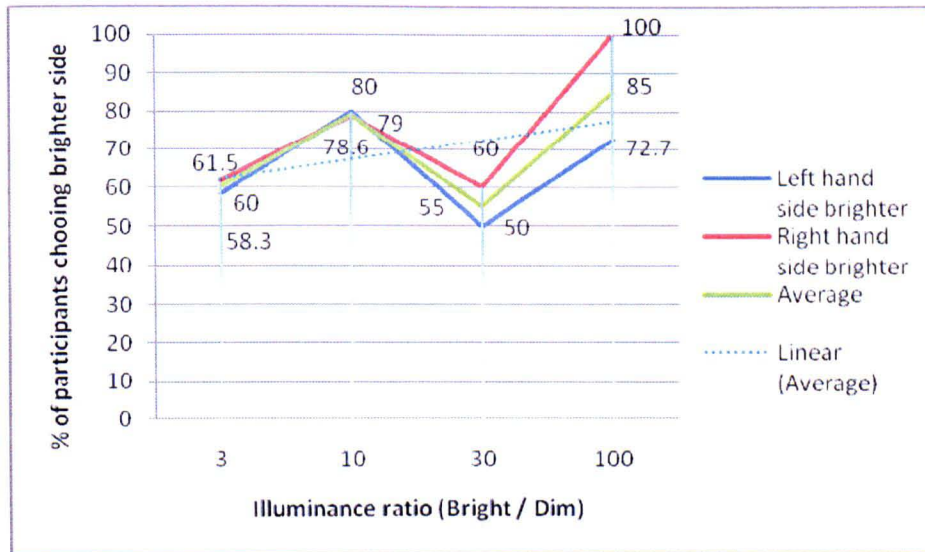
Figure 2.05 Test results from Taylor and Socov's experiment showing percentage of participants who walked towards the brighter side at different illumination ratios – path choices made when the left hand side is brighter, right hand side is brighter and the average of the two. Trend line showing that higher percentage of participants chose the brighter path as the illuminance ratio is higher
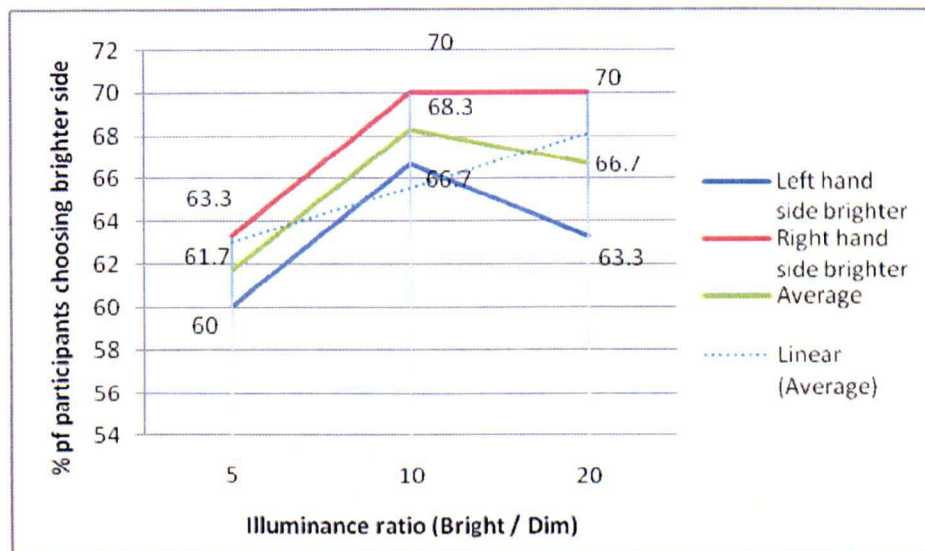
Figure 2.06 Test results from Kang's experiment showing percentage of participants who walked towards the brighter side at different illumination ratios – path choices made when the left hand side is brighter, right hand side is brighter and the average of the two. Trend line showing that higher percentage of participants chose the brighter path as the illuminance ratio is higher

Kang (2004) used Taylor and Socov's experiment as a model and tested with 200

participants using illuminance ratios of 1:1(50 lux), 1:5, 1:10 and 1:20. The summary of Kang's results is shown in Table 2.02. Kang reasoned that Taylor and Socov did not use illumination levels recommended by the Illumination Engineering Society of North America for interior spaces and therefore their experiment was not representative of true scenarios. The illumination on one side as used in Taylor and Socov's experiment was held constant at 11 lux (1fc), which was too dark and therefore not an illumination range people would experience normally when selecting a path for circulation. Results from Kang showed that most participants selected brighter paths rather than dimmer paths with a trend line (Figure 2.06), as with Taylor and Socov's findings, also showing that higher illuminance levels positively influence path choice. Illuminance ratios between 1:1 and 1:5 have a significant effect in increasing path usage while the illuminance ratio above 1:5 had no additional effect in attracting more people to the brighter side.

Taylor and Socov's results are a demonstration of the effects of comparative brightness on wayfinding route choice, however there is a noticeable anomaly in their results for participants at ratio 1:30 (Figure 2.05). No explanation is given for this, nor is one apparent from the method or analysis. The scale of the anomaly may be due to the small number of participants in the study – although 110 took part in the study, this equates to only around 20 participants per ratio. Due to the nature of the experiment it would be difficult to repeat-test each participant to test whether certain participants were influenced more by the RHS bias than others. A further test, not necessarily of the same nature but designed to test for RHS bias, could be undertaken by each participant, and the number of participants overall increased in order that individual decisions had less impact on the overall results.

As mentioned, Kang (2004) suggested that the study by Taylor and Socov might not be representative of real situations. She tested illuminance ratios that better represented the real environment people experience in buildings. However, the RHS bias wasn't considered in Kang's study. The illuminance ratio between the corridor

Data from Taylor and Socov's Experiment						Expected Results if RHS bias only			
Illumination Ratio	Brighter Path	Number of participants			% chose brighter Side		If RHS bias only (RHS figures in italic)		Results which can be explained by RHS bias	Brighter effect above RHS bias
		Choosing brighter side	Choosing dimmer side	Total			Brighter side	Dimmer side		
1:1	/	14	7	21	67					
1:3	R	8	5	13	61.5	60	8.7	4.3	X	X
	L	7	5	12	58.3		4	8	X	√
1:10	R	11	3	14	78.6	79	9.4	4.6	√	√
	L	8	2	10	80		3.3	6.7	X	√
1:30	R	6	4	10	60	55	6.7	3.3	X	X
	L	5	5	10	50		3.3	6.7	X	√
1:100	R	9	0	9	100	85	6	3	√	√
	L	8	3	11	72.7		3.6	7.4	X	√

Table 2.01 Results of path choice experiment conducted by Taylor & Socov (1974)

Data from Kang's Experiment						Expected Results if RHS bias only			
Illumination Ratio	Brighter Path	Number of participants			% chose brighter Side		If RHS bias only (RHS figures in italic)		Results which can be explained by RHS bias	Brighter effect above RHS bias
		Choosing brighter side	Choosing dimmer side	Total			Brighter side	Dimmer side		
1:1	/	13	7	20	65					
1:5	R	19	11	30	63.3	61.7	19.5	10.5	X	X
	L	18	12	30	60		10.5	19.5	X	√
1:10	R	21	9	30	70	68.3	19.5	10.5	√	√
	L	20	10	30	66.7		10.5	19.5	X	√
1:20	R	21	9	30	70	66.7	19.5	10.5	√	√
	L	19	11	30	63.3		10.5	19.5	X	√

Table 2.02 Results of path choice experiment conducted by Kang (2004).

Key : Left hand part showing the number of participants going toward brighter side or dimmer side as influenced by the ratio of illumination levels. The brighter path is specified as being to the left or the right of a person entering the room. The right hand part showing the number of people's route chosen as if considering RHS bias.
'X': fewer people chose the RHS option than expected from null condition results
'√': as expected or more people chose the RHS option than expected from null condition results

and the waiting room as discussed towards the beginning of this section would be between 2:1 and 1:12.5 (the corridor artificially lit at a constant 200 lux, the naturally lit room varying between 100 lux and 2,500 lux based upon an exterior daylight illuminance of 50,000 lux), ratios that are of a similar magnitude to those in the Kang's experiment. Therefore, unless the different qualities of the light have an impact on wayfinding behaviour, the brighter room should attract people when wayfinding as does the brighter space in Taylor and Socov's experiment. Up to an illuminance ratio of 1:5, there is evidence that higher illuminance attracts more people as showed in Kang's study.

2.6.4 Strategy 4: Choose the Wider Corridor

The word 'Corridor' is used here as corridors are commonly occurring circulation spaces within buildings and therefore the paths along which routes exist. Zacharias (2002) investigated route choice preferences within a shopping mall. 63 participants were shown panoramic images taken at the centre of intersections (decision points) within the mall. 32 of the participants were shown photographs, the remaining 31 shown line and fill tracings of the photographs. Six intersections were used in both of the tests. The line and fill drawings were used to limit the amount of environmental information available to the participants to just the major forms and volumes of the spaces and means of circulation. An assessment could therefore be made of the influence other environmental information was having on route choice.

After viewing an image, each participant was asked the following:

- Which path would you take?
- Which path leads into the shopping area?
- Which path leads outside?
- Which path leads to the greatest number of people?
- Which path looks like the most interesting walk?
- Which path leads to more choices of path?

For the majority of intersections there was a clear consensus as to which routes were preferred, amongst both participants who viewed the photographs and those who viewed the drawings. Of the photos, five reveal highly significant preference and of line drawings, three reveal significant preference. In addition to answering the prepared questions, participants were asked to verbalise their reasoning as they made their decisions, resulting in 652 statements across all the participants. This information helped to determine what factors were influencing the answers (and, therefore, may influence wayfinding route decisions likely to be made when navigating the mall). The statements were then classified by keyword in order to qualitatively analyse which factors were considered most frequently during decision making. Table 2.03 shows the results from this.

Zacharias noted that the 'quality of place' comments were predominantly temporal – to do with the people and activities taking place within the space. This may explain the discrepancy between the results from the photographs and from the drawings for the path selection test. A further test with photos at the same intersections without showing any people and activities might be worth conducting to see if there is any difference between photos and line drawings.

Category of comments	Number of comments
Qualities of place (lively, warm, interesting, dead)	191
Width of corridor or size of space	103
Colour	57
Legibility of architectural space	55
Lighting level or quality	50
Ceiling height	38
Length of corridor	9

Table 2.03 Results from Zacharias (2002); Most frequently mentioned comments concerning path options by category of comments

The second highest number of comments relate to the width of the corridor. This suggests that corridor width could be an important factor when choosing a route.

Zacharias' findings demonstrated a preference for exit routes from decision points that featured wide, easily definable corridors (not cluttered spaces) that appeared not to lead to any dead-ends. There is not any mention of percentage of comments given from photos and from line drawings. It would be useful to know if comments from line drawing are similar to the ones from photos.

Wider routes are associated with greater levels of traffic. Gotts (1992) discussed this in vehicular traffic systems and the path choices made on the basis of path width. Guidelines for the design of circulation spaces (Department of Health, Estates and Facilities Division, 2007) cover appropriate corridor widths for a variety of locations within healthcare buildings. These widths are primarily based upon the space required to move hospital beds, wheelchairs etc., however the recommendations do stress the importance of also sizing corridors to suit traffic levels, and provide wider corridors leading to frequently accessed spaces. Their benchmark recommendation in this respect is a spine-like circulation system based around a single 'Hospital street' corridor connecting all parts of the hospital. This is intended for use both by hospital staff and the general public and is distinguished from other corridors by its width.

The presence of a wider corridor may have a psychological influence on wayfinding decisions, assuming the width is due to traffic levels. It has been found that the presence of people is reassurance that an appropriate route has been chosen within buildings (Peponis et. al., 1990; Zimring et. al., 2005) and that groups of people are a draw when wayfinding as it may signify a thoroughfare or a space or landmark of greater perceived importance (Zimring et al., 2005). Larger numbers of people will also boost the 'quality of place' factor found by Zacharias to be of importance when wayfinding.

Zacharias' study (2002) would seem to suggest that corridor width does play an important role in path choice. Corridor width was recorded as the second-most mentioned factor influencing path choice. Also, the research into numbers of people

within a space suggests that people prefer more open spaces, which supports Zacharias' findings to a degree. There has been little further research carried out into the influence of corridor width on wayfinding, however. Zacharias' study, although providing a useful pointer to the importance of corridor width, recorded participants' opinions rather than observing and recording their behaviours, leading to results of spatial preferences that participants are conscious of rather than wayfinding strategies undertaken subconsciously. The results for corridor width also did not distinguish between opinions based on seeing the line drawings and those based on seeing the photographs. In the photographs in particular, there are a great many variables which may have contributed to the corridor width result, and in both the photographs and line drawings the overall cross-sectional area (both the width and height of the space) may be influencing the participants' responses. It was therefore felt that further study of corridor width is essential to support the notion that wider corridors have a positive influence on path choice, and that this study be conducted in a controlled environment to limit the variables involved to just the width of the corridor.

2.7   Stress

Wayfinding is not simply a computational process of resolving problems. Psychological issues are also involved, particularly those of being lost (Passini, 1984). It is difficult to define lostness due to the sensation differing from person to person. This may in part be due to the wide variety of perceptions of complexity in the environment (Conroy-Dalton et al., 2008; Weisman, 1981). Best (1970, p.73) defines being lost as a significant deviation from the most direct route. The definition neatly opposes Peponis' et al. (1990) definition of wayfinding tasks (conducted in 'an expedient manner' – see section 2.3.1), however Best notes that this definition would include situations within which participants being studied did not state that they felt lost. A broader definition may be that a person is lost when constructive exploration does not indicate a route to take, or a route is being taken which the wayfinder is not confident is the correct route. In the latter circumstance, providing reassurance to the wayfinder that they are taking the correct route would be

beneficial (R. Kaplan et al., 1998, p.49).

Passini (1984) notes that there are several levels of sensation of being lost depending, partly, on the wayfinding task being undertaken. Exploration will always involve being in unfamiliar spaces – one factor of being lost. Those who are inquisitive and enjoy gathering new information are likely to have a positive experience from being lost in such circumstances. However, in order to make use of the information collected when exploring and in order to maintain a degree of control over the experience, it is still necessary to maintain or be within easy reach of a means of orientation.

The loss of orientation is attributed as one of the factors that leads to feelings of being lost developing into feelings of stress (Zimring, 1981, p.146). Zimring relates this to confusing environments and consequent deficiencies in the cognitive representation of the environment. Several building case studies were explored which appeared to demonstrate a link between building forms and plans that had a muddling effect on orientation, and instances of stress recorded amongst the visitors to those buildings.

Darken and Peterson (2001) made the suggestion, discussed in Section 2.3.2, that disorientation is sometimes beneficial to wayfinding. They argue that a certain level of disorientation encourages exploration, which helps to build a more complete cognitive map and possibly reveal a more direct way of completing the wayfinding task. However, they and other researchers also recognise that more extreme levels of disorientation are blamed for increased anxiety and stress (Darken & Peterson, 2001, p.493; Passini, 1984). Lawton and Kallai (2002) found variations in anxiety levels between women and men of the same cultural background, connecting feelings of disorientation with a fear of not knowing what is within unknown spaces. No link was found to recorded crime levels. They also found a variance in the use of orientation when wayfinding, with men preferring wayfinding strategies based on orientation to global reference points and women preferring strategies based on route information. Route information based wayfinding carries the disadvantage that

it is necessary to resort to orientation based wayfinding strategies if the route is strayed from. This may be problematic if, through reasons of personal preference or a difficult to understand environment, orientation-based wayfinding strategies were being avoided.

Stress is 'central to the relationship between people and their surroundings' (A. Baum et al., 1982, p.15). Stress is seen as the response to threat in the environment and represents the adaptive behaviour resulting from this response. Threats can be very wide-ranging and may be the threat of not being able to attend a meeting on time or the threat of being mugged. The ability to adapt to the changing circumstances that a threat may impose is useful when adapting to the changes in surroundings experienced as an environment is moved through during a wayfinding task. However, when stress can be 'felt' (i.e., through feelings of fear, anxiety or anger), it has been seen to lead to erratic behaviour which may, as a consequence, impair the ability to perform the complex cognitive tasks required when wayfinding (Zimring, 1982).

Certain wayfinding tasks and situations further exacerbate feelings of stress. These include any situation that is dependent upon the successful completion of a wayfinding task, particularly under pressure of time. Attending appointments, attending meetings or catching planes are examples of tasks which, if not completed, may have serious financial, time or business relationship issues, and all potentially rely on the successful completion of wayfinding tasks. The prospect of these resulting problems may prove stressful (Carpman & Grant, 2002). In some of these instances, particularly in transport buildings, the wayfinding problems resulting from stress may directly impact the function of the building. Stresses external to the wayfinding task may also impact wayfinding ability (and therefore exacerbate stress upon wayfinding mistakes being made) by diverting attention away from the wayfinding task. Such situations include visits to healthcare facilities (Izumi, 1970) where visitors may be preoccupied with the illness of someone emotionally close, or academic facilities (McKean, 1972) where visitors may be preoccupied with their studies. The

cumulative effect of these may overwhelm the finite resources people possess for coping with stress (Evans, 1982, p.4; McGrath, 1970).

All of these issues of being lost and the associated anxiety and stress are experiences of those unfamiliar with their environment (Bell et al., 1990, p.78). However, stress may have an effect on the successful use of wayfinding strategies that unfamiliar users may rely upon as an approach to wayfinding tasks. Mollerup's (2005, p.43 - see section 2.6) definition of a wayfinding strategy specifically excludes random seeking in order to find environmental information, on the grounds that random seeking is not a rational process. It is known that stress impairs logical, rational reasoning (Zimring, 1982), therefore it is possible that stress impairs the ability to use wayfinding strategies. However, random seeking may be undertaken as a means of collecting environmental information when other wayfinding strategies and information from intelligent seeking have been exhausted. Even under pressure from other stresses, this may successfully lead to a wayfinding course of action to take (Seidel, 1982). Wayfinding strategies themselves may be a means of reducing potential stress by allowing rational analysis of an environment when too much information is present (S. Kaplan & R. Kaplan, 1981, p.99).

Environmental factors may also lead to stress in ways not directly related to wayfinding. Zimring (1981) views stress as leading from 'a misfit between individual needs and environmental attributes', a definition that can be applied when wayfinding or not. Environments that do not meet the needs of those that are using them lead to stress when neither the environment can be changed nor a positive change made to the task to be undertaken within that environment.

One group of people who frequently encounter 'a misfit between individual needs and environmental attributes' are those with physical difficulties or visual impairments. Environments which may be easy to wayfind within for the able-bodied population may present varying levels of difficulty to those with a physical impairment – particularly those in a wheelchair – or visual impairment (Passini, 1996;

Ungar, 2000). Not only does this compound stress, it can often discourage people with physical disabilities from venturing from home due to the multiple levels at which they are disadvantaged. In the case of people with severe visual impairments, it has been found that, for those people who do travel outside unaccompanied, this independent travel tends to be limited to known routes (Kitchin et al., 1997b). Straying from these quickly leads to disorientation as most methods of orientation typically require being able to quickly interrogate the environment for information (usually including information which is out of immediate reach) and using wayfinding aids which are traditionally visual (textual signage and pictograms with no companion content for those relying on touch to read). Kitchen et al. noted that stress levels and feelings of panic and fear are particularly pronounced amongst those with visual impairments when they become lost.

While spaces that are easy to wayfind within generally may not automatically be easy for those with physical impairments to wayfind within, they are at least considered to form a sound basis for wayfinding design with physical impairments in mind. It is, however, recognised that wayfinding aids in particular may need supplementing with those suitable for use by people with physical and, in particular, visual impairments (Apelt et al., 2007).

2.8   Summary

This chapter introduced various descriptions of wayfinding and some of the means in which it has been analysed and ways in which it is commonly broken down for study. These covered analysis of the environment in which wayfinding occurs, the cognitive processes that occur during wayfinding and the current understanding of wayfinding amongst the architectural profession. A definition of the term 'wayfinding', as it is to be used throughout the thesis, is given. Following this analysis of knowledge in the world, knowledge in the head (section 2.4) and how these are used when wayfinding, is a detailed analysis of four wayfinding strategies which also have a strong influence on the manner in which wayfinding tasks are undertaken. These

four were studied following evidence from the observational study (documented in Chapter 3) and due to their relationship with the form and arrangement of the circulation spaces within the building and consequently, in certain cases, with the form of the building overall. This thesis' focus is on how a building's spatial design influences wayfinding and how designing to take advantage of known wayfinding behaviours affects the spatial design of a building, hence these four strategies are considered particularly relevant to the aims of this study.

In order to best communicate the intent of the strategies and how they relate to the other aspects of wayfinding, it is proposed that two principles are used as a means of categorisation. These are as follows:

- Reassurance: Each of the strategies chosen has the potential to reassure the wayfinder that they are on the correct route: walking towards brighter spaces and walking along wider corridors both appear to be psychological responses to the environment while having to change direction or floor frequently will undermine the wayfinder's confidence that they are on the correct route.

- Tools: Anything provided to the wayfinder in order to assist the completion of their wayfinding task. Information in the environment (e.g. landmarks), wayfinding devices (e.g. maps and signs) and any means of orientation would also be categorised within the Tools principle.

The intention is that these provide a simple, quick means of analysing an architectural response to a wayfinding issue – if the response fulfils one or both principles (i.e.., provides the tools to assist wayfinding and reassures the wayfinder that they are on the correct route), then the response may be considered basically sound from a wayfinding point of view.

It is proposed that a building's conformance to the four wayfinding strategies will reassure unfamiliar users by ensuring that when wayfinding to their destination the

users experience predictable interactions with the environment (Zimring, 1982) and are not presented with situations which conflict with those expected of someone following the wayfinding strategies. In order that a building's design may benefit from this, it is necessary to consider likely destinations for unfamiliar users and what routes lead them there (R. Kaplan et al., 1998) and what environmental information is presented to visitors along these routes.

This study is therefore based around the following research question:

> *How does the spatial design of a building provide reassurance to users when wayfinding?*

and the following hypothesis is therefore proposed:

> *Wayfinding is naturally easier along routes which conform to the four wayfinding strategies*

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3

Observation of Unfamiliar Users'

Wayfinding Behaviour

3.1   Chapter overview

This chapter describes an exploratory study carried out in the Students' Union

building at the University of Sheffield. This was undertaken to see how unfamiliar

users navigate through a building and to see if their route choices indicate they are

following the four wayfinding strategies investigated in Chapter 2. These four

strategies refer to decisions made at decision points:

- *when there is an option to do so, unfamiliar users will tend to maintain a straight*
  bearing

- *if possible, unfamiliar users will tend to avoid a change of level*

- *when there is an option to do so, unfamiliar users will tend to walk towards*
  brighter space

- *when there is an option to do so, unfamiliar users will tend to choose the wider*
  corridor

Unfamiliar users of the Students' Union building were followed whilst they explored

the building and their route choices subsequently analysed.

3.2 Sheffield University Students' Union building

Sheffield University has a Students' Union (Figure 3.01) that offers a wide variety of events and facilities. The building is located in the centre of the University's main campus, between Glossop Road and Weston Bank, accessed from a large pedestrian plaza linking the Union with many of the other University buildings. The plaza can be very busy, particularly during term time, as it functions as a major urban thoroughfare, allowing pedestrians to bypass the busy Weston Bank road. This activity helps draw people towards the Union and the building's visibility and accessibility increases the likelihood of drawing members of the general public wanting to use the Union's shops and facilities.

Figure 3.01 Main façade of the Student's Union. From left to right: white/grey building is part of Hicks Building (not part of the Students' Union); former Graves Building (3 storeys and pitched roof); new link (3 storeys, upper 2 storeys, both curtain glazed, visible) incorporating the atrium and related spaces; main entrance (1 storey visible); University House (4 storeys visible). Source: author's photograph

The Students' Union building was used in the wayfinding test conducted as part of this study. The Union in its present state comprises several linked buildings and extensions, each constructed to meet demand as the University grew throughout

the 20th Century. The oldest part of the building, the Graves Building, now housing the Interval Café and various Union offices, was the first building purpose built for the Students' Union. From its opening in 1936 to 1962 this was the extent of the Students' Union's accommodation. University House opened in 1962 with a link block linking it to the Graves Building. This new complex also included Bar One (Level 1 of the new building) and a lower refectory with external space (Level 2). Access to this new complex was on Level 3. The remaining parts of the current Union building, fronting the link block occupying the space between University House and the Graves Building, were added between 1993 and 1996. These consisted of the single-storey entrance foyer (including the Union shop, reception and Box Office), the current auditorium, an atrium, The Source and Gallery study spaces, Coffee Revolution cafe, STA Travel travel agency and NatWest bank. At the same time, the lower refectory was converted into the Fusion and its open space covered to become the Foundry, both event spaces (Mathers, 2007).

The variety of spaces and space uses, split over several publicly accessible floors (due in part to the building being built into a sloping site), the variety of types of circulation spaces and the variety of architectural styles, lend a degree of complexity to the building. Despite its compact size it was felt this complexity ensured the building was well suited to the requirements of the study as it allowed the study of a wide range of potential environmental triggers to wayfinding behaviours within each test and the possibility of observing participants responses to combinations of these environmental factors.

Plans of the main body of the Students' Union are shown in Figure 3.02 (Level 2), Figure 3.03 (Level 3, main entrance level) and Figure 3.04 (Level 4). Bar One (Level 1) was not explored as part of the Students' Union test, nor were the upper storeys of University House (Levels 4, 5 and 6) or The Octagon (connected to the Union by a bridge from Level 4 of University House). Spaces are given codes on the plans (as are the decision points on plans later in the thesis) to aid analysis. These codes are used in the description of spaces in the Union building.

3.3   Method

The aim of this test was to see how unfamiliar users navigate a building and how the building layout affects the routes chosen. The test was conducted initially during the Freshers Week in September 2003 and was repeated during the Freshers Week in September 2008. This period is the first week of the first term of the academic year and was chosen as there are always many new students around the University at this time. Many of these will be visiting the Students' Union building for the first time, so provide the test with a sufficient number of suitable participants.

The drawings of the building's plan layout in Figure 3.02, 3.03, 3.04 and 3.06 were sourced from the Estates Department at the University of Sheffield.
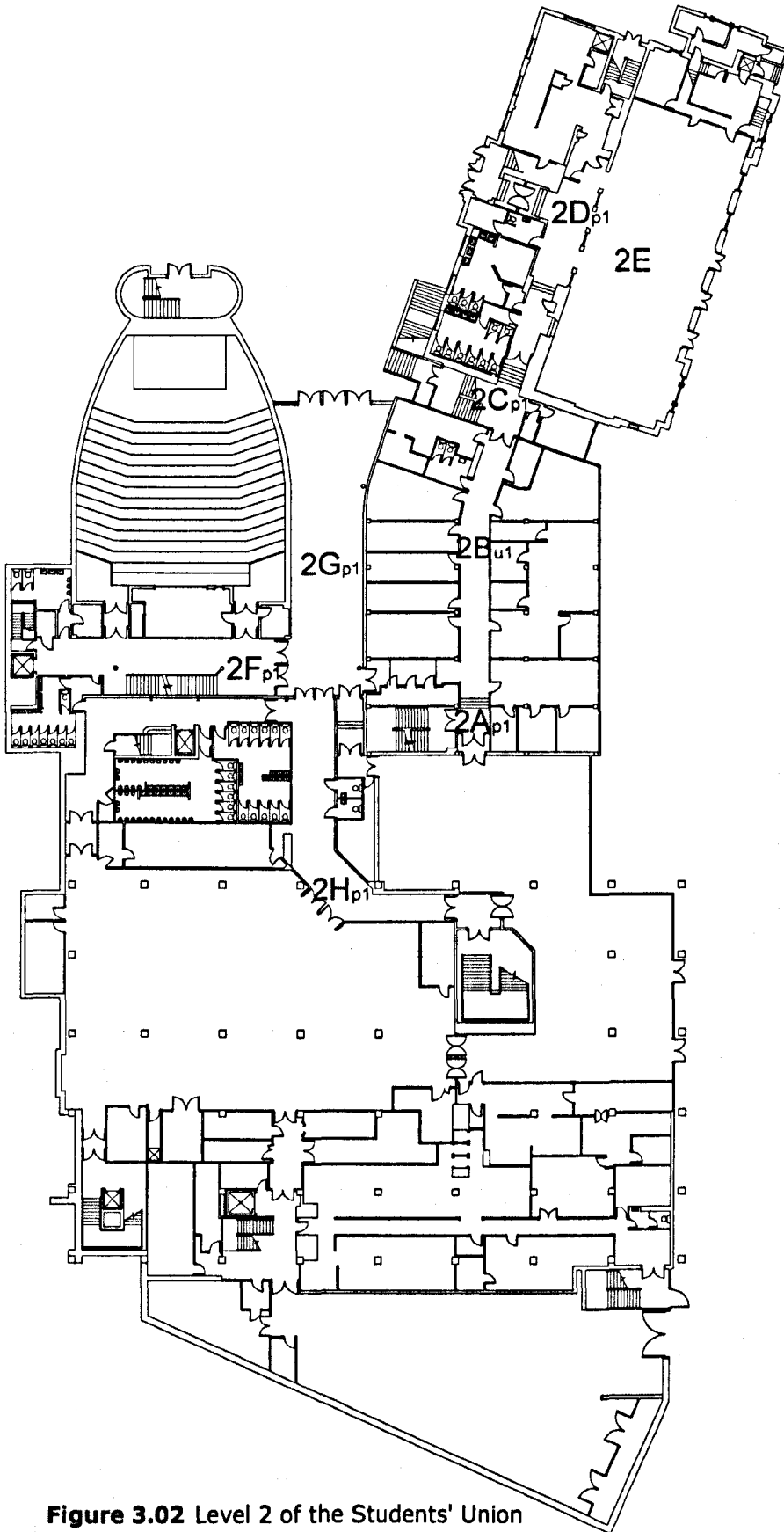
Figure 3.02 Level 2 of the Students' Union
showing decision points
(one level down from main entrance)
Source: Estates Department, University of
Sheffield

73
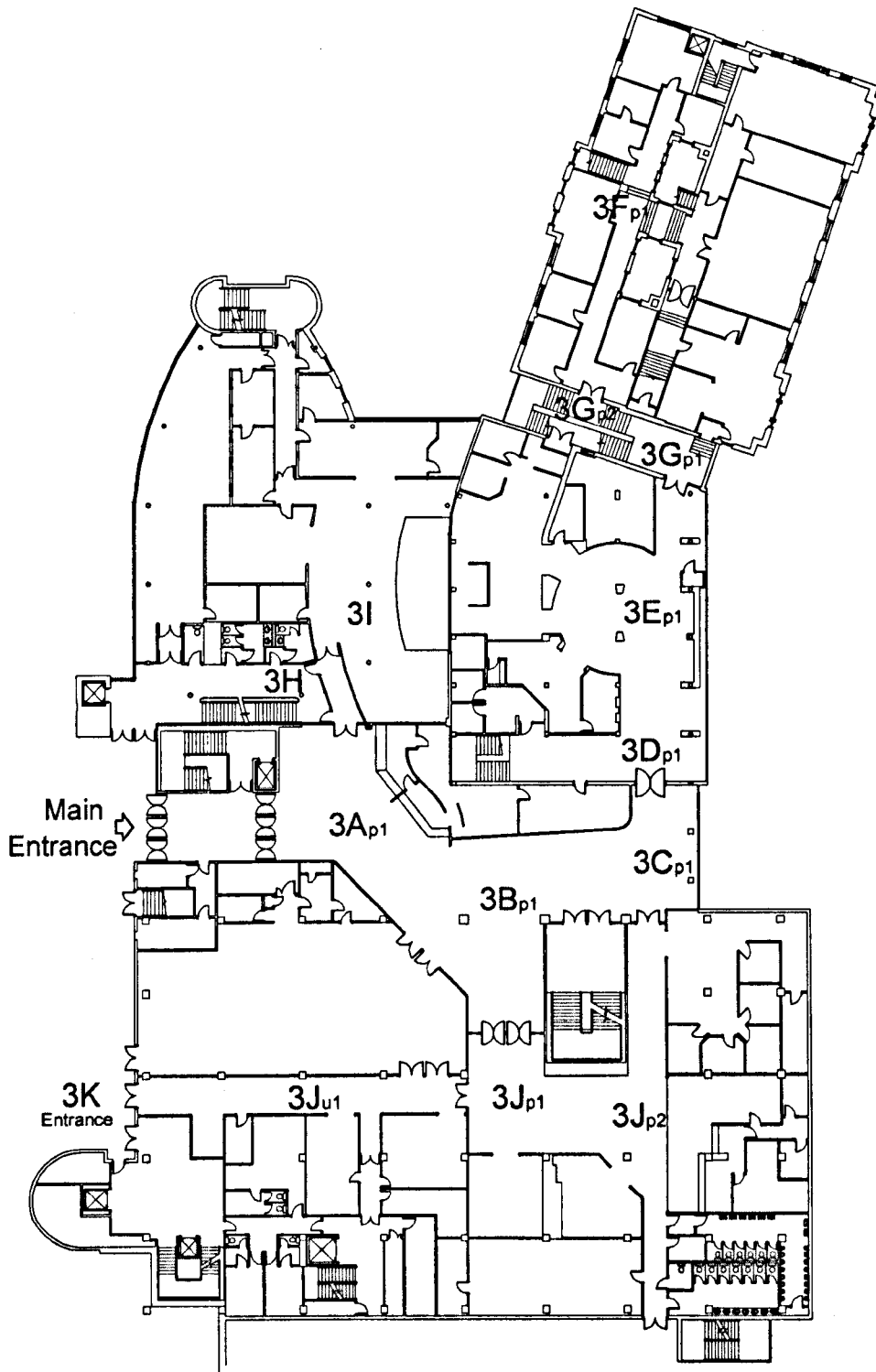
Figure 3.03 Level 3 of the Students' Union showing decision points
(main entrance level)
Source: Estates Department, University of Sheffield
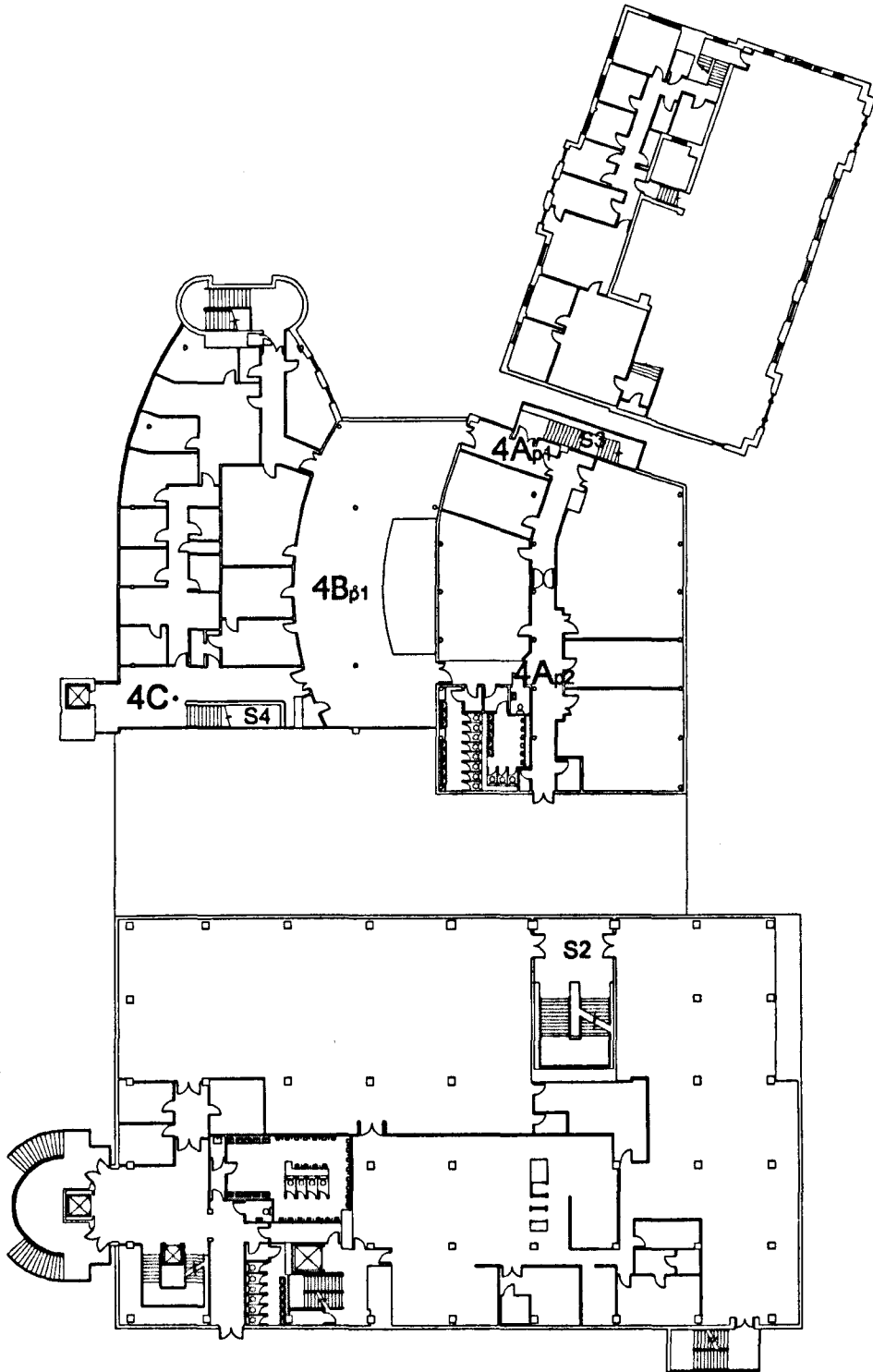
Figure 3.04 Level 4 of the Students' Union showing decision points
(one level up from main entrance)
Source: Estates Department, University of Sheffield

The test was originally set up to test the difference between different sets of instructions given to the participants. Participants were allocated into three groups and different instructions were given to participants within each group. One group navigated around the building without any particular instructions, one group was asked to follow a list of landmarks within the building and one group was asked to follow instructions by building features (e.g. staircase). This study however focuses on spatial design and its influence on people's wayfinding behaviour. Therefore only the results by participants walking around the building without particular instructions are included in this chapter.

There were 12 participants in this group in both the 2003 test (7 males and 5 females) and the 2008 test (6 males and 6 females), and all participants were from the same age group (18 -24 years old). All 24 participants were informed about the purpose of the study and undertook the test individually and were all unfamiliar with the Union Building.

All the participants started at the main entrance on Level 3 (space 3A - Figure 3.03) – the initial space within the building as experienced by most visitors (see section 2.3.3). The View of the main entrance foyer from the starting position is shown in Figure 3.05.

Figure 3.05 Main entrance foyer at Level 3 of the Students' Union from starting point. Source: author's photograph

Participants were asked to walk around the building freely and point out any objects or spaces that they considered to be landmarks. This was done to encourage them to explore the building. This was a blind procedure and the landmarks mentioned are not analysed in this thesis. Instructions given to participants are shown in Appendix A. Time spent by each participant for the test was approximately 15 minutes plus extra time for drawing a sketch map of their understanding of the building at the end of the test. Each of the 24 participants walked around the building followed by the researcher. The researcher subsequently mapped their route (Appendix A).

3.3.1 The Test

All of the 24 participants undertook two laps of the building. On the first lap, they were asked to explore freely around the building – they were not given any guided instructions. As they walked round the building on this first lap, they were asked to point out what objects or spaces they consider as landmarks. The route the participant took and the landmarks they noted were recorded by the researcher. On the second lap, each participant was then taken round by the researcher on the route that was walked in the previous lap and was asked to anticipate which landmarks were expected next. The routes taken by the participants are roughly representative of a route likely to be taken by someone on their first encounter with the building and with limited knowledge of the location of their destination. This is not to assume all participants will take the same route, simply to find out whether unfamiliar users have any preference of route choice.

This test is not a wayfinding test since there is no destination. However, by asking participants to walk around the building as unfamiliar users would gives an indication of which routes the participants feel comfortable exploring.

3.4   Results

The routes taken by all participants are recorded in Appendix A. The 1ˢᵗ lap of the route for all participants is quantified based on the number of decision points and available options in order to see how each of the four wayfinding strategies is

followed. Figure 3.06 shows an example of the route recorded for a participant (in this case participant 1 in the 2003 Test). Tables 3.01 to 3.03 show the results of three of the four strategies. This data covered the total number of decision points navigated, the number of available decision points with each criteria and the percentage of each option taken at decision points for each hypothesis.

When analysed, the routes taken by participants appeared to demonstrate an adherence in the participants' behaviour to several wayfinding strategies. This study focuses on four of these chosen due to the influence that spatial design has on them and the reassurance accordingly designed environments may give to people conducting a wayfinding task.

3.4.1 Maintain a straight bearing

The number of decision points navigated by each participant, the number of decision points with a straight ahead option available and the percentage of this option taken are shown in Table 3.01. There were 268 decision points encountered amongst all 24 participants in the Students' Union building. Of these, 26 were ignored (ignored points include those where the straight ahead option leads to an obvious dead-end, the participant has doubled-back or the participant has already passed through that point) and 112 lacked a straight ahead option. There are 130 decision points with a straight option available out of the total of 268 decision points, and of these the straight ahead option was taken on 103 occasions (79.2%).

Key

○ Start of route

• End of route

▷₁ Go to this point on a different floor

▶₁ Come from this point on a different floor

Main Entrance

Level 3

Level 2
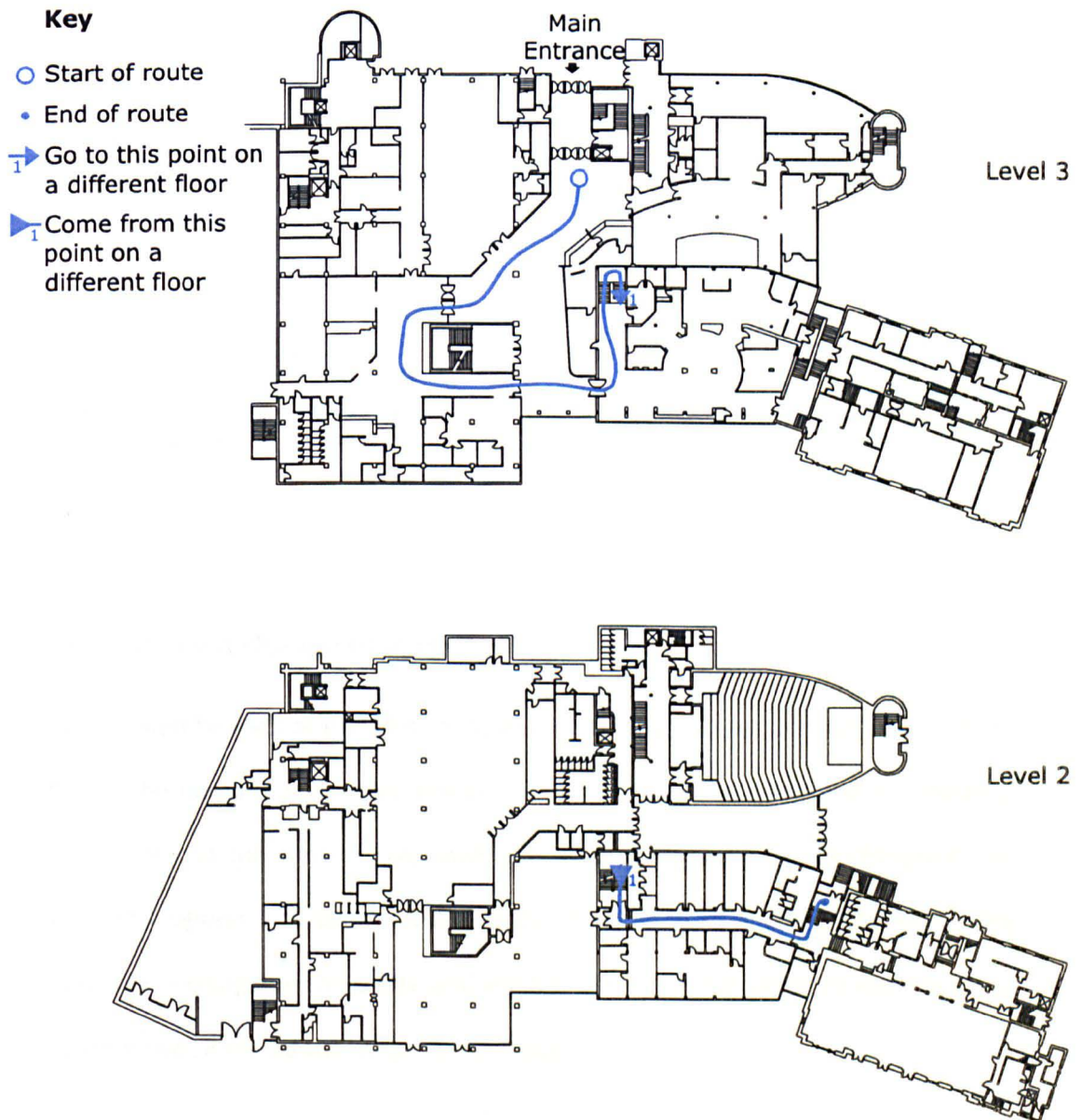
Figure 3.06: Example of the route taken by one participant (in this case participant 1)

	Participant	Number of decision points (DPs)	Number of DPs at which Straight ahead option available		Straight ahead option taken?	
			frequency	% of decision points	frequency	% of available straight option
2003 Test	1	8	5	62.5	3	60
	2	13	7	53.8	6	85.7
	3	14	6	42.9	5	83.3
	4	9	5	55.6	5	100
	5	8	3	37.5	2	66.7
	6	13	6	46.2	6	100
	7	9	4	44.4	4	100
	8	8	4	50	3	75
	9	9	6	66.7	4	66.7
	10	10	5	50	5	100
	11	8	4	50	2	50
	12	9	5	55.6	3	60
2008 Test	13	10	3	30	3	100
	14	13	7	53.8	6	85.7
	15	10	7	70	6	85.7
	16	14	7	50	4	57.1
	17	13	6	46.2	5	83.3
	18	15	6	40	6	100
	19	14	6	42.9	5	83.3
	20	10	3	30	3	100
	21	15	7	46.7	5	71.4
	22	12	5	41.7	4	80
	23	14	8	57.1	5	62.5
	24	10	5	50	3	60
Total:		**268**	**130**	**48.5**	**103**	**79.2**

Table 3.01 Summary of occasions on which participants chose to maintain a straight bearing

3.4.2 Avoid a change of level

Routes taken by each of the 24 participants were mapped (Appendix A) and used to identify the number of decision points at which a change of level was immediately available (i.e. at the entrance to, head or foot of, a stairway) and the frequency by which this option was taken. This analysis only considers a change of level using stairs: the building does have lifts, and subjects were not instructed to not use them, but on no occasion did the subjects use them.

In the test conducted in 2003, all participants passed through the same decision points at which a change in level was available and made the same decision at each of these points, with the exception of Participant 6 who doubled-back partway down staircase S3. All participants passed through decision points 3Cp1, 3Dp1 and 3Gp1. In total, decision points at which a change in level was available were walked through 36 times by all 12 participants.

Approaching 3Gp1 from 3Ep1 there is no option but to change level, other than back-tracking or entering a door clearly labelled as private offices. At this location, Participant 6 and Participant 14 chose to back-track (and hence did not change level) while the other participants chose the change of level option. Given the lack of choice at this decision point results relating to it have been discounted. Therefore only the results from decision points 3Cp1 and 3Dp1 have been analysed. At both of these decision points the participant either had the option of taking a staircase or another means of exit from the space that did not involve stairs or doubling back. In the test conducted in 2003, on 23 of the 24 occasions that these decision points were encountered (96%) a change in level was avoided – only Participant 1 chose to use a stair at a point (3Dp1) in the building where other options for exiting the space were available. In the test conducted in 2008, on 22 of out 25 (88%) occasions, the change of level was avoided. Participant 17 chose to use a stair at two points (3Dp1 & 2Cp1) and participant 21 chose to use a stair at a point (3Dp1) in the building where other options for exiting the space were available.

3.4.3 Walk towards brighter space

The number of decision points travelled by each participant, the number of decision points with a brighter space option available and the percentage of that option taken are shown in Table 3.02. A decision point is considered to have a 'brighter space option' when an exit from the decision point leads to a space which has a higher level of illumination than there is at the decision point.

Participant	Number of decision points (DPs)	Number of DPs at which brighter space option		Brighter space option taken?	
		frequency	% of decision points	frequency	% of brighter option taken
1	8	8	100	4	50
2	13	10	76.9	8	80
3	14	12	85.7	9	75
4	9	6	66.7	5	83.3
5	8	6	75	5	83.3
6	13	9	69.2	7	77.8
7	9	7	77.8	5	71.4
8	8	6	75	6	100
9	9	8	88.9	6	75
10	10	8	80	4	50
11	8	5	62.5	4	80
12	9	6	66.7	6	100
13	10	6	60	4	66.7
14	13	9	69.2	8	88.9
15	10	8	80	7	87.5
16	14	13	92.9	9	69.2
17	13	12	92.3	8	66.7
18	15	11	73.3	7	63.6
19	14	10	71.4	7	70.0
20	10	7	70	5	71.4
21	15	13	86.7	8	61.5
22	12	8	66.7	5	62.5
23	14	13	92.9	9	69.2
24	10	7	70	6	85.7
Total:	268	208	77.6	152	73.1

(Participants 1–12 are labelled "2003 Test"; participants 13–24 are labelled "2008 Test".)

Table 3.02 Summary of occasions on which participants chose to walk toward brighter space

In total, of the 268 decision points in the building, at 208 of these, one (but not all) of the optional routes directed the participant toward brighter space. The remaining 60 points were ignored because these include those without a variety of options available. Table 3.03 shows the 208 points with a brighter space option available. The brighter option was taken on 152 occasions out of 208 decision points (73.1%).

The comparative light levels from their direction of origin, light levels of possible exits from the decision point and the light level of the exit chosen were compared in order to identify whether the exit with the greatest brightness was chosen without doubling-back. Light levels for each exit direction were ranked compared to the light level in the decision point. As comparisons between light levels in all the decision points are not made (only exits from each decision point) it was not necessary to use a scale of lighting that covered the light levels throughout the building. Also, as eyes adapt to light levels at each decision point, it was felt important to have a scale based upon the light level being experienced at each point and the impressions of light levels from that point. It is for this reason that a ranking system was chosen, based on observed light levels rather than measured light levels.

There are two limitations to this manner in which light levels were observed. Firstly, the brightness was judged by the experimenter after the experiment was complete. Brightnesses recorded then may have been different to those experienced by the test participants when they undertook the test. Also, it is recognised that there are subjective differences in brightness perception. The timing of the experiment limited the effects of the first limitation to a degree. All the participants undertook the

experiment on days in mid-September between 10.30am and 4pm (hence all conducted during daylit hours). The light levels throughout the building were recorded for means of analysis at a similar time on a day in September with similar weather. This should limit the variances in light levels to a degree caused by changes in natural lighting levels. Additionally, it is possible that the artificial illumination within the building may have varied between participants and between the test and the light level measurements, however the artificial lighting in the building was found to be rarely turned off.

3.4.4 Choose the wider corridor

The number of decision points travelled by each participant, the number of decision points with wider route / exit option available and the percentage of that option taken are shown in Table 3.03. There were 268 decision points in total, of these, 41 were ignored, which include those where the widest exit option leads to an obvious dead-end, the participant has doubled-back, the widest exit is through a door or the participant has already passed through that point. This leaves 227 points for analysis. In total, of the 227 points with wider route available, the wider corridor or exit option was taken on 174 occasions (76.7%).

Participant	Number of decision points (DPs)	Number of DPs at which Wider option available		Wider option taken?	
		frequency	% of decision points	frequency	% of available wider option
1	8	7	87.5	5	71.4
2	13	10	76.9	8	80
3	14	11	78.6	10	90.9
4	9	8	88.9	7	87.5
5	8	6	75	5	83.3
6	13	9	69.2	9	100
7	9	7	77.8	5	71.4
8	8	7	87.5	4	57.1
9	9	9	100	7	77.8
10	10	9	90	7	77.8
11	8	6	75	4	66.7
12	9	8	88.9	4	50
13	10	7	70	7	100
14	13	12	92.3	9	75
15	10	10	100	7	70
16	14	12	85.7	7	58.3
17	13	10	76.9	7	70
18	15	12	80	8	66.7
19	14	12	85.7	10	83.3
20	10	8	80	7	87.5
21	15	13	86.7	11	84.6
22	12	11	91.7	8	72.7
23	14	13	92.9	11	84.6
24	10	10	100	7	70
Total:	268	227	84.7	174	76.7

Rows 1–12 grouped under **2003 Test**; rows 13–24 grouped under **2008 Test**.

Table 3.03 Summary of occasions on which participants chose to exit a space along the wider route

3.5   Summary

Observations of wayfinding decisions were undertaken in the University of Sheffield Students' Union building in 2003 with a repeat test undertaken in 2008. The route decisions of 24 participants were recorded. Table 3.04 shows the results from both tests. These comprise the percentage of each option taken at available decision points for each wayfinding strategy.

Although the methodology for both the 2008 test and the part of the 2003 test documented here is the same, it was still considered that there may be differences in the results due to different samples. Despite the two tests being conducted for different reasons (the 2003 test to study how directions are followed and landmarks recognised, and the 2008 test to study how wayfinding tasks generally are undertaken), analysis of the routes taken showed similar percentages for route choice based on the various wayfinding strategies. The results from the two tests therefore appear to support each other. The results also support the suggestion that each of these wayfinding strategies does have an influence on path choice. Were each strategy only followed on 50% of occasions, there would be a degree of uncertainty as to the correctness of the strategies, i.e. it could be a chance occurrence that a particular behaviour matched a wayfinding strategy. However, a strong trend of the participants using the strategies to inform their wayfinding behaviour was apparent - in over 70% of occasions when a participant encountered a decision point, their path choice conformed to the various wayfinding strategies, i.e. on those occasions if they were consciously using the strategies to inform their wayfinding behaviour they would have made the same decisions.

Wayfinding strategy	% of Option Taken at Available Decision Points		
	2003 Test (participant 1-12)	2008 Test (participant 13-24)	All 24 participants
Maintain a Straight Bearing	80%	78.6%	79.2%
Avoid a Change of Level	96%	88%	91.8%
Walk towards brighter space	75.8%	70.9%	73.1%
Choose the wider corridor	77.3%	76.2%	76.7%

Table 3.04: Percentage of option taken at available decision points applied to each wayfinding strategy in tests conducted in 2003 and 2008 and the combined results

There are limitations to the test – the number of participants are low and, being conducted in a real environment upon which the experimenter had little control, there are potentially a very wide range of variables influencing the path choices made by participants. The test has also only been conducted within one environment which, while varied, only covers a subset of the range of plan layouts, building elements and transient factors that are present within buildings. However, despite these shortcomings, the four wayfinding strategies explored in Chapter 2 each describe behaviours that were identified as trends in the results from this test and therefore the results support the four strategies. The results from the 2003 test were valuable in determining which strategies to focus on and those results from the 2008 test in further supporting this choice.

Three of the wayfinding strategies have been investigated in some detail in previous research documented in Chapter 2. However, the Choose the Wider Corridor strategy has only received little attention in previous research. As evidence for it could be seen in a range of the trends from this test, it is being considered further within this research and first investigated in further detail in Chapter 4.

3.6   References

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4

Corridor Width Experiment

4.1 Chapter overview

This chapter describes an experiment carried out online to test users' movement preferences in unfamiliar indoor environments. Specifically, the experiment was undertaken to determine whether unfamiliar users, when presented with a variety of routes (typically at a corridor junction or other decision point) have a tendency to choose wider routes. The experiment also explores any conflict that may arise between wayfinding strategies when there is a wider route from a decision point which deviates from the straight bearing.

4.2 Introduction to the experiment

From the observational studies carried out in the University of Sheffield Students' Union building (Chapter 3), various wayfinding behaviours and trends were recorded which fitted those described by the wayfinding strategies explored in the Literature Review (Chapter 2). Of these wayfinding behaviours, one favoured maintaining a straight bearing at decision points and another favoured choosing a wider exit route from a decision point. The Straight Bearing strategy has been quite broadly studied, having been identified by Bailenson et al. (2000) and expanded upon by Hochmair and Frank (2000), Conroy-Dalton (2003) and Hölscher et al. (2004; 2006). By comparison, research into the wider route strategy when used within indoor spaces seems to be limited to a study of path choice in underground spaces (Zacharias, 2002). As with the Students' Union studies, Zacharias' test looks into path choice in a real environment (albeit represented in photographs and abstract drawings rather than first hand) and are therefore influenced by a far wider range of variables than

simply the width of the corridor. The wider route strategy reliably supports many of the path choice decisions made by the participants in the Students' Union studies as well as those in Zacharias' study.

The Corridor Width Experiment was devised in order to identify, within a controlled environment, how corridor width influences path choice in order to support the observed behaviour in the Students Union study. A positive outcome from the experiment would therefore justify exploring the corridor width strategy further. The opportunity was also taken to study how conflicting combinations of a narrow straight bearing route and wider side route are resolved in route decisions. Several of the decisions recorded in the Students Union study could be explained by either the straight bearing strategy or the wider route strategy. Therefore, the experiment also aims to identify whether there is a preference for using the straight bearing strategy or wider route strategy when wayfinding, e.g. how wide does a side exit need to be to encourage users to drop the straight bearing strategy?

This experiment is concerned with how people find their way around unfamiliar indoor environments – scenarios such as attending a guest lecture (and having to find the lecture theatre in an unfamiliar University building) or a consultation in a hospital. The aim of the study is to identify how the spatial design of the building helps to provide reassurance in the wayfinding process in such circumstances. Although primary navigational information is typically gleaned from signage, signs to all locations are never present at all decision points within the building. The experiment is based on the same research question as the thesis study as a whole: in circumstances where signage is not present or is ambiguous, in what way does the spatial design of the space (in this case the corridor width and possible choice of straight or non-straight path choices) aid, hinder or in any other way influence the wayfinding decisions made?

Although this experiment and the related strategy both refer to corridors in their name, it is considered that the strategy and experiment are applicable to routes in

general and circulation spaces besides corridors. However, corridors are commonly occurring circulation spaces within buildings and are therefore used in the computer representations in this experiment. The use of the word 'corridor' in the names reflects this.

Hypotheses of the test:

Hypothesis 1 : Corridor width affects unfamiliar users' route choices at decision points

Hypothesis 2 : An increase in corridor width increases the number of times a route is chosen

4.3   Method

Taylor and Socov (1974) undertook an experiment in a controlled real environment which studied the influence of brightness on path choice. The methodology from this was used as a basis for the corridor width experiment. Taylor and Socov's experiment presented participants with a decision point from which a left or right path choice could be made. The light levels to the two path choices were independently varied, with a different light level ratio for each participant. Participants were directed to the decision point then had to make a decision as to which direction to take. The only information available to them was the environmental information in their immediate surroundings, and the only variation in environmental information between the two routes was the light level. The experiment is discussed further in Chapter 2. The Corridor Width Experiment uses the same basic methodology, albeit with variations in corridor width to the two available paths, rather than variations in light levels.

The comparison with straight bearing extends the Taylor and Socov's test in offering a straight path choice as well as either a left or right direction path choice. In other respects the methodology is much the same as for the left / right wider route choice,

i.e. choose one of two available exits.

The experiment was conducted online, within a limited virtual environment (the environment did not extend beyond the junctions shown in the images). Participants visited a website – http://experiment.chinglan.com – which goes through a series of pages leading to and including the test itself. Multiple images of a corridor junction, each with a slight variation in plan arrangement (shape on plan) and / or corridor width, were generated using architectural modelling software. The images were intended to represent a 'generic' corridor, with largely nondescript architectural features and just enough detail to look realistic. Each image represents a decision point, rendered from the perspective view of an average height user with an eye height of 1.6m from the floor (Adler, 1999). Each decision point has two choices of path exiting the decision point, excluding the path entering the decision point.

Throughout this chapter the entering path is termed the 'reference corridor'. All the images used in the experiment are rendered from the point of view of someone standing in this path (represented as a grey filled circle on the plans in Figure 4.02 and Figure 4.10) and all the ratios quoted throughout this chapter (and later in the thesis) describe the other corridor widths as compared to the reference corridor width. Null conditions occur when the widths of the reference path and all paths exiting the decision points are the same.

Almost all the images are unique – the only duplicate images occur amongst the null conditions. The T junction set, for instance (Set A), comprises a set of images that were rendered with the right-hand path choice drawn at the various width ratios (four images, including the null condition). From these, mirrored copies were produced to produce the total of eight images that are in Set A. The use of mirrored, but otherwise identical, images was is in order to identify what influence handing has on path choice. Taylor and Socov identified handing as a potential source of bias in their results – from their null condition they identified a 67/33 bias in favour of taking the right-hand path (67% of participants taking the right-hand path and 33% taking

the left-hand path when the illumination levels at the end of both paths were equal).

Each participant in this experiment saw all the images, in random order, during the course of the experiment. Each participant only undertook the experiment once. The participants were instructed to consider themselves in a wayfinding scenario: they have reached a junction with no signage and need to make a decision about which way to go. They are told that the images represent permutations of the same junction, not a sequence of junctions, therefore selecting the same direction four times in a row does not send them around in a circle. The participants were presented with only one image at a time (example images are shown in Figure 4.01), and were instructed to identify which direction they would take if presented with this permutation during a wayfinding task. The response was given by clicking on direction arrows. Once an arrow had been clicked, the experiment progressed to the next image. There was no time limit for the test. Responses were automatically recorded by the website software and stored in files on the web server. Access to the files is password protected – the website the participants accessed did not request a password be entered, however this site only stored information; it included no means to retrieve and display information from the files hence there was no risk that third parties could view the files unauthorised.

The image order is chosen at random for each participant by the website software before the experiment commences. Having a different order for each participant is essential to ensuring that trends resulting from unfamiliarity with the experiment do not always affect the same images. The random order also minimises the risk that participants will spot the differences between different images.
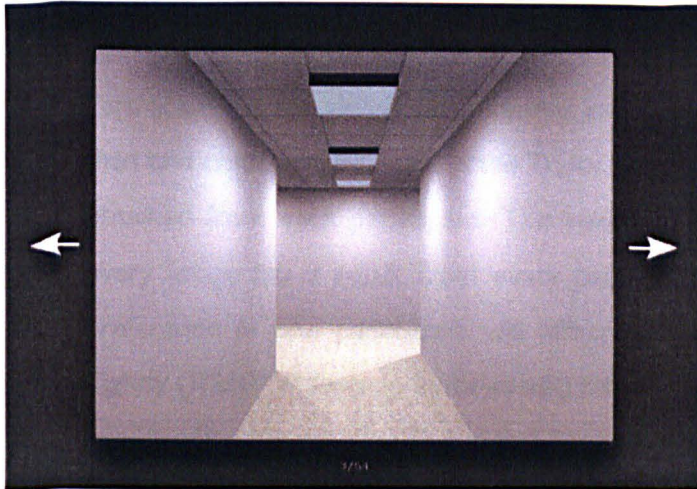
T junction with left and right hand side exit options
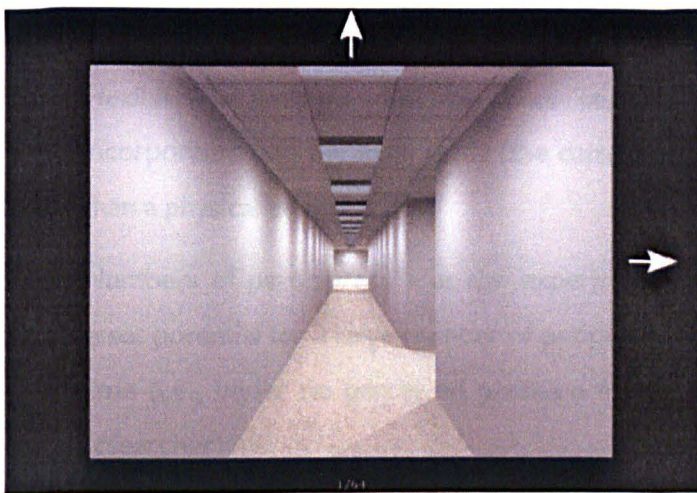
Junction with options to go straight on or make a turn

Figure 4.01 Screenshots of sample images shown in the Corridor Width Experiment with arrows for participants to click to make a path choice

4.3.1 Use of a virtual environment

Taylor and Socov (1974) used a specially constructed, controlled real environment in order to study the influence of brightness on path choice. The current experiment could have been conducted using a similar arrangement, however a virtual environment was chosen instead for a number of reasons:

- Changing the light levels between participants in the Taylor and Socov test required no more than a change to a variable resistor setting. Changing the width of the corridors in a similar real environment test would be significantly more time-consuming and require very careful construction in order that the

same widths could be reliably replicated for the various participants

- Participants in the virtual environment can provide their response to more than one condition, whereas in the Taylor and Socov test only one result was obtained from each participant. This repeated measures approach ensures every image has a result from every participant, a bias or unusual choice preference in one participant will affect the results for each image very slightly ($1/250^{th}$ difference in the result) rather than have a large effect on the results of one image (for Taylor and Socov's experiment, a 'rogue' response would affect a difference of around $1/10^{th}$ in the result for a particular condition).

- Flexibility - findings from the pilot study could quickly and easily be incorporated into the main study (the computer model is far easier to modify than a physical environment)

- Numbers of participants – as the experiment is conducted online, there is great potential for a large number of people to undertake it, within their own time (i.e., under no perceived pressure from undertaking it in front of the researcher)

- Lower cost and quicker to set up

There are downsides to using a virtual environment:

- Developing an intuitive interface is very important – clicking buttons on a screen and / or navigating with a mouse place a barrier between the participant and the decision they wish to give. Physically walking in one direction or another is far more natural. The use of more than one image for each participant is partly to counter this – the high number of images used, the repeated use of the same images and the random order that the images are displayed are all intended to counter the possibility that participants were not familiar with the practical means of response in the early stages of the experiment.

- In the Taylor and Socov experiment, test participants were blind as to the

real purpose of the test, being asked to enter a room (by one of two paths) to carry out a dummy experiment. The path choice was simply perceived by participants as a means into the space in which this dummy experiment was undertaken, and was therefore tackled in much the same way as any path choice taken when wayfinding. The aim of this was to record a natural decision making response to the wayfinding task. By providing a large number of similar images in the corridor width experiment, participants are encouraged not to dwell for too long on each image and instead go with their natural response.

4.4 Pilot Study

A pilot study was carried out prior to the main experiment. This followed the methodology outlined above, which was common to both the pilot study and main study, however the test procedure, images used and corridor width ratios were refined and route options revised following feedback from participants involved in the pilot study.

28 images were produced for the pilot study using computer rendering software (Graphisoft ArchiCAD). Each image showed a representation of a corridor junction, with variations in plan shape and corridor width between each picture. Figure 4.02 shows a diagram of the types of junctions (T shaped junctions and Y shaped junctions, as seen on plan) and ratio changes and Figure 4.03 shows some of the images used in the test. Four different ratios of exit corridor width were used: a=1.0, 1.125, 1.25 or 1.5 and two different reference corridor widths: c = 1.5 m or 3m (Table 4.01 & Figure 4.02). Exit corridor b always has the same width as reference corridor c. Each ratio was used for permutations of narrow reference corridor width (1.5m), wide reference corridor width (3m), T junction and Y junction. The set of images was mirrored, so the increased width appeared as either the left or right exit route choice.

Ratios of corridor width (a/b)	Width of variable corridor for each reference corridor width	
	1.5 m	3.0m
1.0	1.5m	3.0m
1.125	1.69m	3.38m
1.25	1.88m	3.75m
1.5	2.25m	4.5m

Table 4.01 Ratios of corridor tested in pilot study. These ratios applied to both narrow (1.5m) and wide (3m) reference corridors and both T junctions and Y junctions

T Junction   Y Junction

Key:
Exit 'a': same size or wider than entrance 'c'
Exit 'b': same size as entrance 'c'
●: Viewpoint
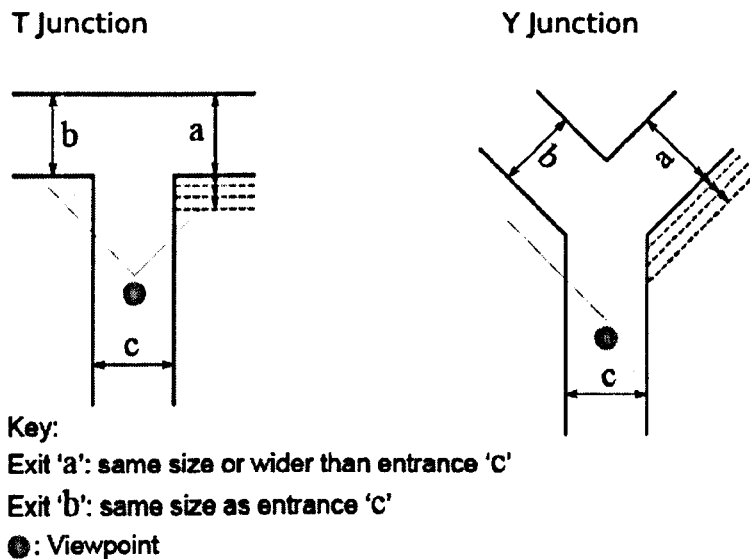
Figure 4.02: Diagram showing type of junctions and ratio changes tested in the pilot study

The test was carried out by ten participants. Of these, eight were in age group 21-30 and two in age group 31-40. Five were female and five male, seven were students, two were designers and one was a teacher. All participants in the pilot study were volunteers, are from Taiwan and are friends of the researcher. Although it is recognised that there may be issues of sampling bias within this set of participants,

this is not considered likely to undermine the aim of the pilot study (to determine whether the method and material of the experiment work).

Codes have been used to give shorthand labels for the different junction arrangements throughout the analysis of the pilot study. Images with a T code are of the T shaped junction while those with a Y code are those of the Y shaped junction. Those with an N code are of corridors with a narrow reference corridor width (1.5m) against which the other corridor widths are calculated, using the ratios. Each of these images therefore has one exiting corridor of width 1.5m and another of width 1.5m, 1.69m, 1.88m or 2.25m depending on ratio. The images with a W code are of the corridors with a wide reference corridor width (3m). These images therefore have one exit corridor of width 3m and another of width 3m, 3.38m, 3.75m or 4.5m depending on ratio. The numbers following this code refer to the ratio (with Null as part of the code for null conditions when both sides are the same width) while the L or R at the end of the code refers to the side (Left or Right) which is wider. As an example, code TN1.5L refers to a T junction with narrow reference corridor (1.5m wide) with the left hand side corridor 1.5 times wider than the right hand side and reference corridors. Figure 4.03 below shows some of the images used in pilot study and demonstrates an example from each of the groups TN, YN, TW and YW.

TNNull: T junction with narrow reference corridor (1.5m) and corridor ratio 1:1(Left : Right), null condition

YN1.125L: Y junction with narrow reference corridor (1.5m), corridor ratio 1.125:1.0 (Left : Right)

YW1.5R: Y junction with wide reference corridor (3m), corridor ratio 1.0:1.5(Left : Right)

TW1.25R: T junction with wide reference corridor (3m), corridor ratio 1.0:1.25 (Left : Right)

Figure 4.03: Some of the images used in the test. These images show T junctions and Y junctions with narrow and wide reference corridors

4.4.1 Pilot study test procedure and scenario

Each participant saw a series of explanatory and information collecting pages at the start of the experiment. A description of the test (without revealing the test's aims) were shown on the first page, along with an explanation that this was contributing to academic research, brief instructions of how to continue (including a request to undertake the test individually and not in groups) and a 'consent' button. Following this was a page collecting age, gender, nationality, occupation and e-mail address data. Once this has been completed and submitted, the participant is given the wayfinding scenario. He / she is visiting a large unfamiliar university building to attend a lecture. The destination is a lecture theatre within the building. The scenario given

is that the participant has followed a sign, which has directed them to a decision point with no further information available. The participant has to make a decision which corridor to take based purely on his / her impression of the space. Participants are asked to make their decision by clicking on one of the direction arrows shown adjacent to each image.

Following the scenario page, each of the 28 images are shown, one at a time in random order. The experiment automatically progresses from one image to the next when the participant clicks on a direction arrow. Once all the images have been shown, the participant sees a page thanking them for their participation. This includes a box to leave comments. There is also the option (a button) to start the experiment again, though it is stressed that this should not be used by individual participants to undertake the experiment multiple times. The experiment will only re-start if this link is clicked – closing and re-opening the browser window or re-visiting the site once the experiment is complete will take participants to the 'thank you' page so that new experiment sessions are not inadvertently started.

4.5   Pilot study results

Raw data from the pilot study is shown in Table 4.02. This shows how many participants chose to turn left or right at each image tested. The graph in Figure 4.04 shows participants have a tendency of choosing to go right when both exits are the same width (null condition). At the null condition T junction with a reference corridor width of 1.5m (hence both exit corridors are also 1.5m wide), 7 out of the 10 participants chose to turn right. 8 out of the 10 participants chose right at the null condition T junction with 3m wide corridors and 6 out of the 10 participants at the null condition Y junction with 1.5m wide corridors. Only at the null condition Y corridor with 3m wide corridors do an equal number of participants go left as go right.

Image	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	T junction														Y junction													
	1.5m reference corridor							3m reference corridor							1.5m reference corridor							3m reference corridor						
Ratio	1.000	1.125	1.250	1.500	1.125	1.250	1.500	1.000	1.125	1.250	1.500	1.125	1.250	1.500	1.000	1.125	1.250	1.50	1.125	1.250	1.500	1.000	1.125	1.250	1.500	1.125	1.250	1.500
Wider Side	/	L	L	L	R	R	R	/	L	L	L	R	R	R	/	L	L	L	R	R	R	/	L	L	L	R	R	R
1	R	R	R	L	L	L	R	L	L	L	L	R	R	R	R	L	L	L	R	R	R	L	L	L	L	L	R	R
2	R	R	L	L	R	R	R	R	L	L	L	R	R	R	L	L	L	L	R	R	R	L	L	L	L	R	L	R
3	R	R	L	L	R	R	R	R	L	L	L	R	R	R	R	R	L	L	R	R	R	L	L	L	L	R	R	R
4	R	L	L	L	R	R	R	R	L	L	L	R	R	R	L	L	L	L	R	R	R	R	L	L	L	R	R	R
5	L	L	R	L	R	R	L	R	L	R	R	L	L	L	L	L	R	R	L	L	L	R	L	R	L	R	R	L
6	L	R	L	L	R	R	R	R	L	L	L	R	R	R	R	L	L	L	L	R	R	R	L	L	L	L	R	R
7	R	R	L	L	R	R	R	R	L	L	L	R	R	R	R	L	L	L	R	R	R	L	L	L	L	R	R	R
8	L	L	L	L	R	R	R	R	L	R	L	R	R	R	R	R	L	L	R	R	R	R	L	L	L	R	R	R
9	R	L	L	L	R	R	R	L	L	L	L	R	R	R	L	L	L	L	R	R	R	R	L	L	L	R	R	R
10	R	R	L	L	L	R	R	R	L	L	L	R	R	R	R	L	L	L	R	R	R	L	L	L	L	R	R	R
Total L	3	4	8	10	2	1	1	2	10	8	9	1	1	1	4	8	9	9	2	1	1	5	10	9	10	2	1	1
Total R	7	6	2	0	8	9	9	8	0	2	1	9	9	9	6	2	1	1	8	9	9	5	0	1	0	8	9	9

Table 4.02 Raw data from the pilot study showing each participant's choice and the ratio and type of junction of each test image
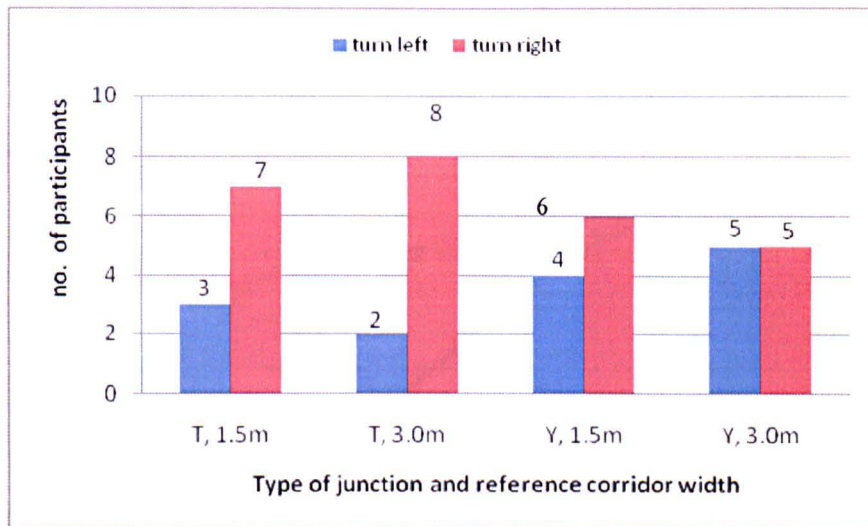
Figure 4.04: Graph showing number of participants choosing to turn left or right at the four test conditions when left and right hand side exits are the same width – null condition

Results from the four different junction arrangements are shown in Figures 4.05~4.08. There is a trend for a higher number of participants to choose the wider corridor across all four conditions. Generally, a larger proportion of participants chose to turn right when the right hand side is wider than turn left when the left hand side is wider, with four exceptions: wide reference corridor at ratio 1.125 (both T and Y junctions, Figure 4.06 and Figure 4.08 respectively) and ratio 1.5, T junction with narrow reference corridor (Figure 4.05) and Y junction with wide reference corridor (Figure 4.08). It would appear from these results that participants therefore have a tendency to turn right, however as this is only based on a result set of 10 participants the results may be heavily influenced by those from any one of the participants.
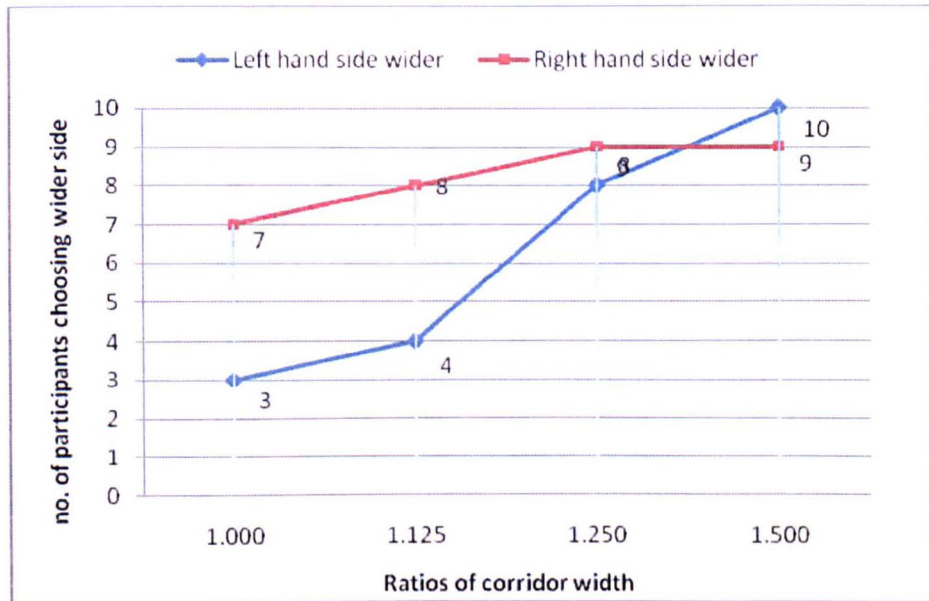
Figure 4.05: Number of participants choosing wider route at each ratio at T junction with reference corridor 1.5m (TN)
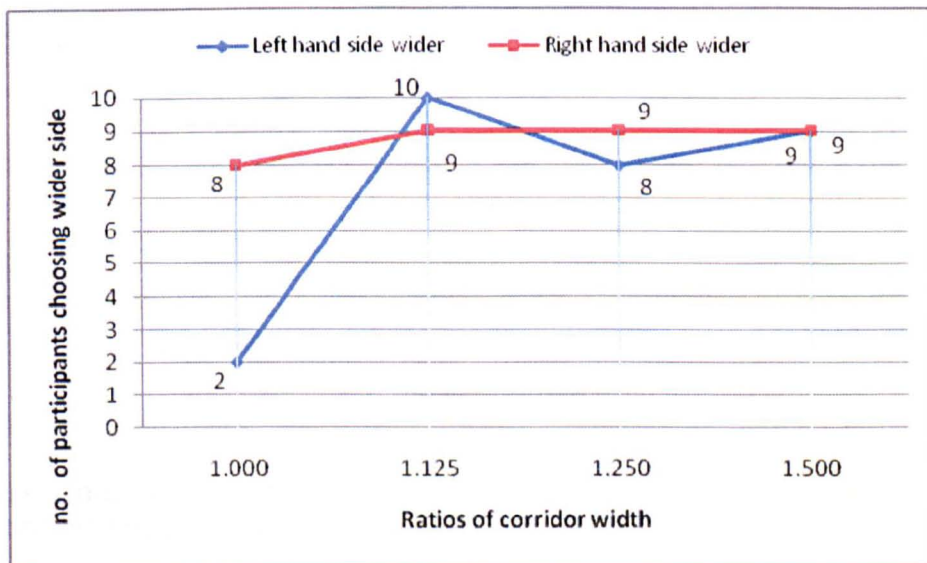
Figure 4.06: Number of participants choosing wider route at each ratio at T junction with reference corridor 3m (TW)
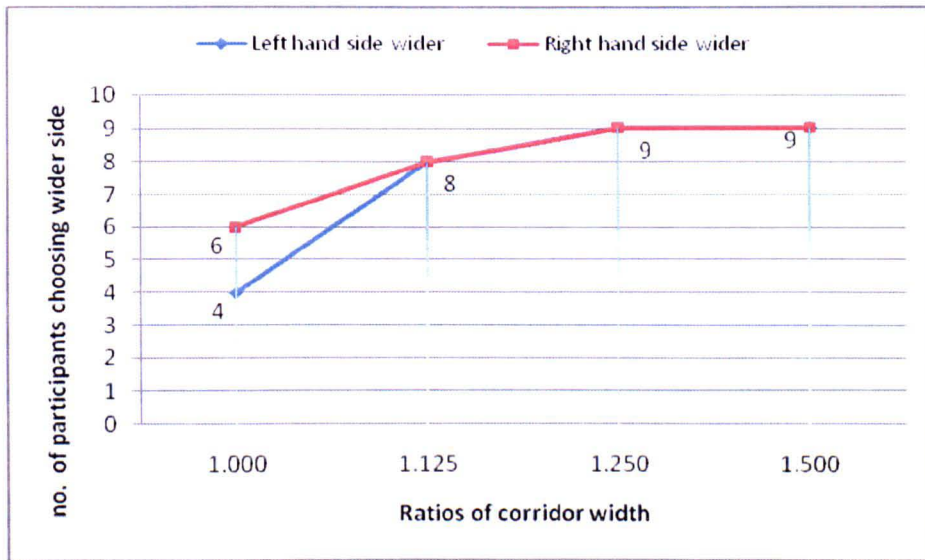
Figure 4.07: Number of participants choosing wider route at each ratio at T junction with reference corridor 1.5m (YN)
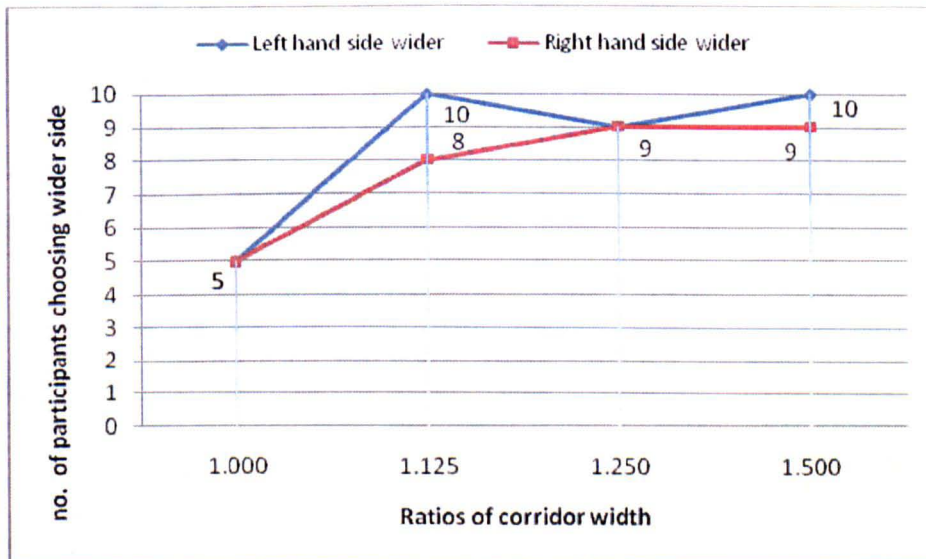
Figure 4.08: Number of participants choosing wider route at each ratio at T junction with reference corridor 3m (YW)

Table 4.03 shows the McNemar test results for pair comparisons of corridor width ratios. The top-right portion of the table shows that, when the wider side is on the

right, there is no significant difference across all pairs of ratios (from the McNemar test p>0.05). The bottom-left portion of the table shows that there is a significant difference at T shape junctions with 3m wide reference corridors at all three ratios when compared with the null condition T junctions with a narrow (1.5m wide) reference corridor (p<0.05).

This analysis of these results suggests that, when the right hand side is the wider side, increasing the width does not attract more people to choose it. This is because there are already more people choosing the right hand side when the left hand and right hand are the same width. However, when the left hand side is the wider side, an increasing number of people tend to go left as the width of the corridor increases. Although these findings are from only a small sample, they do seem to suggest that corridor width has an effect on path choice.

Left hand side wider		Right hand side wider							
		1.0		1.125		1.25		1.5	
1.0		/////	/////	n.s	n.s	n.s	n.s	n.s	n.s
		/////	/////	n.s	n.s	n.s	n.s	n.s	n.s
1.125		n.s	p<0.01	/////	/////	n.s	n.s	n.s	n.s
		n.s	n.s	/////	/////	n.s	n.s	n.s	n.s
1.25		n.s	p<0.05	n.s	n.s	/////	/////	n.s	n.s
		n.s	n.s	n.s	n.s	/////	/////	n.s	n.s
1.5		p<0.05	p<0.05	n.s	n.s	n.s	n.s	/////	/////
		n.s	n.s	n.s	n.s	n.s	n.s	/////	/////

Key:

TN	TW
YN	YW

Table cells above right of hatching show the results when right hand side is wider and table cells below left of hatching show the results when left hand side is wider

Table 4.03: Each pair of ratios compared using McNemar test (results from the Pilot Study)
n.s. : no significant difference for this pair
For example : cell shaded in grey shows significance level of comparison between the pair 'YN1.25R' and 'YN1.125R'

4.5.1 Analysis of the effect of shape of junction and width of reference corridor

The McNemar test was used to identify whether the junction shape (T or Y) affects the route choice. Pairs of images were compared. The only difference in the images within each pair was the shape on plan of the corridors - the reference corridor width, ratio and handing were the same (e.g. TN1.125L was compared with YN1.125L and TW1.5R was compared with YW1.5R). Of all possible pairs in the pilot study, it was revealed that there is no significant difference between the results from the different shapes of junction. The McNemar test is also used to identify whether the width of the reference corridor affects the route choice. Again, this test was applied to pairs of images with only one variable different between images in the pairs (e.g. YN1.25L was compared with YW1.25L). With all possible pairs of wide and narrow reference corridor (15 out of the 16 cases) there is no significant difference between results from the wide and narrow reference corridor - $p > 0.05$. The only pair that shows a significant difference is at ratio 1.125 on T junction with wider exit corridor to the left (TN1.125L compare with TW1.125L) where $p = 0.031$. When the reference corridor was 1.5m wide, only 4 participants turned left while with a 3m wide reference corridor all 10 participants turned left.

4.5.2 Aggregated data

With the small number of participants in the pilot study, it is difficult to identify at what ratio different widths start to make a difference. As there is no significant difference between results arising from the different reference corridor widths and shapes on plan, all the TN, TW, YN and YW sets of results have been aggregated in order to broaden the data set across which the effects of exiting corridor width can be studied. Table 4.04 shows the aggregated data combining both reference corridor widths (1.5m and 3m) and both junction shapes (T junction and Y junction) when the left hand side is wider than the right hand side (McNemar test comparing every possible pair of ratios, $p < 0.01$). Table 4.05 shows the right hand side is wider than the left hand side (also McNemar test on ratio pairs, $p < 0.05$). The results show that there is significant difference when one side is 1.25 times or more wider than the

other side whether the wider side is to the right or the left. When one side is 1.125 times wider than the other side, only when the wider side is on the left is there a significant difference between results from the ratio pairs. As with the null condition, this may be the influence of Right-hand side bias. When the right hand side is 1.125 times wider than the left hand side, it does not draw more participants to turn right.

Figure 4.09 shows that continuing to increase corridor width may not have a linear influence on path choice – there may always be a small proportion of people who choose the narrower corridor.
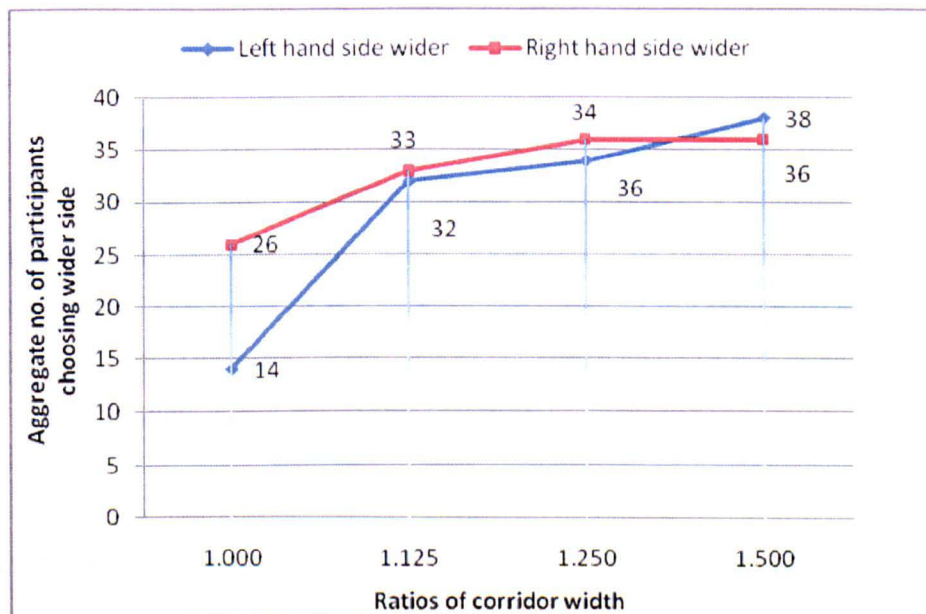
Figure 4.09: Choices made by participants across the aggregate of the results for TN, TW, YN and YW corridors

	1.0	1.125L	1.25L	1.5L
1.0		p<0.01	p<0.01	p<0.01
1.125L			n.s	n.s
1.25L				n.s
1.5L				

Table 4.04 McNemar test showing each pair of ratios comparison when left side is wider

	1.0	1.125R	1.25R	1.5R
1.0		n.s	p<0.05	p<0.01
1.125R			n.s	n.s
1.25R				n.s
1.5R				

Table 4.05 McNemar test showing each pair of ratios comparison when right side is wider

4.6 Pilot study summary

Results from the pilot study suggest unfamiliar users do have a tendency to choose the wider side at decision points when presented with possible route choice of different widths. The shape of the junction and width of the reference corridor do not affect participants' choices in the pilot study. When one side is 1.25 and 1.5 times wider than the other, the wider side is preferred.

The pilot study also suggests that the reference corridor width does not have a significant influence on the users' preference for choosing a wider route. The main test therefore investigates ratios with one reference corridor width of 2m (between the 1.5m and 3m widths used in pilot study) and does not test the difference between T and Y shape junctions.

4.7 Main Experiment

The main experiment followed the same methodology outlined in section 4.3 and

the same broad procedure as did the pilot study. Six things were changed: the route options, the corridor width ratios (which are based upon a logarithmic scale in the main experiment), the reference corridor width, the total number of images presented to the participant, the manner in which the scenario was presented to the participant and the software used to produce the images. The remainder of the methodology and procedure – for example ensuring that the décor, lighting and viewpoint are the same in all images – are shared with the pilot study.

4.7.1 Changes between the pilot study and the main experiment

As the results from the pilot study demonstrated no significant difference in path choice preference between results for the T shaped junctions and Y shaped junctions, the decision was made not to continue studying both of these in the main test. T shaped junctions were chosen as this is a more common plan layout in buildings than Y shaped junctions (Y shaped junctions usually result in rooms that are not orthogonal, or result from two elements of a building meeting at an angle other than 90°). The opportunity was also taken to test path choice based on corridor width against path choice based on straight bearing. For this purpose, images were rendered which showed junctions with one exit corridor continuing in the same direction as the reference corridor (this is the 'straight bearing corridor') and a 'side exit corridor' leading at 90° out of the decision point. The side exit corridor is either on the left or the right, depending on which image is being viewed - taking the side exit corridor involves turning either left or right from the straight bearing.

These junction shape variations allow the influence of corridor width on path choice to be measured independently of other variables (in the T junction set of images) and compared with the influence of the strategy of maintaining a straight bearing (in the side corridor set of images). With the exception of the null condition images, where both exit corridors are the same width as the reference corridor, the side corridor in the images is always wider than the straight bearing corridor. Therefore, taking the side corridor complies with the Choose the Wider Corridor strategy but conflicts

with the Maintain a Straight Bearing strategy, whereas taking the straight bearing corridor complies with the Maintain a Straight Bearing strategy but conflicts with the Choose the Wider Route strategy.

As with the images used in the pilot study, there are always two paths available to choose from in each image used in the main study. + shape junctions were not used to study the influence of the Maintain a Straight Bearing strategy as any results for path choices that strayed from the straight bearing would be split between those taking the left hand exit and those taking the right hand exit. Aggregating the results which strayed from the straight bearing may lead to a bias in the results against the Maintain a Straight Bearing strategy as only one exit would exist which complies with the Maintain a Straight Bearing strategy whereas two would exist which conflict with the Maintain a Straight Bearing Strategy. For this reason, one path choice is presented to the participant which complies with the Maintain a Straight Bearing strategy and one which conflicts with this strategy. Differences in path choice due to the different handing of the junctions (with the side exit on the left or right) and the influence of right hand bias are investigated by undertaking pair comparisons of the junctions with the handing being the only variable.

The corridor width ratios were also revised for the main test. The difference between each ratio in the main test was calculated based upon a logarithmic scale. Logarithmic scales are used in acuity charts (Bailey & Lovie, 1976) as the senses tend to function in a logarithmic fashion (Barlow, 1982). Calculating the ratios based upon a logarithmic scale therefore leads to variations in corridor width that are just large enough to be perceived by the participants as being different to each other without being so obviously different that the participants work out the purpose of the experiment. An added benefit is that the resulting ratios in the main test are more closely grouped than those in the pilot study. For the T junction the ratios are 1.0, 1.122, 1.259 and 1.413 to 1.0 in the main test whereas in the pilot study the ratios were 1.0, 1.125, 1.25 and 1.5 to 1.0. This allowed for finer analysis of the results, in particular the ratio at which the desire to follow the wider corridor overcame the

right hand bias or desire to maintain a straight bearing.

Whereas in the pilot study there were only four ratios, each of which was wider than the reference corridor, in the main test it is necessary to also have some ratios that are narrower than the reference corridor – 0.891, 0.794 and 0.708 to 1.0. This was due to the decision to show two sets of side / straight bearing corridor images to determine whether narrowing the straight bearing corridor had a different influence on path choice behaviour to widening the side exit corridor. These narrower ratios were calculated based on an extension of the same logarithmic scale as used to calculate the wider ratios. Mathematically, therefore, there is no difference between ratios comparing the straight bearing and side exit corridor widths. A ratio of 0.891 : 1.0 (straight bearing corridor width, varying between images : side exit corridor width) is in effect the same as a ratio of 1.0 : 1.122 (straight bearing corridor width : side exit corridor width, varying between images) – both are the inverse of each other. There may be a difference in the perception of width, however, when compared with the reference corridor width and also the height of the corridor, both of which are constant in all images. Furthermore, two larger ratios were used in the study of the side corridor junctions. It was determined from the pilot study that, above a certain ratio, there was a lessening increase in influence on path choice by increasing corridor width. However, it was considered possible that this result for the T junction images may not apply to the side corridor images, and it would be unfortunate if a similar plateau in the influence of corridor width in side corridor junctions could not be determined due to the experiment not extending to large enough ratios. Additionally, as the side exit corridor is always viewed at an angle, it is possible that it may not appear to participants to be as wide as the straight bearing corridor, which is viewed straight on. Larger ratios may therefore be necessary before the increased width of the side exit corridor has an influence on path choice.

The revised junction permutations (shapes and widths) are shown in Figure 4.10 and Table 4.06. These are split into four sets:

- Set A, which is similar to the T junction used in the pilot study. One of the

exits from the decision point always remains the same width as the reference corridor, the other exit corridor width varies (wider than the reference corridor). 8 images in total.

- Set B, with a side exit corridor either to the left or right and a straight bearing corridor. The straight bearing corridor always remains the same width as the reference corridor; the side exit corridor width varies (wider than the reference corridor). 12 images in total.

- Set C, with a side exit corridor either to the left or right and a straight bearing corridor. The side exit corridor always remains the same width as the reference corridor; the straight bearing corridor width varies (narrower than the reference corridor). 8 images in total.

- Set D, with a side exit corridor either to the left or right and a straight bearing corridor. Both the side exit corridor width and straight bearing corridor width vary (the former increases as the latter decreases). 4 images in total.

The larger ratios are used only in Set B. Sets A to C each include images representing the null condition (both exit corridors the same width as the reference corridor). The null conditions for Set B and Set C are therefore identical and Set A has two identical null condition images (one 'right hand', one 'left hand'). Set D was undertaken to investigate more extreme ratios between the widths of the straight bearing corridor and side exit corridor. The Set D images are considered to be 'additional permutations' to Set B and Set C, and therefore Set D does not include null condition images.

Unlike the pilot study, the width of the reference corridor in the main test remains constant (2m). It was found that changing the reference corridor width did not have an influence on path choice. A 2m wide reference corridor was chosen for the main test as this is considered a reasonable average corridor width. 1.5m is close to the minimum corridor width in most buildings, due to access legislation which ensures people in wheelchairs do not occupy the whole corridor width (Stationery Office / NHS Estates, 1999). 3m is considered an overly generous corridor width and only

representative of a small proportion of corridor widths found in buildings.

In the pilot study, each of the 28 images was shown to each participant once. The main test has 32 images, each of which is shown to the participant twice, hence each participant sees a total of 64 images. This change was made to further lessen the influence of learning effect on the results of the images shown early on during each participant's session and also to check whether the path choices were reliably repeated when the image was re-shown, which would highlight whether path choices were just being made at random. In order that comparisons may be made in the analysis, results from the first time the participant sees each image are referred to as the 1st Trial, whereas results from the second time the participant sees each image are referred to as the 2nd Trial.

There are two further differences between the pilot study and the main test. In the pilot study the participant is shown the scenario, then each of the 28 images. This was found to be confusing. The scenario was difficult to understand without having an example image to view at the same time, however by the time the second or third image was reached, the exact description in the scenario could not be recollected and the consequence of making a decision choice not fully understood (some participants in the pilot study thought that, by making the same choice of direction four times in a row, they would return to the junction shown in the first image). The idea that all the images represented variations of the same junction was not always understood.

In order to alleviate this, the description of the scenario was split into two, which reduced the amount of information that had to be absorbed in one go. This resulted in the following test procedure (steps in italics are the same as those in the pilot study, screenshots can be seen in Appendix B):

1. *Brief explanation of the nature of the study and a 'consent' button*

2. *General questions (age, gender etc.)*

3. First part of the scenario. This explains to the participant that they are attending a lecture at a large, unfamiliar university building, that they have reached a junction with no signs and have to make a decision which corridor they would like to take.

4. One random image is then shown at this point and participant asked to make a route choice. This allowed the participant to gain a better understanding of what they would be doing through the rest of the experiment, reinforce the first part of the scenario in their mind (as the first part of the scenario applies to all the images) and have a visual reference when considering the second part of the scenario.

5. Once a route choice has been made, the second part of the scenario is shown. This explains that the following images show variations of the junction design shown in the first image. To render this plausible, these are described as variations being considered by the building's architect.

6. The remaining 63 images are shown to the participant (28 in the pilot study). *Each image is shown to the participant once a path choice decision has been given for the previous image.*

7. *Thank you page.*

The last difference between the pilot study and main test was in the software used to produce the images. Graphisoft ArchiCAD, a Building Information Modelling software package with photorendering abilities, widely used by architects, was used to produce the images in the pilot study. DIALux and POVRay were used in the main test. DIALux is a software package produced by the lighting trade to aid the specification of luminaires. It is capable of outputting modelling information to POVRay, a rendering package, for the purpose of producing visualisations of the effects of the specified luminaires within a space. This combination is therefore aimed at visualisations of interior spaces and was found to produce more realistic looking internal renderings than ArchiCAD. It had been found in ArchiCAD that changing the widths of the corridors had a marked effect on the apparent light levels in the images, possibly due to unsophisticated modelling of the lights and the

shadows they cast. The brightness of the images was therefore manually tweaked to alleviate this effect. By comparison, the images POVRay produced appeared far more evenly matched – there was less of a risk that the lighting or its influence on the appearance of the décor could inadvertently become a variable in the experiment. It was considered necessary to show luminaires in the images as simply placing an 'ambient light source' in the corridors would risk looking unrealistic due to there being no obvious light source. However, as with the décor in the corridors, the luminaires shown were chosen due to their nondescript appearance. Example images can be seen in Figure 4.11.

Screenshots of each page of the experiment website and all the test images in the main test are shown in Appendix B. Plan layouts of the junctions are shown in Figure 4.10. These diagrams show the corridors which remain at a fixed width within each set (2m wide in all instances, including the reference corridor) and the corridor(s) which the ratio change applies to (denoted by an 'a' or a 'b'). The viewpoint for each image is shown as a grey circle, the reference corridor is the corridor this circle is within. Table 4.06 shows the ratios applied in each image.
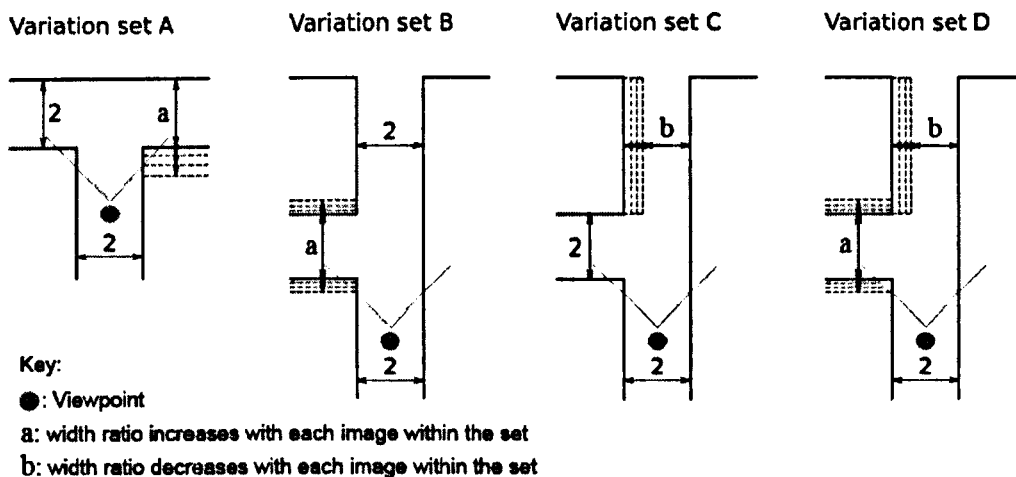
Figure 4.10: Diagrams showing corridor permutations used in the main test

	Set A			Set B			Set C			Set D			
Image no.	b		Image no.	a		Image no.	b		Image no.	a		b	
	ratio	width		ratio	width		ratio	width		ratio	width	ratio	width
1	1.000	2m	9	1.000	2m	21	0.708	1.42m	29	1.122	2.24m	0.891	1.78m
2	1.122	2.24m	10	1.122	2.24m	22	0.794	1.59m	30	1.259	2.52m	0.794	1.59m
3	1.259	2.52m	11	1.259	2.52m	23	0.891	1.78m	31	Same ratios as Images 29 & 30			
4	1.413	2.83m	12	1.413	2.83m	24	1.000	2m	32	apply with 'a' on right hand side			
5	Same ratios as Images 1~4 apply with 'a' on right hand side		13	1.585	3.17m	25	Same ratios as Images 21~24 apply with 'b' on right hand side						
			14	1.778	3.56m								
≀			15	Same ratios as Images 9~14 apply with 'a' on right hand side		≀							
8			20			28							

Table 4.06 Corridor width ratios and widths in the main test for each image within each set
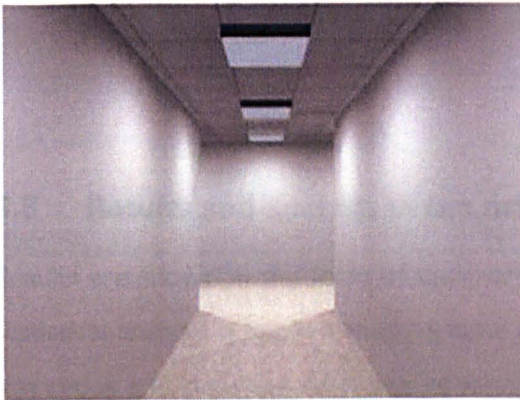
Set A (Image 1 and Image 5): T- junction, Null condition, every corridor at width 2m

Set B (Image 17): Right hand corridor 2.52m, reference and straight bearing corridor 2m

Set C1 (Image 21): Straight bearing 1.42m, reference corridor and left hand corridor 2m
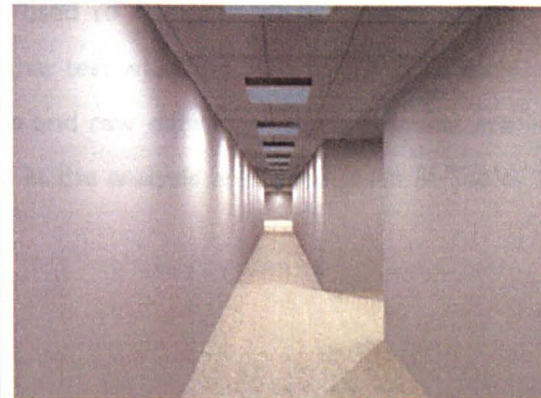
Set C2 (Image 32): Straight bearing corridor 1.59m, right hand corridor 2.52m and reference corridor 2m

Figure 4.11 Some of the images used in the test

4.7.2 Sampling in the main test

Participants were recruited by e-mail, as a link to the website within the e-mail could easily be used by potential participants to access the experiment. Permission was sought from the University of Sheffield to send an e-mail to a mailing list targeting students and staff at the Faculty of Social Sciences[1]. 250 participants undertook the experiment. Of these, 91 were males and 159 were females. The number of participants in each age group is show in Table 4.07.

Age group	Number
18~20	95
21~30	107
31~40	33
41~50	10
51~60	5

Table 4.07 Number of participants in each age group

4.8   Results and analysis of the main test

Results are shown in the form of summary tables and graphs in the following pages. Statistical analysis is applied to determine if there is a significant difference across all test ratios and between each pair of ratios within each trial and each set of images. All statistical analyses were carried out using SPSS. Initially, the Cochran Q test (for non-parametric data, related samples) was used to compare all test ratios within each set (Sets A, B, C and D) and the McNemar test was then used to compare each pair of ratios within the set. All test images and raw data from all participants are shown in Appendix B. Image numbers used in the analysis are those given in Table 4.06.

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[1] The University granted the test its ethical approval, which ensured that participants were not asked inappropriate questions during the test and did not have to use the computer for durations that could lead to eye strain.

4.8.1 Analysis of Set A (T junction)

Set A comprises decision points at T junctions with either the left or right hand exit corridor increasing in width in relation to the other exit and the reference corridor.

Null condition:

The T junction null condition offers two route options: left and right routes of the same width (both the same width as the reference corridor). These were shown to participants four times (once for each handing of the set - Image 1 and Image 5 – and again as all images are shown twice). The results are shown in Table 4.08 and these show that participants have the tendency to choose the right hand side when the choices are of the same width. 135, 136, 145 and 138 participants chose the right hand exit compared to 115, 114, 105 and 112 choosing the left hand exit (for each trial of each image out of 250 participants, therefore on 554 out of 1000 occasions the right hand exit corridors were chosen). Participants choosing to turn left and right are expected to be equal but as shown in the results, more participants chose to turn right when both exits are of the same width. This follows the trend from previous research (Taylor & Socov, 1974; Kang, 2004) and also the pilot study that showed there is a right hand side bias when presented with left and right choices. However, in the corridor width test, the highest percentage of right hand side across all 250 participants is 58% whereas in Taylor and Socov's study the bias was 67% and Kang's was 65%. In both Taylor and Socov's and Kang's research, there were fewer test participants experiencing the null condition (21 and 20 respectively) and, due to the nature of their experiments, each participant only experienced one test condition. Because of the reduced number of participants, each participant's choice will have a greater effect on the bias percentage, which may explain the difference between the bias percentages recorded by Taylor and Socov and Kang and those recorded in the corridor width experiment.

Participant	Image 1		Image 5	
	1st trial	2nd trial	1st trial	2nd trial
P1	1	1	1	0
P2	1	1	1	0
P3	0	0	0	0
P4	1	1	0	0
⋮	⋮	⋮	⋮	⋮
P250	0	1	1	0
Total: Right (1):	135 (54%)	136 (54%)	145 (58%)	138 (55%)
Left (0):	115 (46%)	114 (46%)	105(42%)	112 (45%)

Table 4.08 Summary table showing number and percentage of participants choosing right hand side when presented with the Set A null condition (both left and right options the same width). Images representing Set A null condition shown four times in total.

Main results:

The main results are shown in the graphs in Figure 4.12 and Figure 4.13 and in Table 4.09 and Table 4.10. These show a trend for increases in route width to result in increases in route choice. This stabilises at around 70-80% choosing the wider route. Increasing the ratio further does not continue to result in increasing choices of the wider corridor. This trend is apparent in both the 1st and 2nd Trial results and also in both results where the left hand side is wider (images 1-4) and the right hand side is wider (images 5-8). The influence of right hand bias can be seen at all ratios in the results (there is generally a stronger preference for choosing the wider corridor when it is on the right)

Ratio of corridor width		1.000		1.122		1.259		1.413	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
choosing wider side	no.	115	114	134	152	159	172	164	180
	%	46	46	54	61	64	69	66	72

Table 4.09 Number and percentage of participants choosing wider side at different **left** hand side width ratios: Set A (T junction)
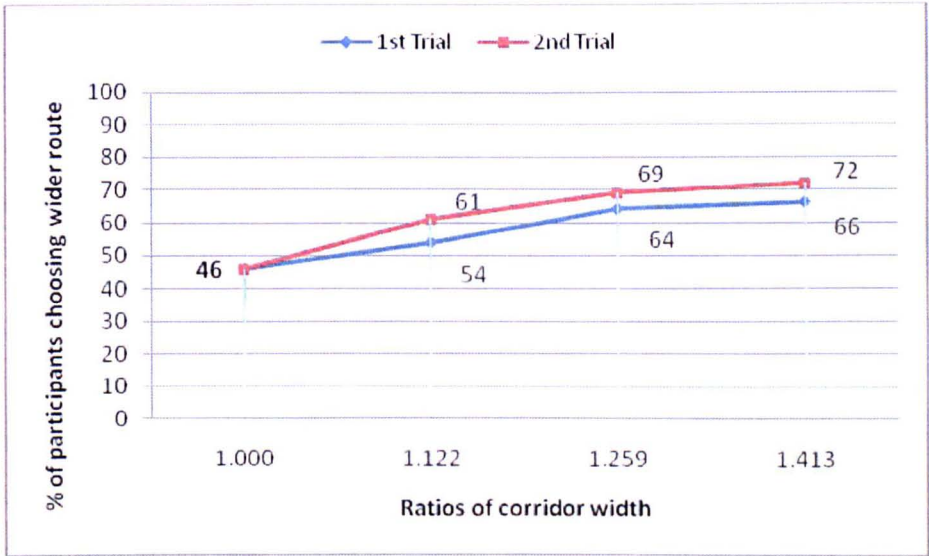
Figure 4.12 Percentage of participants choosing the wider corridor at each ratio when **left** hand side is wider: Set A (T junction)
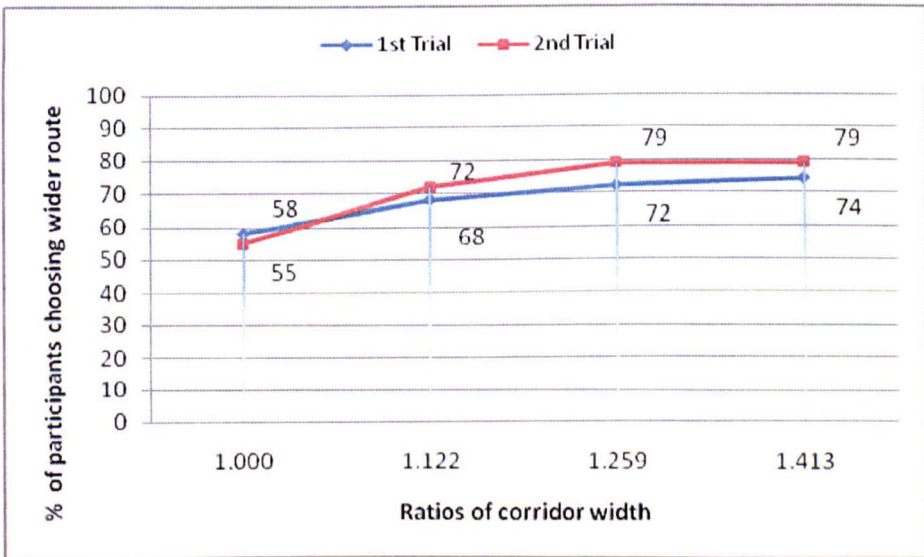
Figure 4.13 Percentage of participants choosing the wider corridor at each ratio when **right** hand side is wider: Set A (T junction)

Ratio		1.000		1.122		1.259		1.413	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
choosing wider	no.	145	138	169	180	179	198	184	197
side	%	58	55	68	72	72	79	74	79

Table 4.10 Number and percentage of participants choosing wider side at different **right** hand side width ratios: Set A (T junction)

Analysis of the results recorded of participants' choices at the T junctions across all four ratios show there is a significant difference ($p < 0.001$, Cochran Q test) when the corridor width ratio increases. This is the case for both trials and when either left or right hand is wider.

Analysis of each pair of ratios comparison for both trails of the same image is shown in tables 4.11 and 4.12. Table 4.11 shows the comparison when the left hand exit increases in width and Table 4.12 shows the comparison when the right hand exit increases in width. The McNemar test reveals that, from the results of Set A, there is a significant difference ($p < 0.05$) in pairs comparing any of the ratios to the null condition. This is the case for both trials and also whether it is the left or right hand side which is wider. As the ratio increases, there are more participants choosing to go towards the wider side. However, there is no significant difference statistically in pair comparisons when between the ratios 1.259 and 1.413. Again, this is the case for both trials and also whether it is the left or right hand side which is wider. This suggests that increasing the ratios further would not necessarily lead to a corresponding further increase in wider path choice.

Set A		1st Trial			
		1.0000	1.122L	1.259L	1.413L
2nd Trial	1.000		$p<0.05$	$p<0.001$	$p<0.001$
	1.122L	$p<0.001$		$P<0.01$	$P<0.001$
	1.259L	$p<0.001$	$p<0.05$		n.s
	1.413L	$p<0.001$	$p<0.001$	n.s	

Table 4.11 McNemar test showing each pair of ratios comparison when **left** hand side is wider

Set A		1st Trial			
		1.000	1.122R	1.259R	1.413R
2nd Trial	1.000		p<0.05	p<0.01	p<0.001
	1.122R	p<0.001		n.s	n.s
	1.259R	p<0.001	p<0.05		n.s
	1.413R	p<0.001	p<0.05	n.s	

Table 4.12 McNemar test showing each pair of ratios comparison when **right** hand side is wider

Amongst pair comparisons of the right hand side ratios (Table 4.12), there are no significant differences within ratio pairs 1.122 and 1.259, 1.122 and 1.413 and 1.259 and 1.413 during the 1st Trial and ratio pair 1.259 and 1.413 during the 2nd Trial. This suggests that there seems to be a right hand side bias; participants are more likely to choose the wider corridor if it is on the right hand side.

From the analysis of the Set A results, corridor width appears to have an influence on path choice. Therefore, the first hypothesis is supported. Participants tend to choose the wider exit at the T junction and as the ratio between the width of the reference corridor and width of the wider exit corridor increase the proportion of the participants choosing the wider corridor also increases. This is the case up to ratio 1.259, above which increasing the ratio does not continue to increase the proportion of participants choosing the wider route. Therefore, the second hypothesis is partially supported – this hypothesis suggested that increasing the ratio would continue to lead to increases in the number of participants choosing the wider path, however the results found this to be true for the smaller ratios only, and above a certain ratio (1.259) the proportion of participants choosing the wider route stabilised. These results correspond with those from the pilot study.

4.8.2 Analysis of Sets B, C and D (junctions with a side exit corridor and a straight bearing corridor)

Sets B, C and D all show a side exit corridor, on either the left or the right, and a straight bearing corridor leading from the decision point (Figure 4.10). Set B comprises decision points where the straight bearing corridor stays the same width as the reference corridor while the side exit corridor increases in width. Set C comprises decision points where the side exit corridor stays the same width as the reference corridor while the straight bearing corridor narrows. Set D is regarded as an extension to either Set B or Set C as it comprises images with more extreme ratio differences between the exit corridors achieved by both narrowing the straight bearing corridor (as Set C) while widening the side exit corridor (as Set B). Set D was conceived to investigate these more extreme ratios and does not include any null condition images. As this set involves changes to more than one variable between images, the results have not been statistically analysed in the same manner as sets A, B and C. For the purposes of comparison, the null condition results for sets B and C are used on the Set D graphs.

Null condition:

The null condition in sets B and C occurs when the straight bearing corridor and side exit corridor are both the same width as the reference corridor (2m wide). Test images showing the null conditions are shown in Figure 4.14 (side exit corridor on the left) and Figure 4.15 (side exit corridor on the right). The number and proportion (expressed as a percentage) of participants who chose to turn or maintain a straight bearing is shown in Table 4.13 (side exit corridor on the left) and Table 4.14 (side exit corridor on the right).
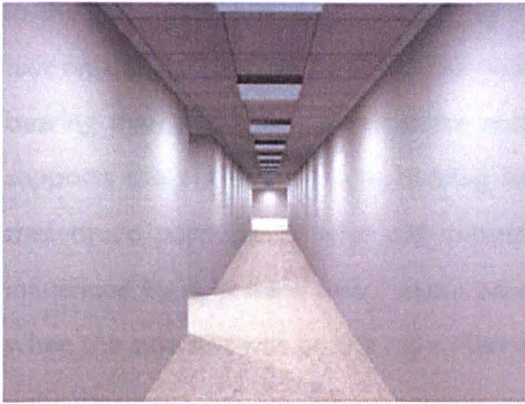
Figure 4.14 Null condition when side exit on the left (test images 9 & 24)
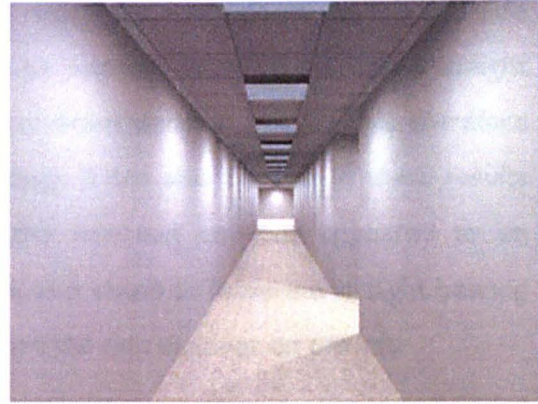
Figure 4.15 Null condition when side exit on the right (test images 15 & 28)

Participant	Test image 9		Test image 24	
	1st trial	2nd trial	1st trial	2nd trial
P1	1	1	1	1
P2	0	1	0	0
P3	0	1	0	1
P4	0	0	0	0
⋮	⋮	⋮	⋮	⋮
P250	0	0	1	0
Total: Turn (1):	89 (36%)	71 (28%)	88 (35%)	73 (29%)
Straight (0):	161 (64%)	179(72%)	162(65%)	177 (71%)

Table 4.13 Summary table showing the number and percentage of participants choosing to make a turn when presented with a null condition junction with a side exit corridor on the **left** and a straight bearing corridor. Images representing Set B and Set C null condition shown four times in total.

Participant	Image 15		Image 28	
	1st trial	2nd trial	1st trial	2nd trial
P1	1	1	1	1
P2	1	0	1	0
P3	0	1	0	1
P4	0	0	0	0
⋮	⋮	⋮	⋮	⋮
P250	1	1	0	0
Total: Turn (1):	99 (40%)	91 (36%)	99 (40%)	78 (31%)
Straight (0):	151 (60%)	159(64%)	151(60%)	172 (69%)

Table 4.14 Summary table showing the number and percentage of participants choosing to make a turn when presented with a null condition junction with a side exit corridor on the **right** and a straight bearing corridor. Images representing Set B and Set C null condition shown four times in total.

In the graph in Figure 4.16, comparing the results for side exit on the left and side exit on the right, it can be seen that more participants chose to maintain a straight bearing than chose to turn at these null condition decision points. This therefore supports the maintain straight bearing strategy. It can also be seen in these results that those participants who did choose the side exit corridor appeared to be influenced by right hand bias – more participants chose to leave the straight bearing when the side exit was on the right than when the side exit was on the left.
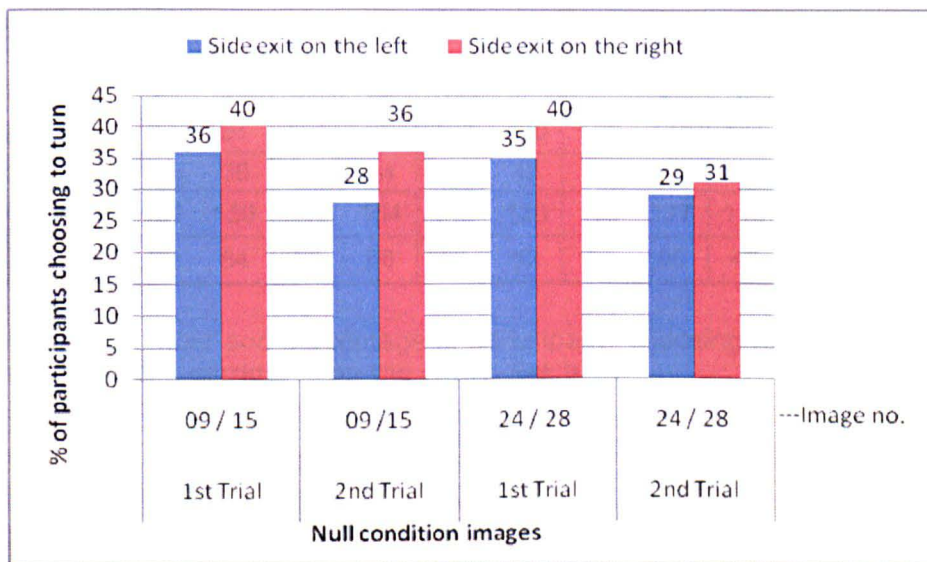
Figure 4.16 Graph showing four occasions of null condition junctions (1st Trial and 2nd Trial of both Set B and Set C) where a straight bearing corridor and side exit corridor are available. Images 09 and 24 have the side exit corridor on the left and images 15 and 28 have the side exit corridor on the right

Analysis of Set B:

In Set B the width ratio of the side exit corridor changes (widens) in relation to the straight bearing and reference corridors (both of which remain at 2m in width, ratio 1.0). Table 4.15 and Figure 4.17 show that, as the ratio between the widths of the side exit and straight bearing corridors grows (where the side exit corridor is on the left), the higher the percentage of participants choosing to make a turn. Table 4.15 and Figure 4.18 show a similar trend when the side exit corridor is on the right.

Ratio (side /straight)		1.000		1.122		1.259		1.413		1.585		1.778	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn	no	89	71	98	91	95	93	116	116	109	114	126	131
	%	36	28	39	36	38	37	46	46	44	46	50	52
Maintain straight bearing	no	101	179	152	159	155	157	134	134	141	136	124	119
	%	64	72	61	64	62	63	54	54	56	54	50	48

Table 4.15 Number and percentage of participants choosing to make a turn when the side exit corridor is on the **left**: Set B

Ratio (side /straight)		1.000		1.122		1.259		1.143		1.585		1.778	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn	no	99	91	101	86	108	120	120	113	131	130	132	149
	%	40	36	40	34	43	48	48	45	52	52	53	60
Maintain straight bearing	no	151	159	149	164	142	130	130	137	119	120	118	101
	%	60	64	60	66	57	52	52	55	48	48	47	40

Table 4.16 Number and percentage of participants choosing to make a turn when the side exit corridor is on the **right**: Set B

Figure 4.17 Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the left: Set B

Figure 4.18 Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the right: Set B

As the corridor width ratio increases, the trend towards choosing a wider corridor becomes apparent. However, overall there is still a tendency for participants to maintain a straight bearing. When the left hand turn is 1.778 times wider than straight on, only 50% (1st Trial) and 52% (2nd Trial) of participants choose to make a turn. At ratio 1.413 and below for both the left and right turn options, there is a stronger tendency to choose to maintain a straight bearing than make a turn, despite the straight bearing being a narrower corridor. Also, although the results do show a link between corridor width and path choice as the ratios increase, the trend is not as pronounced as it is with the T Junction (Set A) where there is no straight bearing option available. Between ratios 1 and 1.413 in Set A there is between a 16% and 26% increase in tendency to choose the wider corridor (see tables 4.09 and 4.10), whereas in between the same ratios in Set B the increase across the same ratios is as little as 8% and no more than 18% (see tables 4.15 and 4.16). Additionally, the results show more anomalies than those for Set A, including a 'negative' result at ratio 1.585 when the left hand side is wider (the 2nd Trial showed no increase in wider route choice over ratio 1.413 and the 1st Trial showed a decrease).

A possible reason for the variability of the results from Set B may be the apparent width of the side corridor compared to the straight bearing choice. In the T Junction (Set A) the ratio between the two corridors available to choose from is easy to compare as the exits are directly comparable (mirrored) and therefore the difference is quite easily apparent, particularly at high ratios. In Set B, it is more difficult to judge the widths of the corridor choices as the angle of view at which the side exit corridor is viewed is different to the angle at which the straight bearing corridor is viewed – the perception of side exit and straight bearing corridors of the same width may be that the side exit corridor is narrower. The set of ratios was extended over those in Set A as this problem was anticipated during the creation of the rendered images. Results from these further ratios generally support the trend established by the smaller ratios. The graphs in figures 4.17 and 4.18 show a continuation of the same trend over the two larger ratios and no sudden change in favour of making a turn over maintaining a straight bearing.

Even at the null condition, there was still a relatively large proportion of participants who chose turn, despite the corridor they were turning into being the same width as the straight bearing corridor (between 28% and 40% across results for both trials and side exit corridors on the left and right side). This conflicts with the Maintain Straight Bearing strategy without there being any corridor width influence. In order to understand the reason for this it would be necessary to compare the null condition results with those from other studies of the straight bearing strategy. If, within other studies, it is found that the straight bearing strategy is used by in excess of 65% of participants (the average of those using the straight bearing strategy at null condition in Set B of this study), this would suggest that in some instances participants in this study are making a turn as they feel that is what the experiment requires them to do. This may therefore make an adjustment to the results for Set B advisable, however this would only reinforce the finding from Set B that the straight bearing strategy appears to have a greater bearing on wayfinding than corridor width.

Cochran Q test was carried out to compare all six ratios tested in Set B. Analysis of the results of the participants' choices within Set B shows that there is a significant difference ($p<0.001$, Cochran Q test) when the corridor width ratio increases. This is the case for both trials and when the side exit corridor is on either the left or right hand side. McNemar test was then carried out to compare each pair of ratios within Set B. Analysis of the ratio pair comparisons of each image for both trails is shown in Table 4.17 and Table 4.18. Comparing with the null condition (where both straight bearing and side exit corridors are 2m), there are significant differences at ratio 1.413 for both trials and when the side exit corridor is on either the left or right hand side. When the side exit corridor is on the left, $p=0.005$ and $p<0.001$ (1st trial and 2nd trial respectively) whilst when the side exit corridor is on the right, $p<0.05$ for both trails. Statistically, when there is a straight bearing corridor available and this corridor maintains the same width as the reference corridor, the side exit corridor needs to be 1.413 times wider than the straight bearing corridor to make people take a turn.

Set B		1st Trial					
		Null (1.000)	1.122L	1.259L	1.413L	1.585L	1.778L
2nd Trial	Null		n.s.	n.s.	p=0.005	p<0.05	p<0.001
	1.122L	p<0.05		n.s.	p<0.05	n.s.	p<0.01
	1.259L	p<0.05	n.s		p<0.01	n.s.	p<0.001
	1.413L	p<0.001	p<0.01	p<0.01		n.s.	n.s
	1.585L	p<0.001	p<0.05	p<0.01	n.s.		n.s
	1.778L	p<0.001	p<0.001	p<0.001	n.s.	p<0.05	

Table 4.17 McNemar test of ratio pairs within Set B where the side exit corridor is on the **left**, showing pair comparisons as the ratio increases

From the analysis of the Set B results, corridor width appears to have a degree of influence on path choice. Therefore, the first hypothesis is supported. There is a roughly linear increase in proportion of participants choosing the wider corridor across the ratios, therefore the second hypothesis is supported. There is a proviso in the support of both hypotheses, however, as the Maintain a Straight Bearing strategy appears to have a stronger influence over path choice than the widths of the corridors at almost all ratios.

Set B	1st Trial					
	Null (1.000)	1.122R	1.259R	1.413R	1.585R	1.778R
2nd Trial — Null		n.s.	n.s	p<0.05	p<0.001	P=0.001
2nd Trial — 1.122R	n.s.		n.s.	p<0.05	P=0.001	p<0.01
2nd Trial — 1.259R	P=0.001	p<0.001		n.s.	p<0.05	P=0.01
2nd Trial — 1.413R	p<0.05	p<0.01	n.s.		n.s.	n.s.
2nd Trial — 1.585R	p<0.001	p<0.001	n.s.	p<0.05		n.s.
2nd Trial — 1.778R	p<0.001	p<0.001	P=0.001	p<0.001	p<0.05	

Table 4.18 McNemar test of ratio pairs within Set B where the side exit corridor is on the **right**, showing pair comparisons as the ratio increases

Analysis of Set C:

In Set C the width ratio of the straight bearing corridor changes (narrows) in relation to the side exit and reference corridors (both of which remain at 2m in width, ratio 1.0). Table 4.19 and Figure 4.19 show that, as the ratio between the widths of the straight bearing and side exit corridors decrease in width (where the side exit corridor is on the left), the higher the percentage of participants choosing to make a turn. Table 4.20 and Figure 4.20 show a similar trend when the side exit corridor is on the right.

Ratio of corridor width	Left	1.000		1.000		1.000		1.000	
	Straight	0.708		0.794		0.891		1.000	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn	no.	159	161	144	146	110	118	88	73
	%	64	64	58	58	44	47	35	29
Maintain straight bearing	no.	91	89	106	104	140	132	162	177
	%	36	36	42	42	56	53	65	71

Table 4.19 Number and percentage of participants choosing to make a turn when the side exit corridor is on the **left**: Set C

These results show some of the clearest links between corridor width and path choice. Despite the plan layout (shape) of the corridor being roughly the same as that in Set B, there is as much as a 40% increase in path choice towards the wider

route across the ratios. 31% of participants chose to turn off the straight bearing at null condition in the 2nd Trial of the right-hand choice – comparable to the identical null conditions in Set B – and 71% or participants chose the wider corridor at the most extreme width ratio presented in Set C (see Table 4.19).

Figure 4.19 Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the **left** : Set C

Ratio of corridor width	Right	1.000		1.000		1.000		1.000	
	Straight	0.708		0.794		0.891		1.000	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn	no.	171	177	143	155	120	122	99	78
	%	68	71	57	62	48	49	40	31
Maintain straight bearing	no.	79	73	107	95	130	128	151	172
	%	32	29	43	38	52	51	60	69

Table 4.20 Number and percentage of participants choosing to make a turn when the side exit corridor is on the **right**: Set C

It is possible that the plan layouts in Set C are being 'read' differently by the participants to the plan layouts in Set B. The ratio changes are relatively easy to see in Set C – the straight bearing corridor is noticeably narrower than the reference corridor. This may be enough to drive people towards making a turn, in all instances into a corridor that is wider. The ambiguity of the results from Set B may be

overcome simply due to the ratios being 'reversed' (the straight bearing corridor becoming narrower rather than the side exit corridor becoming wider). However, it is also possible that the participants read the narrower (in relation to reference) straight bearing corridor as a deviation from the route they are taking, and that they are reading the space as one single-width corridor that turns a corner, with another 'minor' corridor branching off it (albeit this branch corridor continuing in the same direction as the reference corridor). This would seem to suggest that the straight bearing strategy is overcome when maintaining a straight bearing appears to take the participant off their chosen route, even if that route turns a corner.
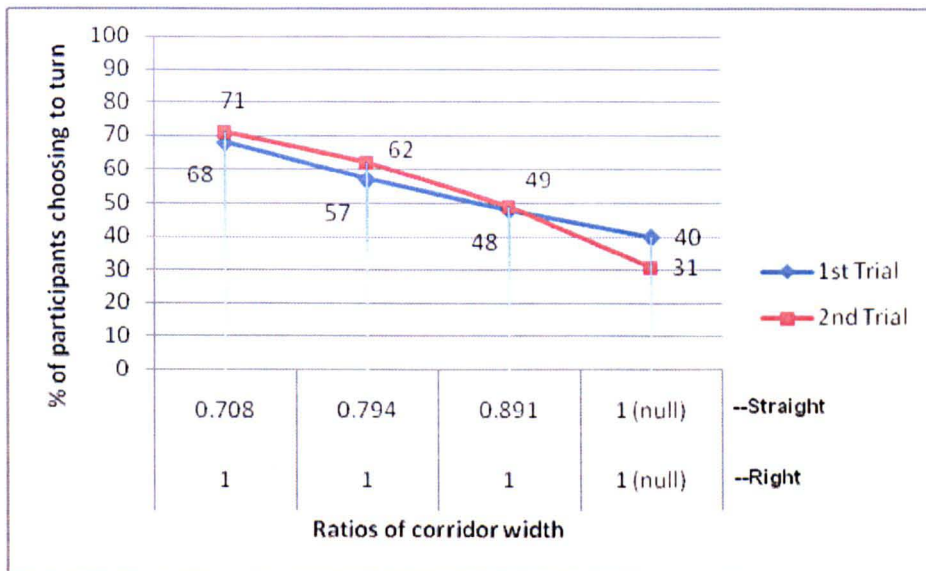
Figure 4.20 Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the **right**: Set C

The results from Set C may also have the same bias as those from Set B, with some participants making a turn as they feel that is what the experiment requires them to do. As with Set B there are around 35% of participants choosing to make a turn even at the null condition, going against the straight bearing strategy even though there is no difference in corridor width to influence their decision. As with Set B this would require further investigation in order to establish, however even if the results were adjusted to take such bias into account and the percentages of participants choosing to turn lowered, the strong correlation between corridor width and path

choice apparent in the results would still be present.

Cochran Q test was carried out to compare all four ratios tested in Set C. Analysis of the results of participants' choices within Set C shows that there is a significant difference ($p < 0.001$) when the corridor width ratio increases. This is the case for both trials and when the side exit corridor is on either the left or right hand side. McNemar test was then carried out to compare every pair of ratios within Set C. Analysis of the ratio pair comparisons of each image for both trails is shown in Table 4.21 and Table 4.22.

Analysis of Set C			1st Trial			
		S	0.708	0.794	0.891	1.000
		L	1.000	1.000	1.000	1.000
	S	L				
2nd Trial	0.708	1.000		n.s.	p<0.001	p<0.001
	0.794	1.000	p<0.05		p<0.001	p<0.001
	0.891	1.000	p<0.001	P=0.001		p<0.05
	1.000	1.000	p<0.001	p<0.001	p<0.001	

Table 4.21 McNemar test of ratio pairs within Set C where the side exit corridor is on the **left**, showing pair comparisons as the ratio increases

Analysis of Set C			1st Trial			
		S	0.708	0.794	0.891	1.000
		R	1.000	1.000	1.000	1.000
	S	R				
2nd Trial	0.708	1.000		p<0.01	p<0.001	p<0.001
	0.794	1.000	p<0.01		p<0.05	p<0.001
	0.891	1.000	p<0.001	p<0.001		p<0.05
	1.000	1.000	p<0.001	p<0.001	p<0.001	

Table 4.22 McNemar test of ratio pairs within Set C where the side exit corridor is on the **right**, showing pair comparisons as the ratio increases

From the analysis of the Set C results, corridor width appears to have an influence on path choice. Therefore, the first hypothesis is supported. There is a roughly linear increase in proportion of participants choosing the wider corridor across the ratios,

therefore the second hypothesis is supported. Unlike Set B, the corridor widths in Set B appear to have a stronger influence over path choice than the Maintain a Straight Bearing strategy, therefore the hypotheses are supported with no provisos.

Analysis of Set D:

Set D comprises images with more extreme ratios between the widths of the corridors, achieved by increasing the side exit corridor width at the same time as reducing the straight bearing corridor width (the reference corridor width always remains at 2m). As mentioned above, this set was conceived as an extension to either Set B or Set C (see section 4.7.1) and therefore does not have any null condition images. The null condition results in the description, tables and graphs below are those from sets B and C.

The number and percentage of participants' route choices are shown in Table 4.23 and Figure 4.21 (side exit corridor on the left) and Table 4.24 and Figure 4.22 (side exit corridor on the right). There is an apparent trend that the wider the side corridor, the more participants choose to make a turn. These results continue the trend apparent in Set C more closely than the trend apparent in Set B – the increase in ratio has a more marked influence on path choice than is evident from the Set B results. It is therefore possibly the decrease in straight bearing corridor width (which can easily be compared with the reference corridor width) rather than the increase in side exit corridor width which is influencing the Set D results.

As with sets B and C, when the side exit corridor is on the right, there is a slightly higher percentage of participants choosing to turn than when the side exit corridor is on the left. When the side exit corridor ratio is 1.122 and the straight bearing corridor ratio is 0.891, 56% of participants chose to turn when the side exit corridor is on the right as opposed to 52% when the side exit corridor is on the left. When the side exit corridor ratio is 1.259 and the straight bearing corridor ratio is 0.794, the percentages are 69% for right and 65% for left.

Results of Set D		Null condition in Set B		Null condition in Set C		Set D			
Ratio	Left	1.000		1.000		1.122		1.259	
	Straight	1.000		1.000		0.891		0.794	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn left	no.	89	71	88	73	119	130	155	162
	%	36	28	35	29	48	52	62	65
Maintain straight bearing	no.	161	179	162	177	131	120	95	88
	%	64	72	65	71	52	48	38	35

Table 4.23 Number and percentage of participants choosing to make a turn when the side exit corridor is on the **left**: Set D

Results of Set D		Null condition in Set B		Null condition in Set C		Set D			
Ratio	Right	1.000		1.000		1.122		1.259	
	Straight	1.000		1.000		0.891		0.794	
Trial		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Choosing to turn right	no.	99	91	99	78	121	139	156	172
	%	40	36	40	31	48	56	62	69
Maintain straight bearing	no.	151	159	151	172	129	111	94	78
	%	60	64	60	69	52	44	38	31

Table 4.24 Number and percentage of participants choosing to make a turn when side exit corridor is on the **right**: Set D
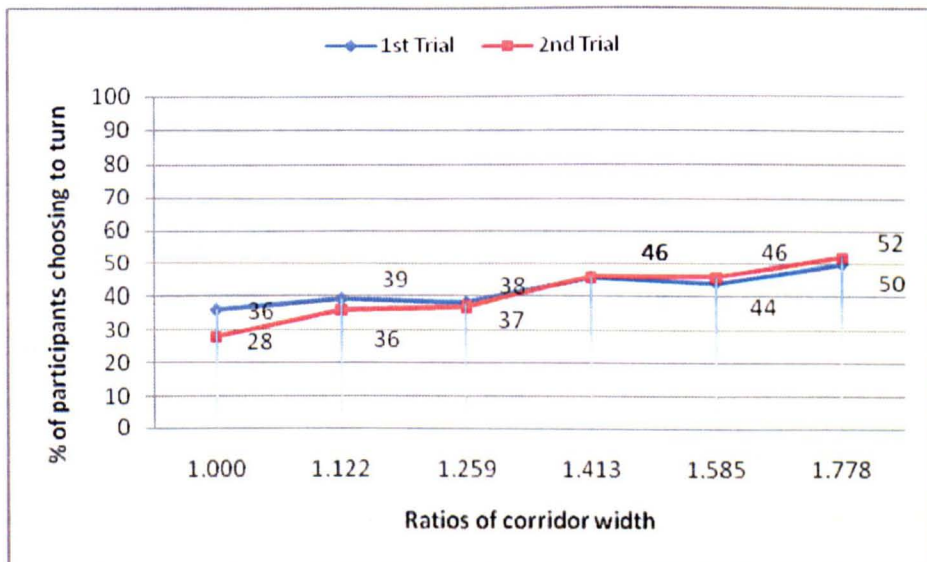

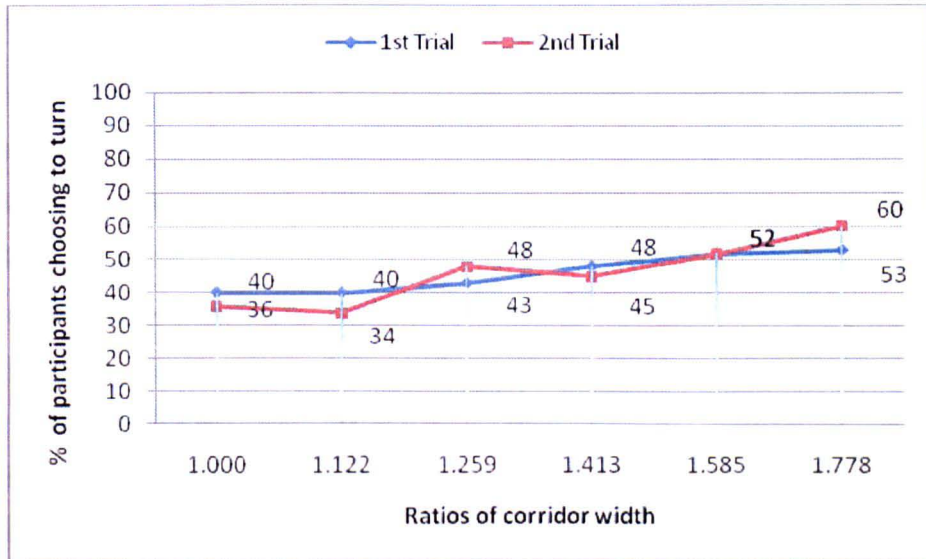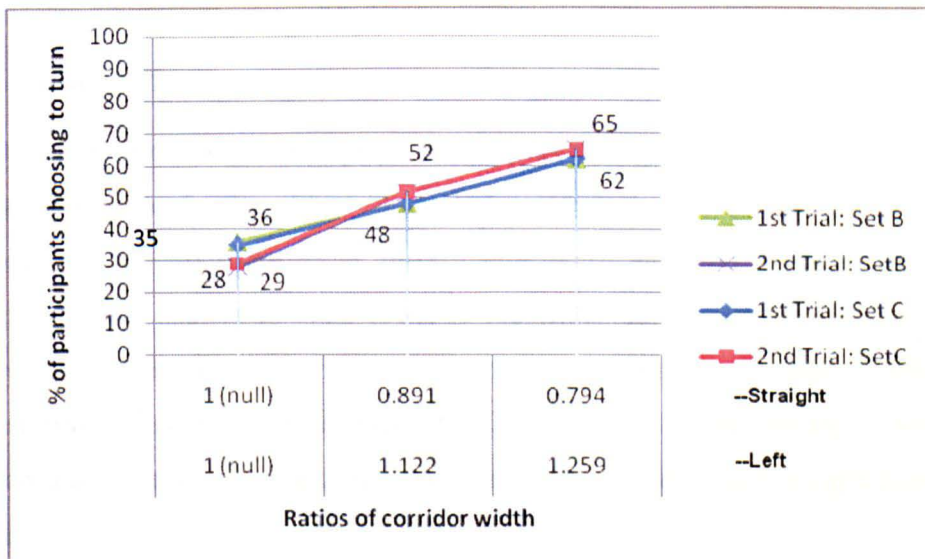**Figure 4.21** Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the **left** : Set D

Figure 4.22 Percentage of participants choosing to make a turn at each ratio when side exit corridor is on the **right** : Set D

The results from Set D support both hypotheses. Corridor width appears to have an influence on path choice (Hypothesis 1) and there is a roughly linear increase in proportion of participants choosing the wider corridor across the ratios (Hypothesis 2).

4.9   Conclusion

Results of the corridor width experiment support the hypothesis that corridor width has an effect on unfamiliar users' route choice. When there is a left and right choice available at T junctions (Set A), as the corridor width increases, a higher number of participants will choose to walk towards the wider corridor. It is also found that when one side is 1.259 times wider than the other side, participants are relatively consistently choosing the wider side. When the left hand side and right hand side corridors are the same width, there is a tendency of choosing the right hand side corridor.

In situations where there is a straight bearing corridor of the same width as the

reference corridor (Set B), and a side exit corridor, increasing the width of the side exit corridor results in an increase in the proportion of participants choosing to take the side exit corridor (when compared with the null condition). However, statistically the side exit corridor needs to be 1.413 times wider than the straight bearing corridor to influence a decision to turn. The Maintain a Straight Bearing strategy therefore appears to have a stronger influence on path choice in this circumstance than the corridor width.

In situations where there is a side exit corridor of the same width as the reference corridor (Set C), and a straight bearing corridor, decreasing the width of the straight bearing corridor results in an increase in the proportion of participants choosing to take the side exit corridor (when compared with the null condition). This is the case at ratio 0.794 and beyond (equivalent to ratio 1.259 in Set B). In this set, the influence of corridor width appears to be stronger than the influence of the Maintain a Straight Bearing strategy.

In all four test sets, the influence of right hand bias is evident (a higher preference to choose the wider path when it is on the right than when it is on the left). This was also apparent in previous studies (Taylor & Socov, 1974; Kang, 2004) and the pilot study of corridor width test.

4.10 Discussion

The findings from this experiment broadly support the hypotheses that corridor width has an influence on the path choices made by people who are in an environment that they are unfamiliar with (unfamiliar users) and that greater ratios between corridor widths have a greater influence on path choice than lesser ratios. The experiment also highlighted that the way in which the ratios are applied to the corridors has an influence on path choice. It was shown that the Maintain a Straight Bearing strategy has a stronger influence, compared to corridor width, on path choices when the straight bearing corridor is the same width as the reference

corridor, however narrowing the straight bearing corridor in relation to the reference corridor encouraged participants to make a turn.

Comments left by participants (see Appendix B) at the end of the experiment largely supported these findings. Several of the comments specifically mentioned corridor width, in particular relating wider spaces to the presence of other people. Some reassurance may potentially be being sought from the presence of other people. Other comments were given about feelings of being lost, which indicate that, even within this wayfinding test, the psychological effects of disorientation are still experienced.

Many of the comments mentioned a preference for maintaining the straight bearing unless instructed otherwise, with one comment relating directly to the Initial Segment Strategy behaviour (undertaking the longest leg available at the start of the wayfinding task). Conditions leading to a change in direction when not forced by the junction shape included the offset wall presented by narrowing straight bearing corridors. There were also several comments about maintaining a straight bearing unless instructed otherwise by signage and only making unforced turns to explore potential routes. Generally, the preference to maintain a straight bearing was given as being due to wishing to avoid complicating the route taken should it be found to be necessary to turn around and re-trace steps.

The latter two findings mentioned above from the results are potentially useful to consider when designing circulation spaces in buildings. The findings from Set B suggest that once an unfamiliar user is walking along a corridor, even if they reach a junction with a wider corridor they are unlikely to take this wider corridor. It may therefore be necessary for designers to deliberately narrow a stretch of a straight bearing corridor (as in Set C) at junctions where the aim is to make users turn into the wider corridor. Conversely, if the design aim is to keep people to the straight bearing corridor, this can be achieved even if wider corridors lead from this straight bearing corridor.

The findings from sets C and D suggest that unfamiliar users wish to continue along the same perceived path (i.e., a corridor of constant width), even if this deviates from the straight bearing. In many buildings, particularly refurbishment projects, the circulation space layout is constrained by the size and form of the building and the other spaces within it, and therefore it may not always be possible for a corridor to maintain a straight bearing. Corridors can therefore be designed to have a constant width, if it is the design intention that they are for unfamiliar users to follow even if they change direction, with smaller width corridors (including those that continue in the same direction as the reference corridor at a decision point) where the design intention is that these smaller corridors are not for use by unfamiliar users.

Although the changes made to the experiment between the pilot study and the main test reduced some of the experiment's limitations, there are still others evident which may be considered and avoided in future research. The straight bearing corridors in sets B, C and D all appear to terminate in a dead-end (mentioned by one participant as a reason for making turns). This is a limitation of using a computer model of limited extent. Zacharias (2002) findings showed that corridors leading to apparent dead-ends were avoided. However, in his study, the circulation spaces were broader and therefore the dead end was more evident. The wall forming the dead end was also very plain in appearance compared to the visually busy shop fronts in the shopping mall setting in the Zacharias study whereas the wall forming the dead end in the corridor width experiment is of the same décor as all the other walls. The only variation in the appearance of the walls in the corridor width study was due to the light cast on them, which applied to all the walls including the dead end wall.

Because of the effects of perspective and the general widths of the corridors, the dead end wall in the corridor width experiment occupies a smaller proportion of each image than the dead end wall in Zacharias' study. The influence of the dead end wall could be limited further by moving it further away from the reference point (the

point at which the participant is 'standing' in each image), making it appear smaller still in each image. Alternatively, the dead end wall could be replaced with a set of doors or other architectural feature, however this risks introducing an additional variable into the experiment. If the dead end wall did have an influence on path choice, then it would positively influence the trend to maintain a straight bearing in Set B and negatively influence the trend to keep to corridors of continuous width in Set C.

As a further point, in the model, the straight bearing corridor does not simply terminate with a dead end wall across the corridor, but terminates in a wider space, the far wall of which is the dead end wall mentioned above. This widening is not readily apparent in the images due to the distance it is from the reference point, however it was done to give the impression that the straight bearing corridor does lead somewhere and not simply to a dead end.

The lighting may also have had an influence on path choice. The cumulative effect of the lights at the junctions, and the end of the straight bearing, makes these spaces appear brighter than the corridors (the wider space at the end of the straight bearing has a number of luminaires corresponding to its size based upon the density of luminaires present in the corridors). This may positively influence the trends to maintain a straight bearing (the wider space at the end of the straight bearing corridor is the brightest space in any of the images). Some of the comments left by participants suggested that these light variations had an influence on their path choices, although one of these comments was to suggest that light be considered in future research hence it is not clear whether for this participant the lighting had an influence on path choices in the current experiment or not.

The lighting may also influence decisions to take the wider route. Although all side corridors have the same number of luminaires, the spill of light from them is limited by the corridor width. As the corridor width increases, the area of light from them perceived by the participant also increases. Therefore, there is the possibility that

the choice of wider route was in fact a choice of brighter lit route. This may have reinforced the decision to take the wider corridor as it is known already that people favour brighter lit exits from junctions. There is even the possibility that the choice of wider route was in fact simply a choice of brighter lit route. In order to establish that this is a possibility, it would be necessary to measure the varying illuminance, or the varying size of the area of the screen which is brighter as a result of the changing corridor width, and check whether it is of the order of magnitude that Taylor & Socov (1974) and Kang (2004) found was required to influence wayfinding decisions.

The influence this light level variation has on path choice may also be dependent on where the participant is looking. For example, the light cast on the floor at a Set A junction increases on the side of the wider exit corridor, but as the luminaires in this part of the corridor are central to those in the narrower corridor, the light cast on the wall which the participant can see always remains the same (images 21 and 32 in Figure 4.11 demonstrate the effect of luminaires being centred on the narrow portion of a corridor which changes width). In the cases of sets B and C, as the side exit corridor increases in width, again the light cast on the floor increases but the luminaires stay central to the corridor and hence gradually move further away from the wall, making it appear progressively dimmer as the corridor width increases. Additionally, as demonstrated in images 21 and 32, the narrow corridor, with its walls close to the luminaires, has more brightly illuminated walls than the side corridor. In these instances it is possible that the Walk Towards a Brighter Space strategy was working against the Corridor Width strategy during the experiment.

Several things could possibly be done to reduce the influence of light levels on the results. The simplest would be to set the rendering software to render softer-edged shadows, making the difference in light level less abrupt. The luminaires could be removed entirely and the 'ambient light level' in the software increased – this however would risk making the scene appear unrealistic. An alternative choice of luminaires could be made that are wall mounted and cast light only on the walls, do not cast a different amount of light on the walls at different corridor widths and do

not cast light on the floors. If analysis were to be undertaken of the increase in illuminance due to corridor width changes, this could then be used to compensate in the rendered images by decreasing the brightness of the luminaires in the wider corridors.

It should be noted that, given the aim of trying to realistically replicate a corridor environment, the issue of light levels may not be confined to the virtual environment used in this experiment. The cumulative effect of light levels and increase of brighter area when corridor width increases could also occur in real environments. It may therefore be considered inappropriate to try to factor this issue out of further experiments although it would still be beneficial to determine to what extent the light is influencing wayfinding decisions.

Further studies could potentially alleviate some of the limitations due to the virtual environment (discussed in section 4.3.1) by conducting the experiment in a real environment akin to that used by Taylor and Socov (1974) albeit involving moveable panels. In order that a sample set of the scale of that studied in the online corridor width experiment be achieved, 250x32 participants would be required. Together with the cost of constructing the test environment this would make such an experiment a major undertaking. However, just undertaking Set A with a smaller number of participants may be an achievable way of confirming that the online experiment findings were applicable to real environments. The applied test in Chapter 5, although not of the same nature as the corridor width experiment, did investigate the applicability of the corridor width experiment findings in a real environment.

The corridor width compares the influence of the maintain a straight bearing strategy and corridor width. There is therefore potential within similar experiments to compare the influence of any two strategies and potentially arrive at a hierarchy of influence – it could therefore be predicted which strategy would have the greatest influence at decision points. There are potentially a very large number of

combinations due to the influences of each strategy having an effect beyond simply the variables being studied. The variables for corridor width and maintaining or deviating from the straight bearing were basically the same in both sets B and C in the corridor width experiment, however the arrangement and application of these variables had a marked influence on the outcome of the experiment. Additionally, there are also further junction shapes (plan layouts) which could be investigated. + shaped corridors, for instance, could be studied – although not studied in this experiment for the reasons given in section 4.7.1, this shape may still have an influence on path choice that the shapes investigated in the experiment do not. Participants suggested further tests including lighting and stairs as ideas for future research. A variant of the experiment, investigating the Walk Towards a Brighter Space strategy, would be relatively easy to undertake and could help identify the degree to which the illuminance variations influenced path choice in the Corridor Width experiment. This would require the same corridor design, width ratios and junction layouts be used as were used in the Corridor Width experiment.

All these further studies could potentially be undertaken in a more sophisticated virtual environment, which would limit the barrier to response placed upon participants by the mouse and website interface. Although there was an interest amongst participants to be able to explore the available routes, it is likely that future experiments would still have to comprise independent junctions rather than a continuous explorable environment as path choices may be made based upon accumulated knowledge of the environment rather than the information in the immediate environment.

4.11 Summary

This chapter documented an experiment into the influence of corridor width on path choice. Put in the context of reassurance given to unfamiliar users when wayfinding (one of the Principles from Chapter 2), Set A (T junction) reassures users that they are taking the correct path by providing them with a wider corridor option, Set B

(junction with straight bearing corridor of the same width as the reference corridor and side exit corridor of varying width) reassures users that they are taking the correct path by providing them with a corridor option that allows them to maintain a straight bearing and Set C (junction with straight bearing corridor of varying width and side exit corridor of the same width as the reference corridor) reassures users that they are taking the correct path by providing them with a corridor of constant width even if that corridor changes direction. Set D was found to have a similar reassurance to Set C.

The findings from this chapter support those in the literature review (Chapter 2), where the influence of corridor width on path choice was found to have been identified in previous research but not investigated thoroughly, and the findings from the observational study (Chapter 3), which demonstrated path choice trends which appeared to follow a strategy to take the wider corridor at decision points. The applied test in Chapter 5 investigates whether these findings, and the other wayfinding strategies, could be used to predict wayfinding difficulty in an existing building.

4.12 References

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5

Applied Study

Experiment in St. George's Complex

5.1 Chapter overview

This chapter describes an experiment carried out in the St. George's Complex at the University of Sheffield. This was undertaken as a means of identifying whether the four wayfinding strategies established through the literature review, the Students' Union observation and the Corridor Width experiment could predict wayfinding behaviour amongst people within an unfamiliar environment.

Both this chapter and Chapter 6 differ from the earlier chapters in investigating how an understanding of wayfinding behaviours and hence strategies may be used to inform building designs that are easy to wayfind within. By comparison, Chapters 2, 3 and 4 were concerned with establishing the relevance and apparent use of the wayfinding strategies through the research of known strategies and their identification and confirmation amongst observed and tested behaviour.

Where not otherwise noted, all drawings in this chapter are adapted from plan drawing by the Estates Department, University of Sheffield.

5.1.1 Hypotheses

The test is to confirm whether unfamiliar users would agree with the ratings given to the five routes.

H_1 : Routes which benefit from positive aspects of the four wayfinding strategies will be judged less difficult than routes which do not benefit from the strategies

H_0 : There is no relationship between route difficulty and the presence of the four wayfinding strategies

5.2   Overview of the test and choice of location

The observation in the Students' Union gave an indication of the degree to which wayfinding strategies are relied upon by people finding their way around an unfamiliar building. In doing so, the observation also supported the need for further study of the corridor width strategy. However, the Union study was comparatively limited in its scope. It was conceived as an observation of movements and hence did not have a targeted objective and methodology to precisely pinpoint the effects (particularly in relation to each other) of the individual wayfinding strategies. It also did not determine whether similar behaviour to that observed could be predicted by analysis of a route against the wayfinding strategies. It did, however, serve in effect as a useful pilot for the St. George's study as both were investigating wayfinding performance in existing buildings.

The experiment documented in this chapter was carried out in the University of Sheffield's St. George's Complex (Figures 5.01 and 5.02) rather than the Students'

Union building for a number of reasons. While there would possibly be some value to undertaking the experiment within the Students' Union building (in order to make a comparison of results with the earlier observational study), undertaking the experiment in the St George's Complex meant it was possible to see if the observational findings from the Union study were applicable to buildings other than just the Students' Union building.

A further factor in the choice of the St. George's Complex was its size and complexity - it was possible to undertake an experiment using five different routes
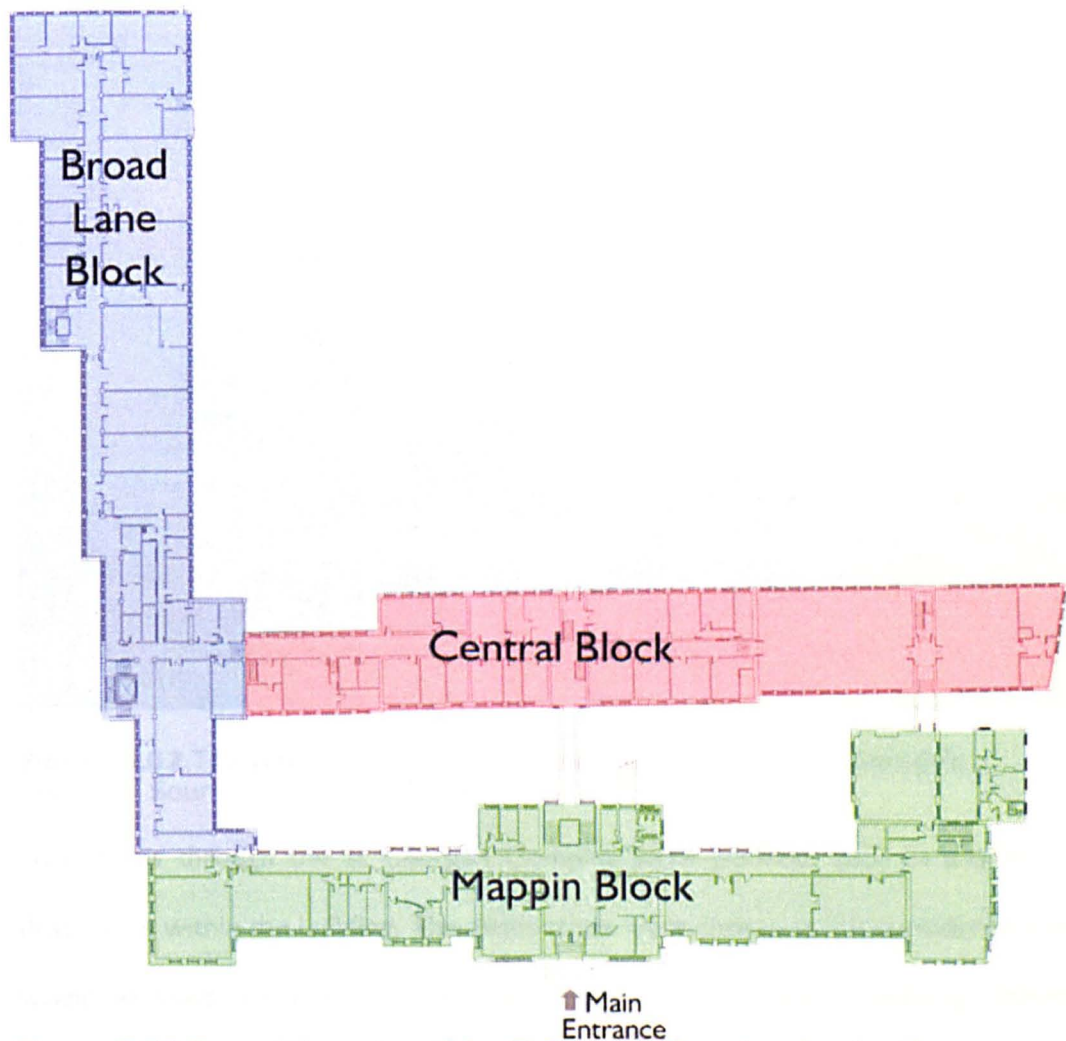
Figure 5.01 Ground floor plan of the St George's Complex showing the location of each block.

through the building that overlapped only minimally. Several buildings around Sheffield were investigated as potential locations for this experiment. The St. George's Complex was chosen as, although it is an academic building, its use, size and architectural detail are significantly different to the Students' Union building. However, in common with the Students' Union building, the St George's Complex has 'grown' over time, with various blocks, extensions and link routes added to the original building. From outside, this variability is not perceived – the Mappin frontage to the building that visitors generally enter through reads as a complete building - however the interior architecture changes perceptibly from block to block.

Figure 5.02 The view inside the Main Entrance Lobby of the St George's Complex. Source: author's photograph

Five routes through the St George's Complex were planned, each to a different destination within the building. The destinations were chosen as it is considered they would be typical destinations for a visitor who is unfamiliar with the building. Visitors to the departments may look for the departmental enquiries office - Routes A, D and

E are based upon this scenario – whereas route B (a non-departmental computer room) leads to a destination likely to be sought by someone from a different faculty in the University and route C (a lecture theatre) leads to a destination which may be visited by those attending open lectures. Each route was given a category rating (Coolican, 1999) on a scale of 1 to 4 (1 being very easy to 4 very difficult). This was based upon analysis of each decision point along the most direct route and whether the decision necessary to reach the destination conformed or conflicted with the wayfinding strategies. Conformance with the wayfinding strategies would lead to a predictable experience of the environment, which should reassure visitors that they are taking the correct route to their destination. The aim of the experiment was to see if people unfamiliar with the building found wayfinding to the five destinations as easy or difficult as predicted and see if, following the experiment, the participants agreed with the rating given to each route.

5.3   Test routes

Five routes through the St. George's Complex were selected to test the four strategies for wayfinding. The difficulty of each route was rated on a four-point scale (1 being very easy to 4 very difficult). The aim of this test was to identify whether unfamiliar users agreed with these ratings. A plan of Level D is shown in Figure 5.03, with the start points of the two practice routes and the five test routes marked. Figure 5.03 also shows the Level D extent of each route. Some routes are conducted entirely on Level D, others partly on Level D and partly on other floors within the building. Figure 5.04 shows the relationship of the floors in addition to the start and finish points of each route.

Key:

▬▬	Route A
▬▬	Route B
▬▬	Route C
▬▬	Route D
▬▬	Route E
▬▬	Practice Route 1
▬ ▬	Practice Route 2
●	Start Point
■	Finish Point
▲	Mid-Point at Change of Level
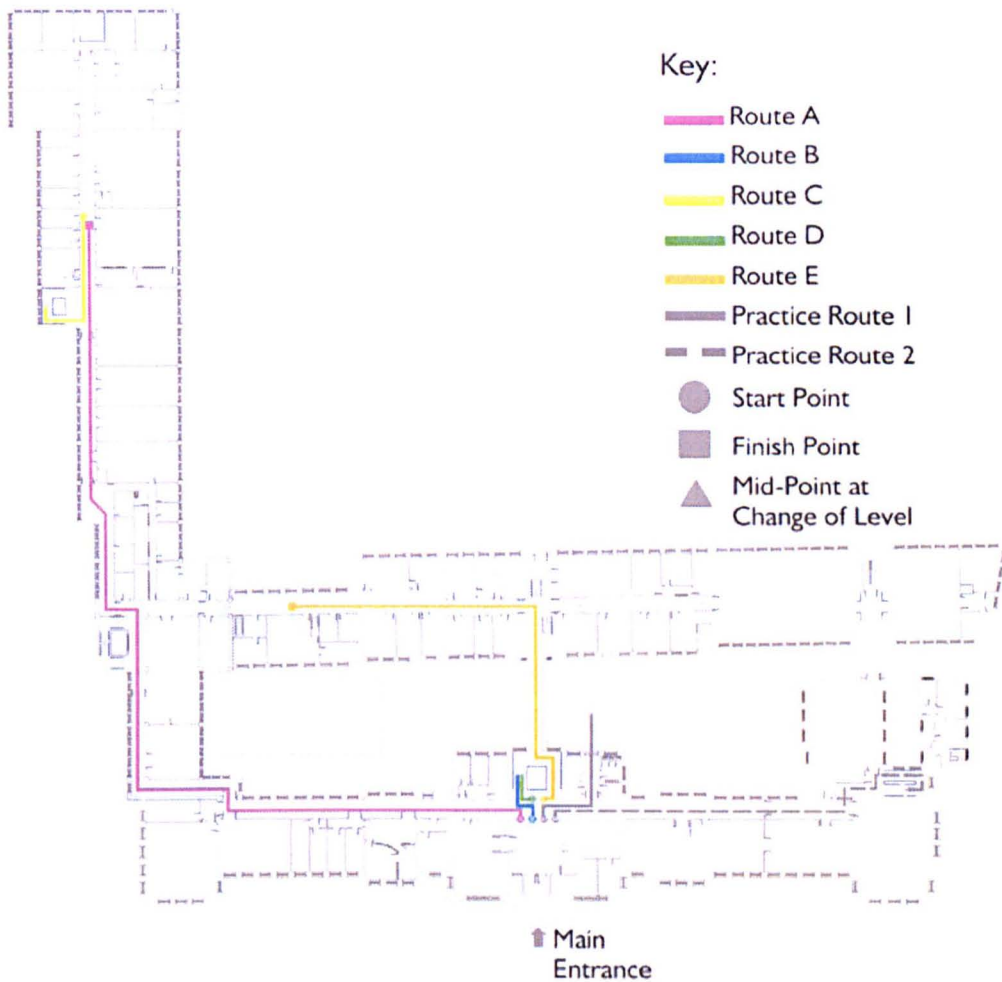
⬆ Main
Entrance

Figure 5.03 Main entrance level (Level D) of St George's Complex with start points of all the test routes and practice routes

The predicted difficulty of each route was initially rated by the experimenter giving consideration to the four wayfinding strategies explored in previous chapters (Table 5.01). Participants initially followed two practice routes, conducted in a separate part of the building to the five test routes. These were chosen as examples of easy and difficult routes, and this was conveyed to the participants to anchor their responses. Following each individual test route, its difficulty was rated using a category rating scale (1=very easy, 2=moderately easy, 3=moderately difficult and 4=very difficult). Four categories were chosen to avoid the potential contraction bias that is

Level F

B'

P2'

Level E

C'

P1'

D'

Level D

A' & C

E'   Main Entrance

A, B, D & E
P1 & P2
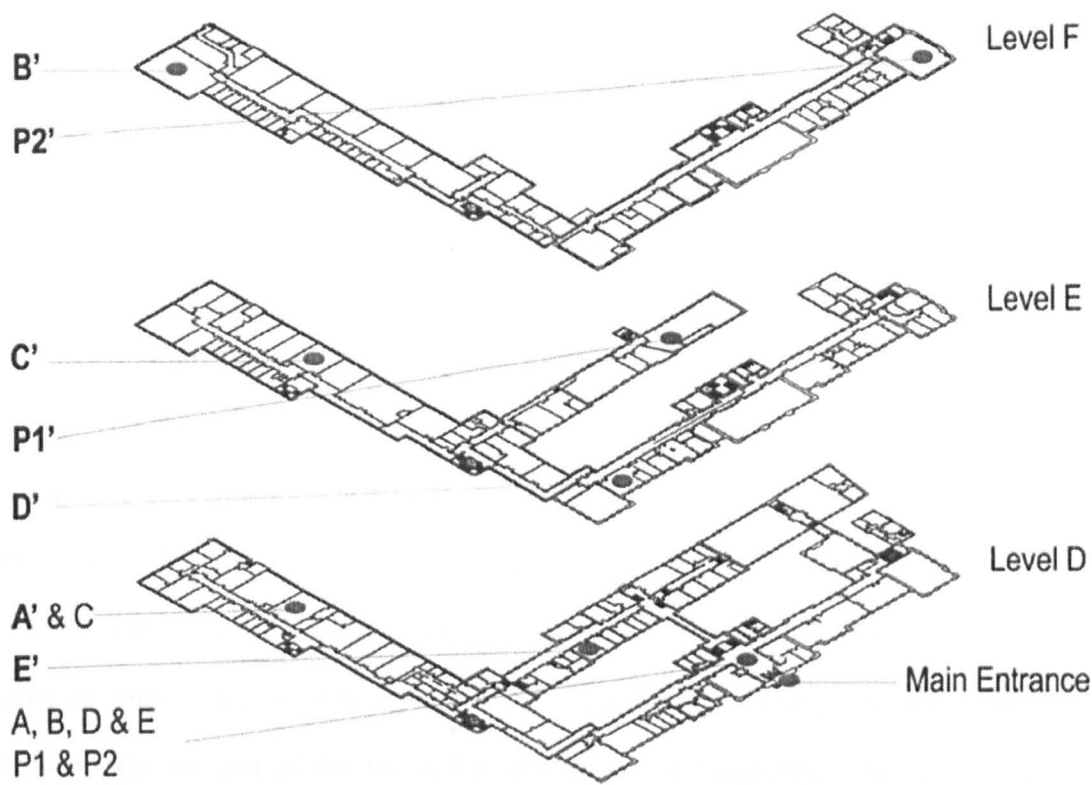
Figure 5.04 Plans of the St. George's Complex including start and finish points of all five test routes (e.g. A-A') and the two practice routes (P1-P1' and P2-P2').

Strategy	Route A	Route B	Route C	Route D	Route E
Maintain a Straight Bearing	√	√	X	√√	X
Avoid a Change of Level	√√	√	X	√	√
Walk Towards a Brighter Space	√	√√	X	√√	√
Choose the Wider Corridor	√	X	√	√	√
Predicted Rating (1-4)	2	3	4	1	3
Predicted Ranking (1-5)	2	3	5	1	4

Table 5.01 Route Difficulty predicted based on 4 strategies
√: Correct path choice at some decision points along the route conform to this strategy
√√: Correct path choice at all decision points along the route conform to this strategy
X: Correct path choice at one or more decision points conflicts with this strategy

possible when scales include an obvious middle (neutral) category (Poulton, 1989;

Fotios & Houser, 2009). On completion of all five routes, their relative difficulty was

judged by listing them in rank order (1=easiest to 5=most difficult) with tied ranks

not a permitted response. The use of two mechanisms for judging difficulty offsets

the bias inherent within each, and this enables more confidence to be placed in the

findings. All participants undertook both practice routes and all five test routes.

The five chosen test routes and how their ratings were determined are described

below. The letters 'DP' followed by a number refer to decision points along each

route – corresponding numbers, in italics, can be found on the plan drawings for

each route. Only decision points at junctions are shown on the plans – it is accepted

that there are potentially decision points at each door, however there are occupancy

signs on most doors so it is considered unlikely that the participants will confuse

these rooms for part of the route. For brevity in the route descriptions, the four

strategy names are shortened to MSB (Maintain a Straight Bearing), ACL (Avoid a

Change of Level), WBS (Walk Towards a Brighter Space) and CWC (Choose the

Wider Corridor). Where a decision would conflict with or deviate from a particular

strategy, the term 'conflicts with MSB/ACL/WBS/CWC' is used. Where there is some

ambiguity over whether a decision can be related to a particular strategy (e.g., going

from one wide corridor to another equally wide corridor), the strategy is not

mentioned, otherwise the term 'conforms to MSB/ACL/WBS/CWC' is used. Where

an entire route can be completed while following a particular strategy this is

expanded upon in the route's introduction and not mentioned elsewhere in the

description. Figures 5.05 to 5.09 show the most direct route to each destination and

all the decision points along the routes. The assessment is based on a running tally

score of conformance or confliction, shown in brackets after the strategy

abbreviations in the route descriptions. If a route conforms throughout to a
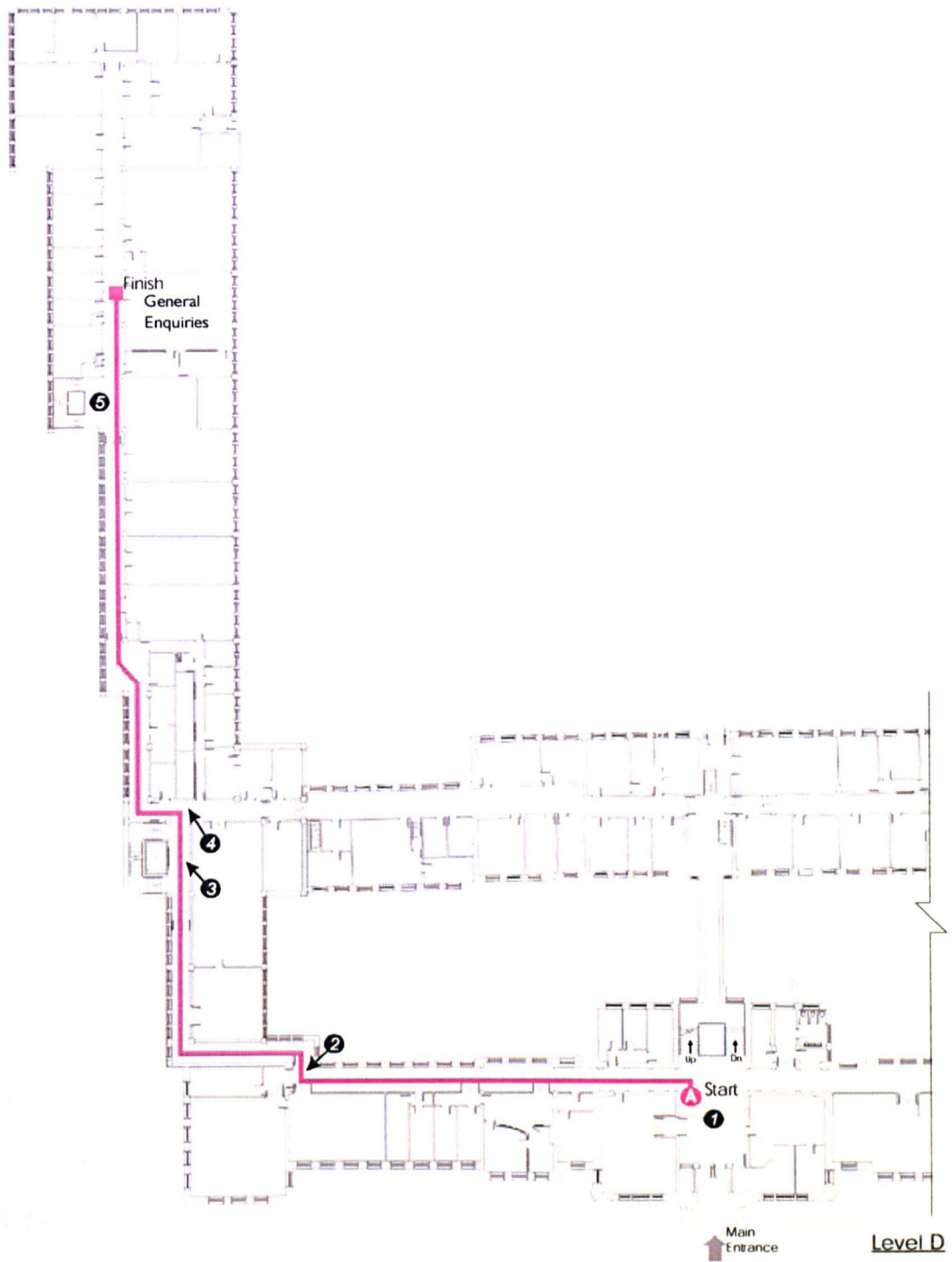
Figure 5.05 Test route A: main entrance to Civil and Structural Engineering Dept. General Enquiries

particular strategy, it will be given two ticks, otherwise the running tally will comprise ticks added and removed depending on conformance with the particular strategy. At any point along the route (and also at the end of the route), the route's conformance score for the strategy is recorded as √√: good; √: acceptable; or X: poor.

5.3.1 Route A

Route A (Figure 5.05) was predicted to have a difficulty rating of 2 (i.e. moderately easy). The route takes visitors from the St George's Complex main entrance to the Civil and Structural Engineering Enquiries Office. This department occupies most of the Broad Lane Block and the Enquiries Office is on the same floor (Level D) as both the entrance to the department and the main entrance to the St George's Complex as a whole. This route therefore can be completed while following ACL (√√). However, any visitor entering the St George's Complex from the main entrance has to walk to the far end of the Broad Lane Block before they reach this Enquiries Office. There are a few changes in corridor width along the route, however all doors across the route are double doors and the largest ratio between neighbouring corridors is 1.0:1.11. This is the ratio of the corridor widths either side of DP2 to each other; this ratio conflicts with CWC (√) as it is the corridor beyond DP2 which is narrower. However, the ratio is smaller than the ratios studied in the Corridor Width Experiment and therefore considered unlikely to have an influence on decisions.

There are signs to the department in the main entrance lobby (DP1) directing the

visitor towards DP2 (conforms to MSB (√√), partially conforms to WBS (√) – the corridor from DP1 to DP2 is naturally lit and brighter than DP1, but DP2 itself is in a darker corner). Signage through the correct door at DP2 is out of the line of sight (signage for a different department is more obvious), however the series of spaces beyond are predominantly naturally lit (partially conforms to WBS (√), although again the next DP, DP3, is darker than the corridor). The corridor does not fully conform to MSB (√), however this is not at any route choice decision points. Any decision at DP3, other than to stay on the route, would conflict with both MSB and ACL – the correct route decision conforms to these strategies (MSB √√, ACL √√). DP4 is encountered immediately following DP3.

The route from DP4 to DP5 follows a similar pattern. From DP4 a corridor conforming with WBS (√√) is followed, however although the route is superficially straight, it follows the façade of the building which steps out as it follows the road (partially conforms to MSB, √). There is a further 'destination' (rather than direction) sign for the department over one set of double doors between DP4 and DP5. As with DPs 2, 3 and 4, DP5 is in an area darker than the preceding corridor (conflicts with WBS, √). The destination is in a space not noticeably darker than DP5.

The entire route is therefore deemed overall to have the following conformance score for each of the strategies: Maintain Straight Bearing - √; Avoid a Change of Level - √√; Walk Towards a Brighter Space - √; Choose the Wider Corridor - √.
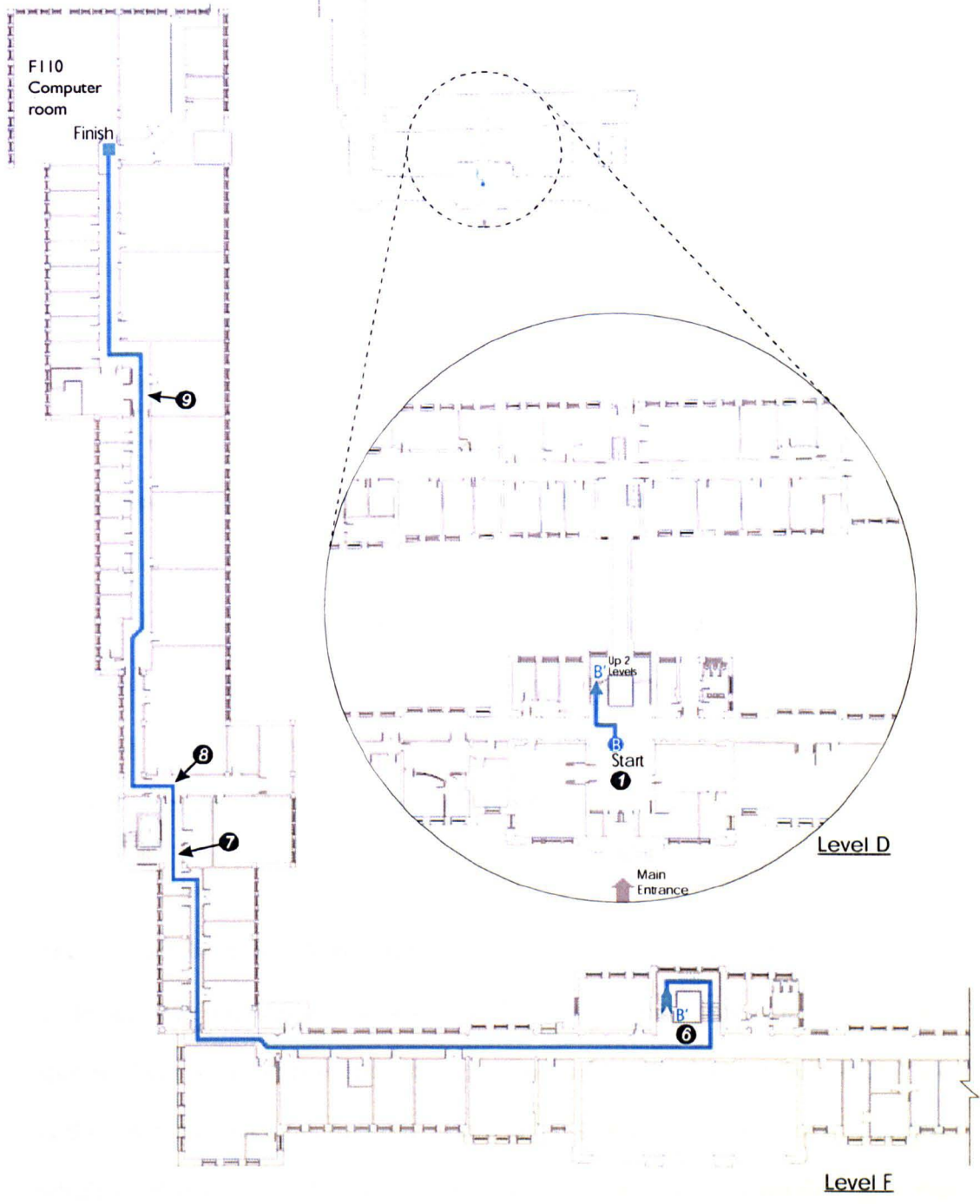
Figure 5.06 Test route B: From Main Entrance to F110 computer room

5.3.2 Route B

Route B (Figure 5.06) was predicted to have a difficulty rating of 3 (i.e. moderately difficult). The route is similar to Route A, taking visitors from the St George's Complex main entrance to room F110, one of the main computer rooms within the building. As with the Civil and Structural Engineering Enquiries Office, room F110 is at the far end of the Broad Lane Block, this time on Level F. Three of the staircases within the building, each of which is clearly visible from the route, may be used to make the change of level. The experimenter did not tell participants which staircase to use, however the building's signage to room F110 directs visitors up the flight of stairs in the main entrance lobby (DP1 to DP6). Following this sign therefore leads to almost all the wayfinding task being conducted on a different floor to that experienced in Route A. As the stair is at the point of entry into the building and once the change of level has been made no further changes of level are required, Route B is considered to partially conform to ACL ($\sqrt{}$).

The corridor beyond DP6 is naturally lit (hence initially complies with WBS ($\sqrt{}$) as, during the day, the natural light will make this space brighter lit than its neighbouring spaces), but the naturally lit section of corridor ends some distance before DP7 and at the same time narrows (there is a ratio of 1.0:2.36 between the corridor widths, which is of the order of those found to have an influence on wayfinding in the Corridor Width Experiment). The direction also changes, once through 90° then a further zig-zag shortly before reaching DP7. This section of the route therefore conflicts with WBS (X), CWC (X) and MSB (X). DPs 7 and 8 are almost adjacent to

each other – they occupy the same location on plan as DPs 3 and 4 (in Route A). From DP8 to DP9 the participant initially enters a naturally lit corridor, however reaching this corridor from DP8 conflicts with MSB (X). The remainder of the corridor complies with MSB (√). DP9 is not in a naturally lit space, therefore DP8 to DP9 only partially complies with WBS (√). From DP9 to the destination a further zig-zag is encountered (partially complies with MSB - √). The partially-glazed doors to room F110 are across the corridor at the end of this route, and F110 is brightly (naturally) lit, hence complies with WBS (√√). CWC from DP7 to the end of the route is not deemed to conform or conflict as the narrowing may influence the path decision made at DP6 as it is from this decision point the narrowing can be seen. The corridor widens out of site of DP6, however this happens between decision points and is not considered to be in a location that would influence route decisions. Following DP8 the corridor remains the same width to the end of the route.

The entire route is therefore deemed overall to have the following conformance score for each of the strategies: Maintain Straight Bearing - √; Avoid a Change of Level - √; Walk Towards a Brighter Space - √√; Choose the Wider Corridor - X.

Figure 5.07 Test route C: From Civil and Structural Engineering Dept General Enquiries to Lecture Theatre 5

5.3.3 Route C

Route C (Figure 5.07) was predicted to have a difficulty rating of 4 (i.e. very difficult). The route takes the visitor from the Civil Engineering Enquiries Office to Lecture Theatre 5, which is on Level E. Lecture theatres are not numbered by department, so this one is located potentially anywhere within the building. On plan it is easy to find from the Enquiries Office. To reach it the participant has to climb one storey up a staircase they will have already passed and Lecture Theatre 5 is within the vicinity as soon as they reach the landing.

The route does not conform to ACL (X) – unlike routes B, D and E the stair which is used in the route is not encountered immediately upon entering the building. Nor does the route conform to MSB (X) – although the stair lobby is on a straight bearing from the start point, when the change of level has been completed the participant has to double-back on themselves in order to reach the destination. The route also conflicts with WBS (X) – DP11 is naturally lit (and can be seen from DP10 at the top of the stairs), however keeping to the naturally lit space takes the participant away from the destination – the destination is not naturally lit. Although there is a wider section of corridor at DP11, this is not maintained and corridors in all directions from DP11 are the same width, hence the route is not considered to conform to or conflict with CWC (√).

Figure 5.08 Test route D: Main Entrance to Electronic and Electrical Engineering General Enquiries

The entire route is therefore deemed overall to have the following conformance score for each of the strategies: Maintain Straight Bearing - X; Avoid a Change of Level - X; Walk Towards a Brighter Space - X; Choose the Wider Corridor - √.

5.3.4 Route D

Route D (Figure 5.08) was predicted to have a difficulty rating of 1 (i.e. very easy). The route starts from the St George's Complex main entrance and takes visitors to the Electronic and Electrical Engineering (EEE) General Enquiries Office. This is on Level E, close to the staircase in the main entrance lobby. Signage from the main entrance lobby (DP1) directs participants up the staircase within the lobby to DP12. This is considered to partially conform to ACL (√) as the change of level is by the point of entry into the building and once the change of level has been made no further changes of level are necessary. The route from DP12 to the destination is naturally lit (conforms to WBS - √√) and no changes of direction are required (conforms to MSB - √√). The corridor width is largely constant throughout the route, therefore the route is considered to neither conform to nor conflict with CWC (√).

The entire route is therefore deemed overall to have the following conformance score for each of the strategies: Maintain Straight Bearing - √√; Avoid a Change of Level - √; Walk Towards a Brighter Space - √√; Choose the Wider Corridor - √.

5.3.5 Route E

Route E (Figure 5.09) was predicted to have a difficulty rating of 3 (i.e. moderately difficult). The route also starts from the St George's Complex main entrance and takes visitors to the Mechanical Engineering Department General Enquiries Office. This is the only route that requires visitors to go down (Figure 5.10) from the main entrance lobby (deemed to partially conform to ACL (√) as the change of level is at the start of the route by the point of entry into the building and no further changes of level are required beyond this). This Enquiries Office is in the Central Block, which is parallel to the Mappin Block and the main facade of the building.

DP13, which is partway down the staircase, is naturally lit, but not quite to the same degree as the upward flight of stairs (partially conforms to WBS (√) – the windows are smaller than those on the upward flight and are also obscured by the elevator). The route from DP13 to DP14 takes participants through an enclosed bridge which has heavily obscured windows – this space is not brighter than the adjoining spaces hence WBS is considered to be neither conformed to nor conflicted with at this point (√). The route from DP13 to DP14 does not involved a change of direction (conforms to MSB - √√) and the corridor widens as it reaches DP14 (the ratio between corridor widths is 1.0:2.87, this is at least of the order of those that are studied in the Corridor Width experiment, therefore this conforms to CWC - √√). At DP14, a change of direction has to be made, however as DP14 is a crossroads junction a change of direction is not enforced by the plan geometry of the junction (conflicts with MSB - √).
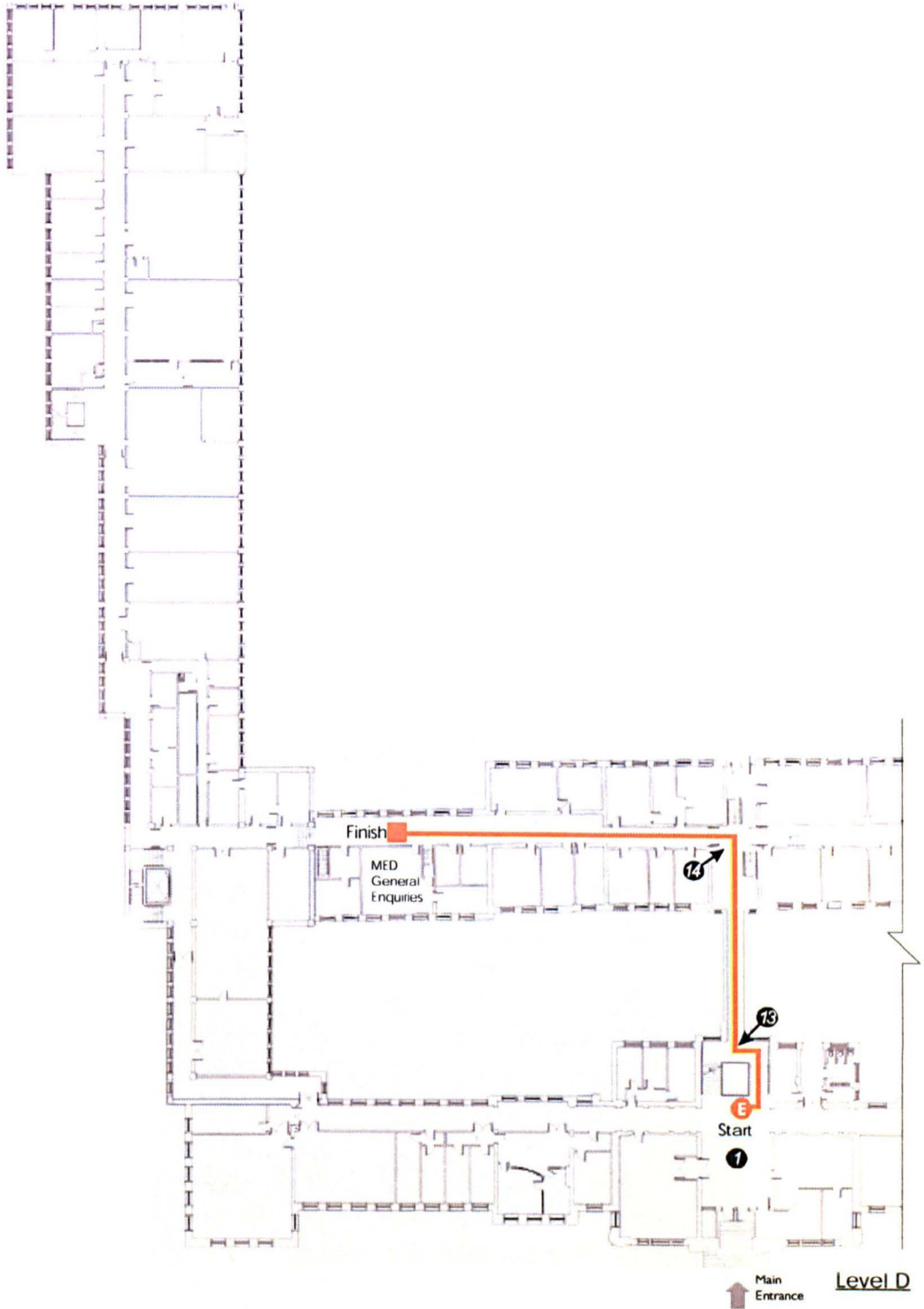
Figure 5.09 Test route E: Main Entrance to Mechanical Engineering (MED) General Enquiries

All the corridors leading from DP14 are of the same width, however the corridor leading to the destination widens partway along. Despite this, the corridor may be read (from DP14) as narrowing slightly, as there is a small step in the line of the corridor (therefore partially conforms to CWC - √). It is worth noting that the corridor leading in the opposite direction forces a change of level (walking that way would conflict with ACL). The destination is in a naturally lit space, however this is some distance from DP14 so may not be noticeable to participants standing at DP14 (partially conforms to WBS - √).

In rating Route E, one factor concerning the signage was considered. The signage convention used in the building is that an 'up' arrow denotes 'walk straight on'. However, the sign at DP1 (Figure 5.10) has 'up' arrows on the left hand side of the

Figure 5.10 Sign at Main entrance (DP1). 'Up' arrows on the right of the sign are in fact directing people downstairs ('Up' arrows are used throughout the signage in the building to mean 'go straight ahead', in this case 'go straight ahead to the downward flight of stairs'). Figure 5.02 shows a photograph of the signs' location

sign denoting 'walk straight on to the upward flight of stairs' for computer room F110 and the Electronic and Electrical Engineering Department (Routes B and D) whereas on the right hand side of the sign there is an 'up' arrow denoting 'walk straight on to the downward flight of stairs' for the Mechanical Engineering Department (Route E). It was considered that using an up arrow to instruct people to go downstairs may be confusing, hence when considering the relative rankings of the equally rated routes B and E, the influence of this factor (which is outside the scope of the wayfinding strategies and therefore will not have influenced the ratings) was considered and consequently E was ranked harder than B.

The entire route is therefore deemed overall to have the following conformance score for each of the strategies: Maintain Straight Bearing - X; Avoid a Change of Level - √; Walk Towards a Brighter Space - √; Choose the Wider Corridor - √.

5.3.6 Test route orders

Every participant undertook the routes in a different order. See Table 5.02 for the test sequence each of the participants undertook and Table 5.03 for the number of times each route was undertaken in a particular position in the sequence. The reasoning behind the choice of these five routes is that they all lead to rooms in the building likely to be destinations for unfamiliar visitors. Route A and Route B are two longer routes in the test and are designed for participants to navigate toward the same block of the whole St. George's Complex. Routes C, D and E are shorter routes and each of these covers a different part of the complex. Participants undertook the routes in a variety of orders.

Order in which Route A – Route E were taken					
Participant	1st	2nd	3rd	4th	5th
1	A	B	C	D	E
3	B	A	E	D	C
4	B	D	A	C	E
2	C	A	B	E	D
5	C	B	D	E	A
6	B	E	C	D	A
7	D	B	A	E	C
8	A	D	E	B	C
9	A	D	B	C	E
10	D	E	C	A	B
11	D	B	E	C	A
12	D	C	A	E	B
13	A	C	E	B	D
14	E	A	D	B	C
15	E	A	B	C	D
16	E	D	C	A	B
17	C	E	A	B	D
18	E	C	D	A	B
19	A	B	E	C	D
20	B	C	D	E	A
21	C	D	A	B	E
22	D	A	C	E	B
23	E	D	B	A	C
24	C	E	B	D	A

Table 5.02 Test sequence for each participant – sequence different for each participants

Route	1st	2nd	3rd	4th	5th
A	5	5	5	4	5
B	5	4	5	5	5
C	4	5	5	5	5
D	5	6	4	4	5
E	5	4	5	6	4

Table 5.03 Number of times each route was used as 1st, 2nd...5th in test procedure.

5.4   Experiment design

For each participant, five routes through the St. George's Complex were selected as

shown in Table 5.04. Each participant was given the routes as wayfinding tasks – for example, for Route A they were taken to the St George's Complex main entrance and told 'Please find the Civil and Structure Engineering Department General Enquiries'.

		Routes	Predicted	
			Rating	Ranking
Test Routes	A	Main entrance to Civil and Structural Engineering Dept General Enquiries	2	2
	B	Main entrance to F110 computer room	3	3
	C	Civil and Structure Engineering General Enquiries to lecture theatre 5	4	5
	D	Main entrance to Electronic and Electrical Engineering (EEE) General Enquiries	1	1
	E	Main entrance to Mechanical Engineering Dept (MED) General Enquiries	3	4
Practice	1st	Main entrance to the St. George's IT Centre	1	
	2nd	Main Entrance to room F166, Electronic Systems Group Digital Systems Lab	3	

Table 5.04 Predicted rating and ranking scores for the routes and practice routes

As shown in Table 5.04, the five routes were considered to represent the complete range of difficulties. There is generally an even spread of predicted ratings given to the routes, the exceptions being Routes B and E both with a rating of 3. The routes are given a predicted ranking with B and E ranked 3 and 4 respectively. Although Route B is longer and more convoluted than Route E, it is well signposted and has a clearly visible destination. The entrance to computer room F110, the destination of Route B, is across the end of a main corridor whereas the entrance to the MED General Enquiries office, the destination of Route E, is along one side of a main corridor. Route B takes the visitor through some spatially tight areas, however, these are midway along the route, some distance into the building. The start of Route E involves taking the least visible, most constricted exit from the St George's Complex

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main entrance lobby, and the signage at this point is considered potentially confusing. As this is the first decision the participant has to make it is considered potentially to have a large impact on the task.

5.4.1 Practice Routes

Two further routes were chosen for practice trials, one short and relatively simple, one longer and more complex, to demonstrate the experimental procedure. As with the other five routes, these two practice routes were given to participants as wayfinding tasks to complete. Two routes were chosen that demonstrated different levels of wayfinding tools and reassurance, one given a predicted rating of 1 (very easy) and the other 3 (moderately difficult) on the 1-4 scale. These ratings were assigned the same way as the ratings given to the other five routes, i.e., based on an analysis of the comparison of the routes against the wayfinding strategies. When rating the five main wayfinding tasks all participants would therefore be basing their ratings on the same scale range. The practice trials help to reduce the learning effects.

The two practice routes were contained in an area of the building that participants would not need to explore while undertaking the five main wayfinding tasks. Knowledge of this area of the building was therefore considered of limited advantage to the participants when undertaking the five main routes. On three occasions, participants looked likely to stray outside the area of the building containing the two practice routes so they were stopped. However, participants were not stopped from exploring this area of the building later in the experiment while undertaking the five

main wayfinding tasks as little of the information in this area of the building was considered likely to be of use to the participants when undertaking the five main tasks.

5.5   Test procedures

The test was carried out by 24 participants as shown in Table 5.05. These participants reported that they had not previously visited the St. George's Complex. Of the 24 participants, all were in the age group 21-30 with the exception of two (#3 and #7) in the 31-40 group and one (#19) who was in the 41-50 group. 12 of the participants were female and 12 male. The majority of the participants (20) were students. Of the remaining four, two were musicians, one a graphic designer and one a caterer. Eleven of the participants were British, six Taiwanese, four Chinese, two Thai and one Iranian.

Participant	Age group	Gender	Nationality	Occupation
1	21-30	F	Thai	Student
2	21-30	M	Chinese	Student
3	31-40	M	Chinese	Student
4	21-30	M	British	Student
5	21-30	M	British	Student
6	21-30	F	Iranian	Student
7	31-40	M	Thai	Student
8	21-30	F	Taiwanese	Student
9	21-30	F	Taiwanese	Student
10	21-30	F	Taiwanese	Student
11	21-30	M	Taiwanese	Student
12	21-30	M	Chinese	Student
13	21-30	F	Taiwanese	Student
14	21-30	F	Chinese	Student
15	21-30	F	British	Student
16	21-30	M	British	Graphic Designer
17	21-30	M	British	Musician
18	21-30	F	Taiwanese	Student
19	41-50	M	British	Caterer
20	21-30	F	British	Musician
21	21-30	M	British	Student
22	21-30	F	British	Student
23	21-30	F	British	Student
24	21-30	M	British	Student

Table 5.05 Details of participants in the St. George's Complex test

The test was undertaken by each participant individually. The participants were first given the two practice wayfinding tasks to complete, after which they were taken back to the St George's Complex main entrance. The participants then undertook the five main wayfinding tasks. Each participant carried these out in a different order (Table 5.02) to avoid any effect of order e.g. due to learning the task, gaining familiarity with the building or changing their personal reference of difficulty. Were all

the routes carried out in the same order for each participant, the later wayfinding tasks (i.e. those for Routes D and E) would have their results skewed towards being easier as in the course of undertaking the earlier wayfinding tasks the participant will have started to build up a cognitive map of the building. Avoiding order effect ensures that participants' cognitive maps are not always positively influencing the same routes. After each individual test route was completed, the participant was asked to complete a questionnaire (Figure 5.11). They were also asked to give each task a rating between 1 and 4, 1 being very easy, 2 moderately easy, 3 moderately difficult and 4 very difficult. Prior to undertaking the five main wayfinding tasks, the participant was told that the practice routes had a 1 and 3 rating respectively in order that they may gauge the rating scale. After completing all 5 routes, the participants were asked to rank the five test routes in order of difficulty, 1 being the easiest and 5 the most difficult (Figure 5.12).

Most of the routes started in the main entrance lobby (the first space encountered when entering the building). They were taken back to the main entrance through the building's basement between each route (apart from prior to Route C). The basement offers no views outside and is not part of any of the routes, therefore gaining environmental knowledge from the basement was not considered beneficial to the wayfinding performance when undertaking the other routes. Further details of the experiment and a transcript of the instructions given to the participants can be found in Appendix C.

1st Route: Main entrance to General Enquiries in Civil and Structural Engineering Department
Did you feel comfortable and confident following this route? .... Yes / No
Did you feel lost? .... Yes / No
Did you feel signage useful? .... Yes / No
Did you feel signage confusing? .... Yes / No
How would you say this route is? Please circle one.

1	2	3	4
Very easy	Moderately easy	Moderately difficult	Very difficult

Are there any comments you would like to make?

Figure 5.11 Example of questionnaire participants completed at the end of each route

Please rank all 5 routes in the order of easiest to the most difficult

(I easiest, 5 most difficult)

I* Main entrance to Civil and Structural Engineering Enquiries   _____

2* Civil and Structural Engineering Enquiries to Lecture Theatre 5   _____

3* Main Entrance to F I 10 Computer Room   _____

4* Main Entrance to Electronic and Electrical Engineering Enquiries   _____

5* Main Entrance to Mechanical Engineering Department Enquiries   _____

Are there any comments you would like to make?

Figure 5.12 Example of questionnaire participants completed at the end of all 5 routes

5.6   Analysis

Statistical analysis was applied to the ratings and rankings given by participants to determine how closely across the sample the ease with which the routes could be undertaken corresponded with the predictions for each route. Comments given by participants are also considered as part of the analysis.

5.6.1 Rating data

The results of the route ratings are shown in Table 5.06. These are the rating data recorded after each individual route. These are related data (repeated measure) and being on a 1-4 scale, are ordinal, non-parametric values.

The hypotheses are:

   H_1 :   The participants would give a different rating to each route

   H_0 :   No significant difference in the ratings between routes

Table 5.06 shows the predicted rating, mean rating and mode for each route. Route D was predicted the easiest while Route C was predicted the most difficult. Except for Route C, the mode rating given by participants matches the predicted rating. For Route C, the mode response is easier than predicted but the mean rating suggests it was the most difficult of the five. Overall, the mean rating and the mode tend to match the predicted rating. The order of difficulty of each route as predicted is the same as that in the results.

Participant	Rating of route difficulty (1=very easy; 4=very difficult)				
	Route A	Route B	Route C	Route D	Route E
1	2	2	3	1	2
2	2	2	3	1	3
3	3	3	4	1	4
4	2	4	3	2	2
5	3	2	3	1	2
6	3	3	3	1	4
7	2	3	3	1	4
8	2	3	4	1	4
9	2	3	4	1	3
10	2	2	4	1	3
11	3	2	4	2	3
12	3	3	4	2	4
13	2	3	3	1	3
14	3	3	4	2	3
15	2	3	4	2	3
16	1	3	3	1	3
17	3	3	4	1	4
18	2	3	3	1	4
19	2	3	3	2	2
20	2	3	4	1	3
21	2	3	4	1	4
22	3	4	4	1	3
23	2	3	3	1	3
24	2	2	3	1	3
Mean	2.29	2.83	3.50	1.25	3.17
Std. dev	0.54	0.55	0.5	0.43	0.69
Mode	2	3	3	1	3
Predicted Rating	2	3	4	1	3

Table 5.06 Recorded rating data and predicted rating

Statistical analysis was applied to determine if the ratings given by the participants to each route are significantly different. All statistical analyses were carried out using SPSS. Initially, the Friedman test (for non-parametric data, related samples) was used to compare all 5 routes. The Friedman test suggests that the ratings applied to the

five routes are significantly different (p<0.001).

The Wilcoxon Signed-Rank test (for non-parametric data, related samples) was then used to analyse the rating difference between each pair of route combinations. Since this demands 10 applications of the test, the Bonferroni correction was applied in order to ensure that the cumulative difference across all the pairs did not lead to a high familywise error rate (Field, 2005). Therefore, the criterion for significance is $p \leq 0.005$ (i.e. $p = 0.05/10$). Table 5.07 shows the p value of each pair of route combinations.

Route	B	C	D	E
A	p=0.005	p<0.001	p<0.001	p<0.001
B		p=0.001	p<0.001	n.s. (p=0.59)
C			p<0.001	n.s. (p=0.033)
D				p<0.001

Table 5.07 Significance of difference in ratings applied to each pair of route combinations. (Tested using Wilcoxon Signed Rank Test, 2-tailed, n.s. = not significant)

It was predicted (Table 5.06) that Route A would be rated as 2 and Route B as 3 on the 1-4 scale of difficulty, i.e. Route A slightly easier than Route B. The results show that Route A was rated slightly easier (mean rating = 2.29) than Route B (mean rating = 2.83). According to the Wilcoxon Signed-Rank test (Table 5.07), the ratings for Route A and Route B are significantly different (p=0.005). Therefore, this confirms the prediction.

It was predicted (Table 5.06) that Route C would be rated as 4 and Route D as 1 on the 1-4 scale of difficulty. The results show that Route C was rated more difficult (mean rating = 3.50) than Route D (mean rating = 1.25). According to the Wilcoxon Signed-Rank test (Table 5.07) ratings are significantly different ($p<0.001$). Therefore, this confirms the prediction.

It was predicted (Table 5.06) that Route C would be rated as 4 and Route E as 3 on the 1-4 scale of difficulty. The results show that Route C was rated slightly more difficult (mean rating = 3.50) than Route E (mean rating = 3.17). According to the Wilcoxon Signed-Rank test (Table 5.07) ratings are not significantly different ($p=0.033$, if the significant level is $p\leq0.005$).

It was predicted (Table 5.06) that Route D would be rated as 1 and Route E as 3 on the 1-4 scale of difficulty. The results show that Route D was rated easier (mean rating = 1.25) than Route E (mean rating = 3.17). According to the Wilcoxon Signed-Rank test (Table 5.07) ratings are significantly different ($p<0.001$) Therefore, this confirms the prediction.

5.6.2 Ranking data

The hypotheses are:

H_1 : Routes considered to be more difficult by consideration of the four wayfinding strategies will be ranked more difficult

H_0 : No significant difference in rankings of difficulty

The results of the route rankings are shown in Table 5.08. This is the ranking data recorded after all five routes were undertaken. These are related data (repeated measures) and, being on a 1-5 scale, are ordinal, non-parametric values. Table 5.08 shows the predicted ranking, mean ranking and mode for each route. Route D was predicted the easiest and Route C the most difficult. Overall, the mean ranking and the mode tend to match the predicted ranking. Analysis of Routes D, A and B, which had predicted rankings of 1, 2 and 3 respectively, produced mean and mode rankings that do match those predicted. Routes C and E, ranked 4 and 5 respectively in the predictions, have mode rankings of 5 and 4.

The reason for the discrepancy between the predicted and recorded rankings of Route E may be the result of the poor signage described in Section 5.3.5. Participants often referred to the signage in their comments, with numerous negative comments about the signage for this route. Also, this is the only route that requires participants to navigate to a destination on a floor below the main floor as a consequence of the building's construction on a sloping site (commented upon by eight participants). Tseng-Chyan and Lai (2004) note that floors below the main entrance floor are often not considered when wayfinding as they may be misinterpreted as basements, a problem in buildings built into sloping sites. These factors may have made the apparent difficulty of the Route E task higher. Participants who did not immediately take the correct (downward) flight of stairs from the main entrance lobby DP1 tended to rank the task at a higher level of difficulty than predicted, whereas the participants correctly navigating the first staircase gave rankings closer to those predicted. These two distinct sets of rankings are reflected in the standard deviation – the standard deviation of route E is the highest of all the routes at 1.09.

Participant	Ranking of route difficulty 1 = easiest to 5 = most difficult				
	Route A	Route B	Route C	Route D	Route E
1	2	4	5	1	3
2	2	3	4	1	5
3	2	3	4	1	5
4	3	5	4	1	2
5	2	3	4	1	5
6	3	2	4	1	5
7	3	4	2	1	5
8	2	3	4	1	5
9	2	3	5	1	4
10	2	3	5	1	4
11	3	2	5	1	4
12	2	3	4	1	5
13	2	3	4	1	5
14	2	4	5	1	3
15	2	3	5	1	4
16	1	4	5	2	3
17	2	3	4	1	5
18	2	3	4	1	5
19	3	4	5	2	1
20	2	4	5	1	3
21	2	3	4	1	5
22	2	3	5	1	4
23	2	3	5	1	4
24	2	3	4	1	5
Mean Rank	2.17	3.25	4.38	1.08	4.13
Std. dev	0.47	0.66	0.70	0.28	1.09
mode	2	3	4	1	5
Predicted Ranking	2	3	5	1	4

Table 5.08 Recorded ranking data and predicted ranking

In order to determine if the rankings between all the participants are correlated, Kendall's coefficient of concordance W (Kendall's W test) was carried out using SPSS. Kendall's W was used to compare all five routes. It is an ordinal, non-parametric statistical procedure. This test is used for assessing the agreement between participants, where Kendall's W ranges from 0 (no agreement between participants) to 1 (complement agreement between participants) (Field, 2005).

Kendall's W test suggests that the rankings of the five routes are highly concordant (w=0.76, p<0.001). Therefore, the null hypothesis was rejected. All participants tend to give the same rank to each route.

Friedman's test was also used to determine if the rankings between the five routes were significantly different. The test suggests that the rankings applied to five routes are significantly different (p<0.001). The Wilcoxon Signed-Rank test was then used to analyse the ranking difference between each pair of route combinations. The criterion for significance is p≤0.005 (i.e. p=0.05/10 combinations). Table 5.09 shows the p value of each pair of route combinations.

Route	B	C	D	E
A	p<0.001	p<0.001	p<0.001	p<0.001
B		p<0.001	p<0.001	n.s. (p=0.017)
C			p<0.001	n.s. (p=0.403)
D				p<0.001

Table 5.09 Significance of difference in rankings applied to each pair of route combinations. (Tested using the Wilcoxon Signed Rank Test, 2-tailed) n.s. = not significant

It was predicted (Table 5.07) that Route A would be ranked as 2nd easiest and Route B as 3rd on the 1-5 ranking scale. The results show that Route A was ranked slightly easier (mean ranking = 2.17) than Route B (mean rating = 3.25). According to the Wilcoxon Signed-Rank test (Table 5.09), the rankings are significantly different (p<0.001) and this suggests that the prediction that Route A would be considered easier than route B was correct.

It was predicted (Table 5.07) that Route C would be ranked as 5th (the most difficult) and Route D as 1st (easiest) on the scale of 1-5. The results show that Route C was ranked more difficult (mean ranking = 4.35) than Route D (mean ranking = 1.08). According to the Wilcoxon Signed-Rank test (Table 5.09) ratings are significantly different (p<0.001) and this suggests that the prediction that Route C would be considered more difficult than Route D was correct.

It was predicted (Table 5.07) that Route C would be ranked as 5th (the most difficult) and Route E as 4th on the scale of 1-5. The results show that Route C was ranked slightly more difficult (mean rating = 4.35) than Route E (mean rating = 4.13). According to the Wilcoxon Signed-Rank test (Table 5.09) ratings are not significantly different (p=0.403). This disagrees with the prediction.

It was predicted (Table 5.07) that Route D would be ranked as 1st (easiest) and Route E as 4th on the scale of 1-5. The results show that Route D was rated easier (mean rating = 1.08) than Route E (mean rating = 4.13). According to the Wilcoxon Signed-Rank test (Table 5.09) ratings are significantly different (p<0.001) and this suggests that the prediction that Route D would be considered easier than route E was correct.

5.6.3 Responses to Yes / No questions

This data is from the list of Yes / No questions that participants were asked to complete at the end of each route. All the answers with "Yes" were given a score of "1" and answers with "No" were given score of "0".

Question 1 asked: 'Did you feel comfortable and confident following this route?'

Cochran's Q test suggests that the answers for Question 1 applied to five routes are

significantly different ($p < 0.001$). Table 5.10 shows results from the test and Figure

5.13 shows the sum of all yes and no answers. The wayfinding task can be

considered easier the more yes answers there are for its route. This corresponds

accurately to the predicted rating – routes with easier ratings (lower numbers) have

more yes answers to Question 1.

Participant	Route A	Route B	Route C	Route D	Route E
1	1	1	0	1	1
2	1	0	0	1	0
3	1	0	0	1	0
4	1	0	0	1	1
5	1	1	0	1	0
6	0	0	0	1	0
7	1	0	0	1	0
8	1	0	0	1	0
9	1	0	0	1	0
10	1	0	0	1	0
11	1	1	0	1	1
12	1	0	0	1	0
13	1	0	0	1	0
14	1	0	0	1	0
15	1	0	0	1	0
16	1	0	1	1	1
17	0	1	0	1	0
18	0	0	0	1	0
19	1	1	0	1	1
20	1	0	0	1	0
21	1	1	0	1	0
22	1	0	0	1	0
23	1	0	0	1	0
24	1	1	0	1	1
Sum	Yes=21 No=3	Yes=7 No=17	Yes=1 No=23	Yes=24 No=0	Yes=6 No=18
Predicted Rating	2	3	4	1	3

Table 5.10 Results of question 1: Did you feel comfortable and confident following this route? Data are for all 5 routes (Yes=1, No=0)
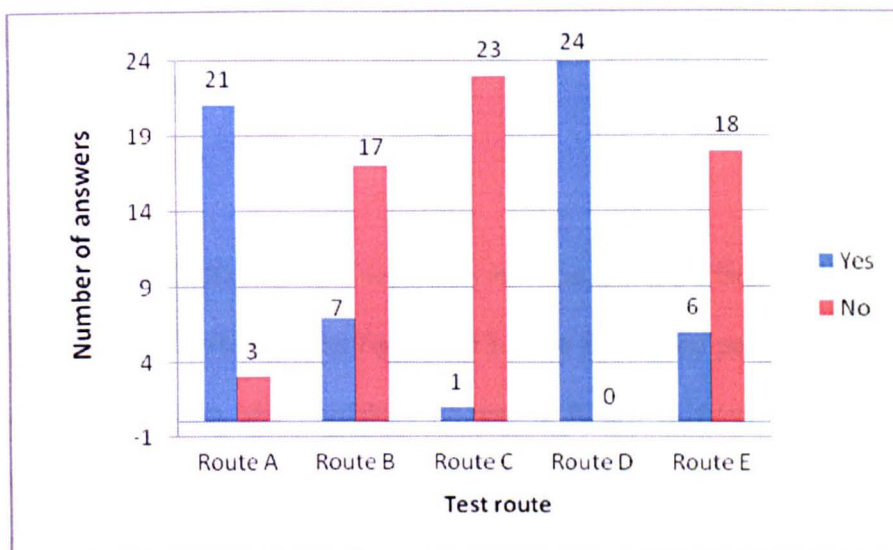
Figure 5.13 Comparison of numbers of Yes and No answers given for Question 1 for each test route.

The results are then analysed using McNemar Test (for dichotomous data) to see if participants have given the same answers to each route. The criterion for significance is $p \leq 0.005$ (i.e. $p = 0.05/10$ combinations). P values are shown in Table 5.11.

Route	B	C	D	E
A	p=0.001	p<0.001	n.s. (p=0.25)	p<0.001
B		n.s. (p=0.07)	p<0.001	n.s. (p=1)
C			p<0.001	n.s. (p=0.063)
D				p<0.001

Table 5.11 McNemar Test for paired comparison for comfort and confidence of the routes (Exact Sig. (2-tailed)) n.s. = not significant

It was predicted that Route A would be rated as an easier route than Route B. The results in Table 5.10 show that more people answered they felt more comfortable and confident navigating Route A (was answered yes by 21 participants) than Route B (was answered yes by 7 participants). McNemar test (Table 5.11) shows the answers

to Route A and Route B are significantly different (p=0.001). This confirms the prediction.

It was predicted that Route C would be rated as a more difficult route than Route D. The results in Table 5.10 and Figure 5.13 show that more people answered they felt more comfortable and confident navigating Route D (was answered yes by 24 participants) than Route C (was answered yes by 1 participant). McNemar test (Table 5.11) shows the answers to Route C and Route D are significantly different (p<0.001) and this suggests that the prediction that Route C would be considered more difficult than route D was correct.

It was predicted that Route C (predicted rating 4) would be rated as a slightly more difficult route than Route E (predicted rating 3). The results in Table 5.10 and Figure 5.13 show that more people answered they felt more comfortable and confident navigating Route E (was answered yes by 6 participants) than Route C (was answered yes by 1 participant). It is predicted that both routes are difficult routes and, therefore, participants would not feel comfortable navigating these routes. McNemar test (Table 5.11) shows the answers to Route C and Route E are not significantly different (p=0.063). This suggests that participants didn't feel comfortable and confident navigating both Route C and Route E, therefore, the predicted difficulty of both routes are supported.

It was predicted that Route D would be rated as an easier route than Route E. The results in Table 5.10 and Figure 5.13 show that more people answered they felt

more comfortable and confident navigating Route D (was answered yes by 24 participants) than Route E (was answered yes by 6 participants). McNemar test (Table 5.11) shows the answers to Route D and Route E are significantly different ($p<0.001$) and this suggests that the prediction that Route D would be easier than Route E was correct.

Question 2 asked: 'Did you feel lost?' Cochran's Q test suggests that the answers for Question 2 applied to five routes are significantly different ($p<0.001$). Table 5.12 shows results from the test and Figure 5.14 shows the sum of all yes and no answers. This time, the wayfinding task can be considered easier the more no answers there are for its route. This corresponds accurately to the predicted rating – routes with easier ratings (lower numbers) have more no answers to Question 2.
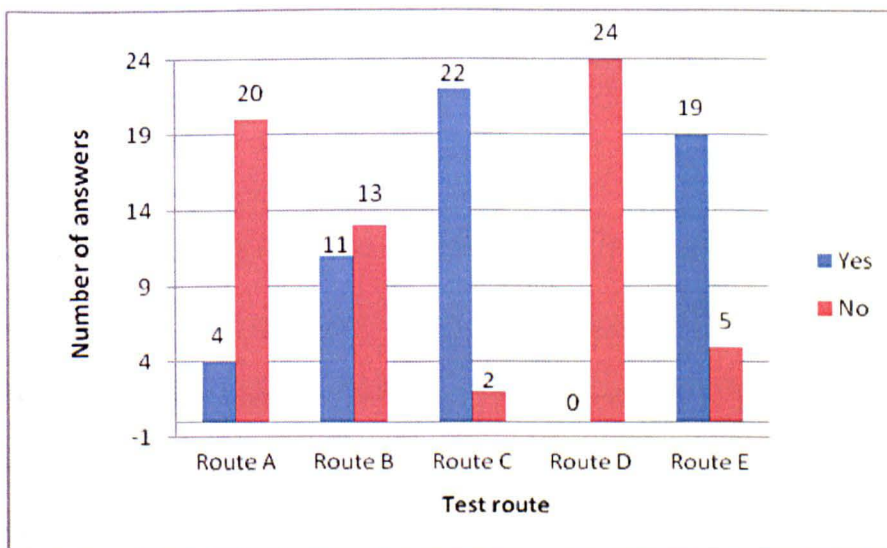
Figure 5.14 Comparison of numbers of Yes and No answers given for Question 2 for each test route.

Participant	Route A	Route B	Route C	Route D	Route E
I	0	1	0	1	1
2	0	0	0	1	0
3	0	0	0	1	0
4	0	0	0	1	1
5	I	1	0	1	0
6	I	0	0	1	0
7	0	0	0	1	0
8	0	0	0	1	0
9	0	0	0	1	0
10	0	0	0	1	0
11	0	1	0	1	1
12	I	0	0	1	0
13	0	0	0	1	0
14	0	0	0	1	0
15	0	0	0	1	0
16	0	0	1	1	1
17	I	1	0	1	0
18	0	0	0	1	0
19	0	1	0	1	1
20	0	0	0	1	0
21	0	1	0	1	0
22	0	0	0	1	0
23	0	0	0	1	0
24	0	1	0	1	1
Sum	Yes=4 No=20	Yes=11 No=13	Yes=22 No=2	Yes=0 No=24	Yes=19 No=5
Predicted Rating	2	3	4	1	3

Table 5.12 Question 2: Did you feel lost? Data are for all 5 routes (Yes=1, No=0)

It was predicted that Route A (predicted rating 2) would be rated a slightly easier route than Route B (predicted rating 3). The results in Table 5.12 and Figure 5.14 show that more people answered they felt lost when navigating Route B (was answered yes by 11 participants) than Route A (was answered yes by 4 participants). However, McNemar test (Table 5.13) shows the answers to Route A and Route B are not significantly different (p=0.065) which suggests that there might not be a big difference in feeling lost in both routes. This statistical analysis supports the prediction that there is little difference in difficulty between Route A and Route B.

Route	B	C	D	E
A	n.s. (p=0.065)	p<0.001	n.s. (p=0.125)	p<0.001
B		p=0.001	p=0.001	n.s. (p=0.021)
C			p<0.001	n.s. (p=0.25)
D				p<0.001

Table 5.13 McNemar Test for paired comparison for "feeling lost or not" for the routes (Exact Sig. (2-tailed)) n.s. = not significant

It was predicted that Route C (predicted rating 4) would be rated as a more difficult route than Route D (predicted rating 1). The results in Table 5.12 and Figure 5.14 show that more people answered they felt lost when navigating Route C (was answered yes by 22 participants) than Route D (was answered yes by 0 participants). McNemar test (Table 5.13) shows the answers to Route C and Route D are significantly different (p<0.001) and this suggests that the prediction that Route C is more difficult than Route D was supported.

It was predicted that Route D (predicted rating 1) would be rated as an easier route than Route E (predicted rating 3). The results in Table 5.12 and Figure 5.14 show that more people answered they felt lost when navigating Route E (was answered yes by 19 participants) than Route D (was answered yes by 0 participants). McNemar test (Table 5.13) shows the answers to Route D and Route E are significantly different (p<0.001) and this suggests that the prediction that Route D is easier than Route E was supported.

Question 3 and question 4 are both related to signage. Question 3 asked: 'Did you feel signage is useful?' Question 4 asked: 'Did you feel signage is confusing?' Cochran's Q test suggests that the answers for questions 3 and 4 applied to the five

routes are significantly different (p<0.001). Table 5.14 shows results from the test and Figure 5.15 shows the sum of all yes and no answers for Question 3. Table 5.16 and Figure 5.16 shows the same for Question 4. For Question 3, the wayfinding task can be considered easier the more no answers there are for its route. For Question 4, the wayfinding task can be considered easier the more yes answers there are. This corresponds accurately to the predicted rating – routes with easier ratings (lower numbers) have more no answers to Question 3 (Table 5.14 & Figure 5.15) and more yes answers to Question 4 (Table 5.16 and Figure 5.16).

Participant	Route A	Route B	Route C	Route D	Route E
1	1	1	0	1	0
2	1	1	0	1	0
3	1	1	0	1	0
4	1	1	0	1	1
5	1	1	1	1	1
6	1	1	1	1	0
7	1	1	0	1	0
8	1	1	1	1	1
9	1	1	1	1	0
10	1	1	0	1	1
11	1	1	0	1	1
12	1	1	0	1	0
13	1	1	0	1	0
14	1	1	0	1	1
15	1	1	0	1	0
16	1	1	0	1	0
17	0	1	0	1	0
18	1	1	0	1	0
19	1	1	0	0	1
20	1	1	0	1	0
21	1	1	0	1	0
22	1	1	0	1	0
23	1	1	0	1	0
24	1	1	0	1	1
Sum	Yes=23 No=1	Yes=24 No=0	Yes=4 No=20	Yes=23 No=1	Yes=8 No=16
Predicted Rating	2	3	4	1	3

Table 5.14 Question 3: Did you feel signage useful?
Data are for all 5 routes (Yes=1, No=0)
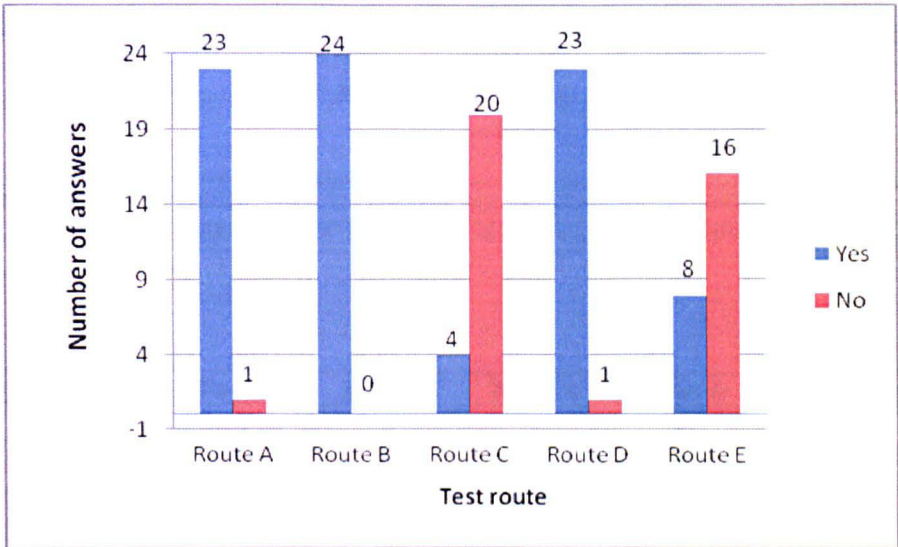
Figure 5.15 Comparison of numbers of Yes and No answers given for Question 3 for each test route.
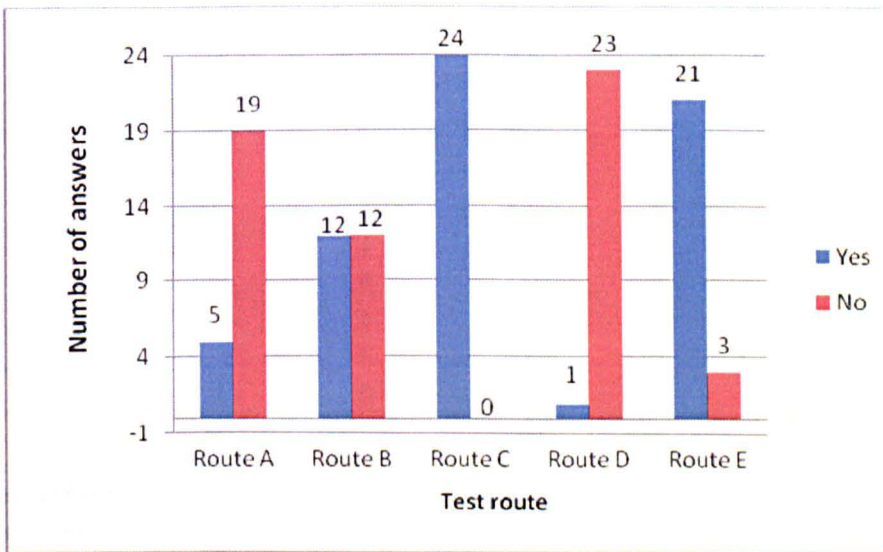
Figure 5.16 Comparison of numbers of Yes and No answers given for Question 4 for each test route.

Route	B	C	D	E
A	n.s. (p=1)	p<0.001	n.s. (p=1)	p<0.001
B		p<0.001	n.s. (p=1)	p<0.001
C			p<0.001	n.s. (p=0.289)
D				p<0.001

Table 5.15 McNemar Test for paired comparison for "Signage useful or not" on the routes (Exact Sig. (2-tailed)) n.s. = not significant

Participant	Route A	Route B	Route C	Route D	Route E
1	1	0	1	0	0
2	0	0	1	0	1
3	0	1	1	0	1
4	1	0	1	1	0
5	0	0	1	0	1
6	0	0	1	0	1
7	0	1	1	0	1
8	0	0	1	0	1
9	0	0	1	0	1
10	0	0	1	0	1
11	1	0	1	0	1
12	0	1	1	0	1
13	0	1	1	0	1
14	0	0	1	0	1
15	0	1	1	0	1
16	0	1	1	0	1
17	1	1	1	0	1
18	0	1	1	0	1
19	0	1	1	0	0
20	0	1	1	0	1
21	0	0	1	0	1
22	0	1	1	0	1
23	0	1	1	0	1
24	1	0	1	0	1
Sum	Yes=5 No=19	Yes=12 No=12	Yes=24 No=0	Yes=1 No=23	Yes=21 No=3
Predicted Rating	2	3	4	1	3

Table 5.16 Question 4: Did you feel signage confusing? Data are for all 5 routes (Yes=1, No=0)

Signage along Routes A, B and D was felt by the participants to be useful. All participants answered "Yes" to this question. Results (Table 5.15) show that answers for Route C and Route E are not significantly different (p=0.289). Most participants

felt the signage along these two routes was not useful. This supports the prediction that Route C and Route E are ranked more difficult routes than Route A, B and D.

Route	B	C	D	E
A	n.s. (p=0.118)	p<0.001	n.s. (p=0.125)	p<0.001
B		p<0.001	p=0.003	n.s. (p=0.012)
C			p<0.001	n.s. (p=0.250)
D				p<0.001

Table 5.17 McNemar Test for paired comparison for "signage confusing or not" on the routes (Exact Sig. (2-tailed)) n.s. = not significant

Most of the participants felt the signage was not confusing for Route A, (19 of the participants answered "no" when asked if the signage was felt to be confusing) and Route D (12 of the participants answered "no"). The participants rated these two routes as easier routes. Although Route B is rated slightly more difficult than A, both routes have signage wherever needed.

Most of the participants answered "yes" for Route C and Route E when asked if they felt the signage was confusing. There is no significant difference (p=0.250) between Route C and Route E (Table 5.17). Most participants felt the signage was confusing for both Route C (ranked 5th, the most difficult route) and Route E (ranked the 4th difficult route).

5.7 Discussion

Table 5.18 shows the predicted rating, ranking and results broadly match. These analyses suggest that routes that allow wayfinding that conforms to the wayfinding strategies are easier to complete than those that do not.

Order of difficulty	Predicted		Results of tests			
	Rating	Ranking	Rating	Ranking	Question1	Question2
1 (easiest)	D	D	D	D	D=A	D=A
2	A	A	A	A	D=A	D=A
3	B=E	B	B=E	B=E	B=E=C	B
4	B=E	E	B=E	B=E	B=E=C	E=C
5 (Most difficult)	C	C	C	C	B=E=C	E=C

Table 5.18 Summary comparing predicted route difficulty with the results from the four test questions

Table 5.18 shows the predicted rating, ranking and statistical comparison from rating, ranking and questions tests. In cases where the statistical difference is insignificant, X=Y is listed; for example, the Predicted Rating of D and A is significantly different, hence they have been listed separately, however the difference between them for Results of Tests Question 1 is not significant hence they have both been listed on both difficulty rows 1 and 2 as D=A.

From the rating results, the Wilcoxon Signed-Rank test shows that Route B and Route E are not significantly different (p=0.59). From the ranking results, Route B and Route E are not significantly different (p=0.017, significant level 0.005). From the Question 1 results, McNemar Test shows that Route A and Route D are not

significantly different (p=0.25). Route B and Route C are not significantly different (p=0.07). Route B and Route E are not significantly different (p=1). Route C and Route E are not significantly different (p=0.063). From Question 2 results, Route A and Route D are not significantly different (p=0.125). Route C and Route E are not significantly different (p=0.25).

It was predicted that Route C would be rated as the most difficult route. The mean rating confirmed that Route C is slightly more difficult than Route E, however in the ranking data, Route E was ranked 5th (most difficult) the most frequently. The signage of both Routes C and E was felt to be very confusing. There is no direct visual accessibility to the Mechanical Department entrance. Eight participants reported that they would not expect the main entrance to a department to be lower than the main entrance to the St. George's Complex which mirrors trends identified by Tseng-Tseng-Chyan and Lai (2004). Therefore, they assumed the department would be either on the same level as the entry level or higher. The frequency of this response suggests that this would be a suitable area for further research into developing wayfinding design strategies that accommodate buildings built into sloping sites.

Various comments were given by participants, both verbally during the test (and recorded by the researcher) and written at the end of the test. The written comments are documented in Appendix C. Many of these related to signage, supporting the findings from previous research (chapter 2) that poor signage hampers wayfinding performance and when wayfinding problems are encountered it is frequently the signage which is blamed. The signage basis for Route E's ranking was supported in the comments, with participants criticising the signage for being

confusing and misleading.

The influence of corridor width was evident in comments for Route B, corresponding with the results from the Corridor Width experiment and comments recorded in the Corridor Width experiment about preferences for wider routes. Support for the Avoid a Change of Level strategy could be seen in comments for Route C, with participants finding difficulty due to the different plan arrangements on the two floors and one participant commenting that he tried to look for the destination on the floor that the route started on. As already mentioned, there were eight comments given about confusion leading from having to go downstairs to reach the destination in Route E, including one written comment. The issue of destinations in lower floors than the main entrance floor is a possible route for further research, particularly of wayfinding difficulties experienced in buildings in hilly cities such as Sheffield where buildings may be built into the slope of a site and have entrances on several floors. Several of the other comments for Route E explained problems due to not being able to see the department. This is supportive of the idea of a zoned approach to wayfinding within buildings and the need to maintain visual accessibility to important environmental information, both identified amongst previous research in Chapter 2.

The number of comments given corresponded with the ranking of the routes – the harder routes had more comments than the easier routes.

5.8   Conclusion

Five routes were chosen and their difficulty rated according to their conformance to

the wayfinding strategies explored earlier in the thesis. Table 5.19 shows a summary of each pair comparison for rating, ranking and two Yes / No questions. This relates back to the grouping of routes in Table 5.02 – Routes A and B (which are grouped together) are compared to each other as are pairs from Routes C, D and E (also grouped together).

	A & B	C & D	C & E	D & E
Predicted Rating	2 , 3	4 , 1	4 , 3	1 , 3
Easier route	A	D	E	D
Easier route in pairs according to :				
Ratings	A $p=0.005$	D $p<0.001$	n.s. $p=0.033$	D $p<0.001$
Rankings	A $p<0.001$	D $p<0.001$	n.s. $p=0.403$	D $p<0.001$
Question 1 (comfort)	A $p=0.001$	D $p<0.001$	n.s. $p=0.063$	D $p<0.001$
Question 2 (lost)	n.s. $p=0.065$	D $p<0.001$	n.s. $p=0.021$	D $p<0.001$
Conclusion from test results	A	D	C=E	D

Table 5.19 Summary of pair comparison

These predictions of difficulty were tested in a series of trials, where unfamiliar users walked a route and subsequently described it. These measures were recorded: rating, ranking and questions. Essentially, this is three ways of asking the same questions. Table 5.19 shows the significant level of difference for each pair comparison. Route A and Route B, as they cover the same part of the building, albeit on different floors, are always compared to each other. Pairs are then compared from the group of Routes C, D and E, which are all shorter and similar complexity. It was found that the response of unfamiliar users matched the predictions.

The hypotheses for the test are:

H_1 : Routes which benefit from positive aspects of the four wayfinding strategies will be judged less difficult than routes which do not benefit from the strategies

H_0 : There is no relationship between route difficulty and the presence of the four wayfinding strategies

The hypothesis (H_1) has been confirmed.

5.9   Summary

Chapter 5 took the Wayfinding Strategies that were derived from the literature review, observation study and Corridor Width experiment and tested them within the St George's Complex at the University of Sheffield. The test at the St George's Complex involved asking participants to navigate around various routes within the building and asking them to give a difficulty score to each route. The routes were deliberately chosen to cover the range of wayfinding scenarios and factors likely to be covered by the Wayfinding Strategies. It was therefore possible by comparing the building with the Wayfinding Strategies to predict the level of complexity for each route, which could be compared against the levels of complexity recorded by the participants.

Results from the test met predictions. It is felt that this provides verification of the validity and use of the wayfinding strategies.

5.10 References

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6

Discussion and Implications

6.1 Chapter overview

This chapter explores the design possibilities stemming from the wayfinding strategies explored in the thesis. Chapters 2, 3 and 4 identified and investigated four wayfinding strategies that are used by people when wayfinding within unfamiliar spaces. Chapter 5 investigated whether the ease of wayfinding within a building could be predicted based on how faithfully the building allowed the wayfinding strategies to be followed. The results from the test in Chapter 5 supported the predicted wayfinding difficulties. Chapter 6 investigates possible ways in which these findings may be used to guide building design.

6.2 Scope of the implications discussion

This chapter is not intended to be an exhaustive list of measures which can be made to improve wayfinding within buildings, nor a true 'proof of concept' as the scope of the chapter does not extend to studies of completed buildings where the wayfinding strategies have been considered as part of the design. Rather, the discussion and exploration of examples have been undertaken to determine whether it is practical to use the wayfinding strategies as design guidance. It is considered that architects are only likely to consider using the strategies as a basis for design decisions if they

do not conflict with the various other factors that architects have to work to, including budget, aesthetic, available space and legislative requirements.

Additionally, up to this point the influences of the wayfinding strategies have only been considered in the positive sense. The research in the earlier chapters considers a visitor's attempts to find a space within a building which is open to the public, and for this purpose spaces which are considered likely destinations for such visitors have been focussed on. However most buildings, including those used for the observation and applied test (the Students' Union and St Georges Complex respectively), do not consist entirely of such spaces likely to be of interest to unfamiliar users. Therefore, the influence of both conforming to and deliberately conflicting with the wayfinding strategies is considered, as means of both drawing visitors towards spaces considered to be likely destinations and away from spaces that are not considered to be likely destinations. Several of the strategies rely upon contrast for their effect (brighter lit / dimmer lit spaces and wider/narrower corridors), which therefore lend themselves well to buildings with a mix of spaces likely to be of interest and not likely to be of interest to unfamiliar users.

6.2.1 Example buildings used

The Sheffield University Students' Union building and St. George's Complex have been used as the basis of most of the design discussions as detailed descriptions of each of these buildings, in their current form, feature elsewhere in the thesis for comparison. However, other buildings are also used on occasion when they are considered to form a sound base for a particular point in the discussion. These are:

the Northern General Hospital (the larger of the two main hospitals serving Sheffield); the Millennium Galleries in Sheffield's City Centre and Chep Lap Kok airport in Hong Kong. Norman Foster and partners' Chep Lap Kok airport is included essentially as an example of a successful design fundamentally conforming to a wayfinding strategy (section 6.3) as its entire layout is based upon a logical progression along a straight bearing through the building. The Millennium Galleries is also included as an example of a very clear circulation design which conforms well to several of the wayfinding strategies. By comparison, the Northern General Hospital's current layout is convoluted and confusing, largely due to the complex having grown over time rather than being planned. It is included as an opportunity to compare the designs which this discussion proposes with those that would result from following the NHS Wayfinding guidelines (Stationery Office / NHS Estates, 1999), and as its circulation spaces presently conflict with the wayfinding strategies.

The architectural application discussions deliberately include both new-build and refurbishment. Existing wayfinding problems in buildings to be refurbished may be considered to be difficult to overcome within the structural and spatial constrictions of the building and budgetary constrictions of the project. For the guidelines to be useful, they should offer practical solutions for problems within such circumstances. Some of the strategies would, at first sight, appear to rely upon specific plan layouts in order to function correctly. Section 6.3 demonstrates these specific plan layouts (titled Fundamental Designs). It is accepted that a refurbishment project can rarely involve the adoption of these basic layouts given the structural restrictions based on earlier layouts imposed by existing buildings. The revision to an existing building to provide, for example, a perfectly straight route linking all major destinations would

be excessively disruptive to other spaces in the building and the building's structure. Therefore, Section 6.4 in discussing the practical application of the strategies explores changes that may be made within the restrictions imposed by existing buildings.

Drawings used in this discussion, where not listed otherwise, were produced by the author.

6.3   Fundamental designs conforming to the wayfinding strategies

This section introduces very basic designs demonstrating fundamental applications for each of the wayfinding strategies. This is intended as a reference against which further discussion is considered, to ensure the examples do not stray too far from this 'ideal'.

6.3.1 Maintain a Straight Bearing strategy

A building designed to the Straight Bearing strategy and ignoring other constraints would likely feature one straight corridor, either for the whole building or for each district, linking together all the rooms or zones featuring in that building or district. The building would score well in any tests undertaken to demonstrate wayfinding ease based on the Initial Segment Strategy (Section 2.6.1).

Were the building to have more than one corridor (in the case of buildings split into districts) they should radiate from a central hub. It is also possible that large buildings

could utilise a grid of corridors, akin to the grid patterns of North American cities. This would limit the number of turns necessary to get to any point to one, though as such a layout would be a slight departure from the Straight Bearing ideal it would benefit from further investigation.
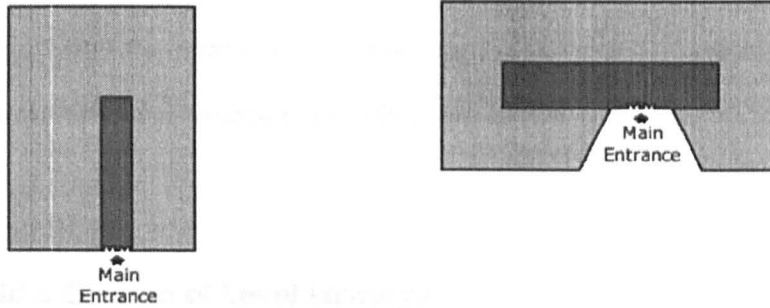
Figure 6.01 Two example diagrammatic plans conforming to the Straight Bearing strategy

The examples shown in Figures 6.01 and 6.02 include curved corridors. The findings from the Corridor Width Experiment (specifically those from Variation Set C) suggest that it is not strictly necessary to have straight corridors in order to conform to the Straight Bearing Strategy. The primary concern is to avoid deviation from the
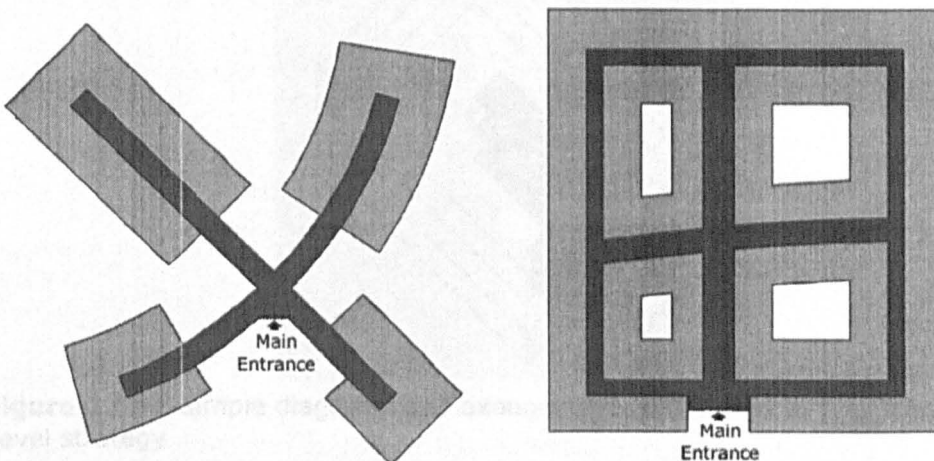
Figure 6.02 Two possible solutions conforming to the Straight Bearing strategy in multiple corridor scenarios

main path – as long as the continuity of that path is maintained and identifiable along its length (for example, by ensuring the width remains the same), the path can potentially make abrupt changes of direction or possibly curve. Curved corridors may in fact benefit wayfinding by promoting exploration (Matsumoto et al., 1997), however careful consideration should be made to their design as layouts involving curved circulation spaces may introduce wayfinding difficulties by restricting visual access to the immediate locality and, in reducing the number of corners, potentially reducing the number of reference points (Sivadon, 1970).

6.3.2 Avoid a Change of Level strategy

A building designed to the Avoid a Change of Level strategy and ignoring other constraints would be zoned so as to ensure any destinations of interest to new visitors are on the ground floor and any building districts are not spread over more than one floor. Necessary changes of level in any wayfinding task should be made close to the building's main entrance (Figure 6.03).
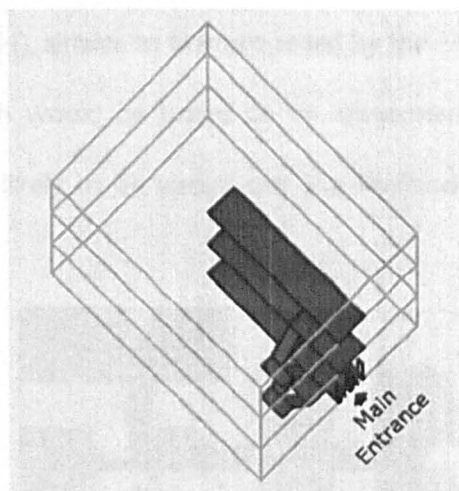
Figure 6.03 Example diagrammatic axonometric conforming to the Change of Level strategy

6.3.3 Walk Towards a Brighter Space strategy

A building designed to the Walk Towards a Brighter Space strategy and ignoring other constraints would feature a distinct contrast of lighting levels between spaces, with decision points (particularly those at major hubs within the building) and destinations likely to be of interest to unfamiliar users more brightly lit than adjacent areas. Natural lighting may be used to this effect as it has the effect of making spaces appear brighter (Binggeli, 2002), however should not be relied upon due to its variability.

6.3.4 Choose the Wider Corridor strategy

A building designed to the Choose the Wider Corridor strategy and ignoring other constraints would feature wider corridors along any route leading to major destinations within the building. There could potentially be a hierarchy of corridor widths, with visitor wayfinding deliberately influenced by including narrower corridors in places intended for limited public access and / or leading to minor destinations (Figure 6.04), similar to that proposed by the NHS wayfinding guidelines (1999). Corridor width would be based on an assessment of the frequency with which a destination is likely to be visited and the likelihood that it will need to be
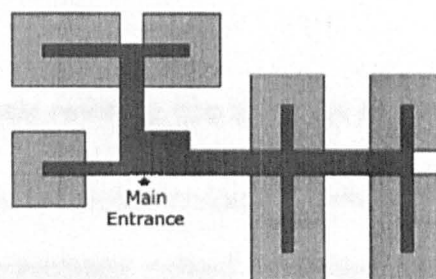
Figure 6.04 Example diagrammatic plan conforming to the Wider Corridor strategy

visited by those unfamiliar with the building. The assessment should also include general factors known to influence corridor width, such as fire assessments and volume of traffic, so that when designing buildings to meet the Choose the Wider Corridor strategy the architect can take advantage of corridors that have to be a certain width.

6.4   Exploration of practical applications

This section comprises an exploration of building designs based on the wayfinding strategies. Unlike 6.3, this discussion is based on existing buildings rather than simplified designs. For each strategy the feasibility of incorporating conformance to the strategy in a refurbishment scheme is considered, as is the feasibility of incorporating conformance in a new-build project based on the same site and accommodation requirements. This section is intended as a brief exploration of potential practical design applications that allow conformance to the wayfinding strategies, in doing so identifying any anticipated problems with such practical applications. As with the rest of the thesis, the Students' Union building and St. George's Complex are the focus of the discussion, however the designs of other buildings which show a clear conformance to particular wayfinding strategies (intentional or not) are also explored.

6.4.1 Refurbishments: revising the location of destinations

As discussed in 6.2, it is not always practical in refurbishment projects to revise an internal layout to accommodate revised circulation spaces that conform to the wayfinding strategies discussed in this thesis, in particular the Maintain a Straight
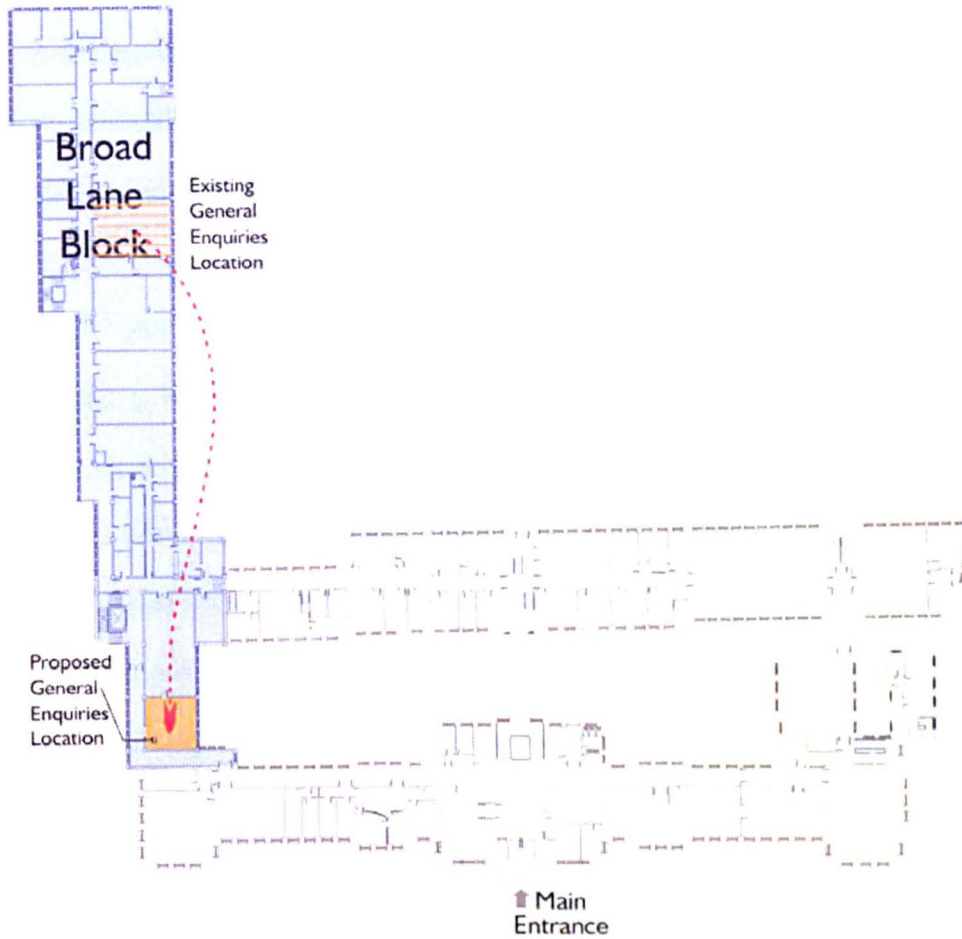
Figure 6.05 Plan of a hypothetical refurbishment of the St George's Complex involving a modification (moving the Civil and Structural Engineering Enquiries Office) that would bring conformance with the Maintain a Straight Bearing and Choose the Wider Corridor strategies, and avoid undermining existing conformance with the Avoid a Change of Level strategy. Source: based on drawing from Estates Department, University of Sheffield

Bearing and Choose the Wider Corridor strategies. An alternative in such circumstances would be to revise the locations of destinations within a building.

The Civil and Structural Engineering Department in the St George's Complex may be considered to be a 'destination zone' (Passini et al., 1998) – an area of the building within which likely destinations may exist, but which, for the purpose of breaking the

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wayfinding task down (and reducing the building to a series of districts; Lynch, 1960) is in itself considered a destination. The Civil and Structural Engineering Enquiries office in the St George's Complex, one of the destinations in the St George's test in Chapter 5, would potentially benefit from relocation for the purpose of improving conformance to the Maintain a Straight Bearing and Choose the Wider Corridor strategies (Figure 6.05). The Enquiries Office is likely to be the first port of call for anyone visiting the Civil and Structural Engineering Department for the first time, however, from the main entrance, visitors have to walk through most of the department before they reach the Enquiries Office. The department covers the area of Level D shaded in Figure 6.05. Were the Enquiries Office moved to the proposed location, near the point where the department is entered, its new location would fulfil the requirements of several of the wayfinding strategies: visitors can presently reach the entrance to the department by following a straight bearing along a wide corridor from the main entrance lobby, at which point the Enquiries Office would be within sight and they do not have to change level as part of this wayfinding task.
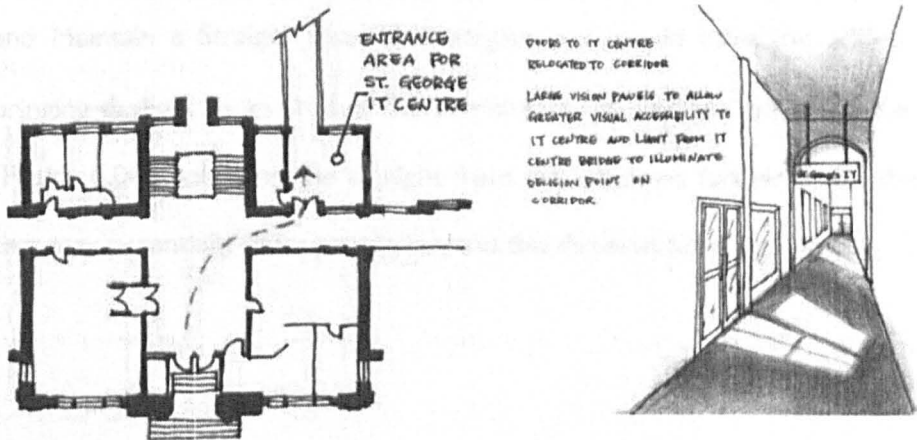
Figure 6.06 Sketch plan of a hypothetical refurbishment of the St George's Complex (changes to the IT suite) conforming to the Maintain a Straight Bearing and Avoid a Change of Level strategies and avoiding existing conflicts with the Avoid a Change of Level and Walk Towards a Brighter Space strategies. Source: author's drawings

The St George's IT Centre is an example of an independent destination within a building. Students wishing to use the IT Centre may be from any department in the University, and the IT Centre is not linked to any of the departments within or outside the St. George's complex. Access to the IT Centre from the main entrance lobby is by a corridor opposite the corridor leading to the Civil and Structural Engineering Department. Perpendicular to this wide corridor is a narrower corridor which leads to a flight of stairs and a bridge crossing the courtyard at the centre of the complex. Conformance to the Choose the Wider Corridor strategy is undermined at the point the visitor has to turn off the wider corridor into the narrower corridor. This could be rectified either by widening this narrower corridor and narrowing the rest of the wider corridor, which would reinforce the route to the IT Centre in its current location but would not conform to the Maintain a Straight Bearing strategy. An alternative would be to relocate the entrance to the IT Centre to the start of the narrow corridor (providing an entrance lobby to the IT Centre in place of WCs that are presently in that location), effectively making that corridor and the bridge part of the IT Centre. This latter solution, similar in principle to moving the Civic Engineering main office, would fulfil both the Choose the Wider Corridor and Maintain a Straight Bearing strategies and would have the added benefit of bringing daylight to an area of the corridor at the decision point for the IT Centre (Figure 6.06), balancing the daylight from the windows further down the corridors that may potentially draw people beyond this decision point.

6.4.2 New-build – providing a main corridor

Should the Maintain a Straight Bearing Strategy and the Choose the Wider Corridor strategies be considered during the design of a new building, both may be conformed to in a design which incorporates a central corridor. This, however, is dependant to an extent on the shape of site available and the direction of approach to the main building as these would be determining factors in providing a central circulation space which is directly accessible from the main entrance. A redevelopment of the Students' Union building (new building on the same site and with the same accommodation) could incorporate a central hub serving a main corridor radiating out either side of the hub as the site is wider than it is deep. Such a design would suit the use of the building well as the building's various functions could be strung along the corridor and access to various parts of the corridor controlled in the evenings (Figure 6.07).
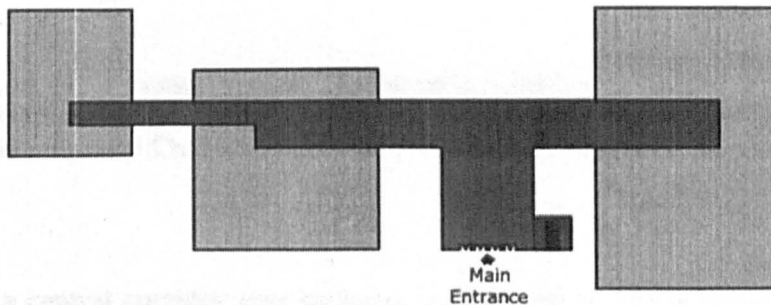
Main
Entrance

Figure 6.07 Diagrammatic sketch plan of a hypothetical redevelopment of the Students' Union conforming to the Maintain a Straight Bearing, Choose the Wider Corridor and Avoid a Change of Level strategies

Departments don't
span floors

Main
Entrance

Indicative of main vertical circulation
Staff only vertical circulation in other
places on plan
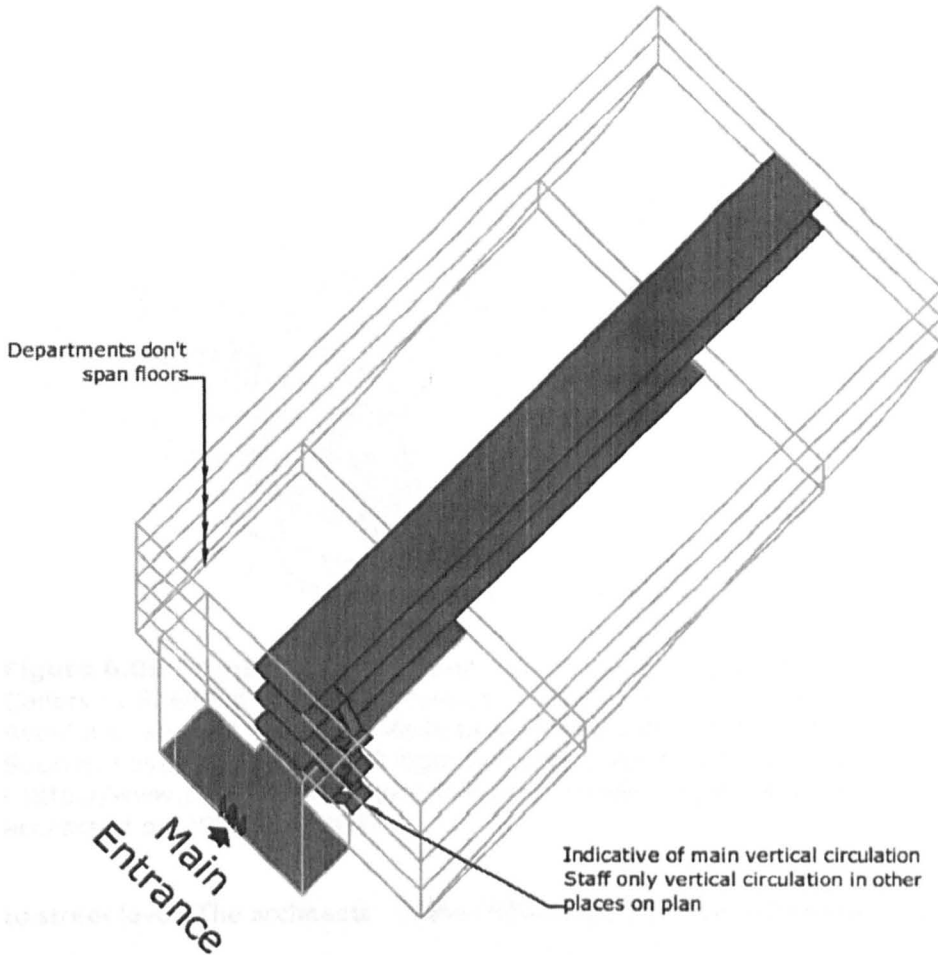
Figure 6.08 Diagrammatic sketch section of a hypothetical redevelopment of the
Northern General Hospital conforming to the Avoid a Change of Level, Maintain a
Straight Bearing and Choose the Wider Corridor strategies

Providing a central corridor may be more problematic in circumstances where the

building is built into a sloping site. This is the case in the Students Union, however

the main circulation route runs along the contour lines of the site's slope. By

comparison, a central corridor serving the Northern General Hospital, as the

hospital's present Vicker's Corridor does, would cross the contour lines of the site's

slope. The Vickers Corridor does not resolve this – the corridor terminates at the

top of one of the buildings at the lower end of the site with no obvious means of exit

Winter Garden entrance, street level access (ground level)

Exhibition area with straight access route adjacent

Point of vertical circulation

Main entrance, street level access (lower ground)
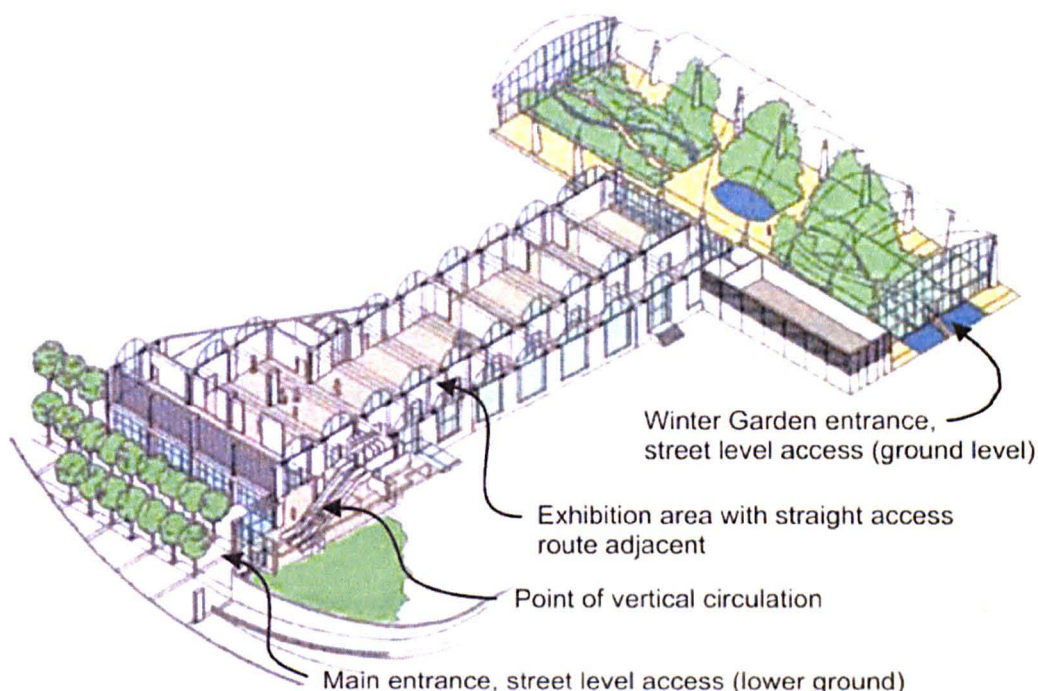
Figure 6.09 Drawing demonstrating the circulation spaces within the Millennium Gallery in Sheffield with level access from two street levels, conforming to the Avoid a Change of Level and Maintain a Straight Bearing strategies.
Source: based on image on Pringle Richards Sharratt Architects website
(http://www.prsarchitects.de/media/prsa_milleniumgall.88dd5cdc.pdf, accesssed on 29th Jan 2009)

to street level. The architects[1] of the Millennium Galleries in Sheffield faced a similar problem and resolved it by placing the building's main vertical circulation at the lowest end of the site and having 'stacked' circulation – two main corridors, one above the other, each serving parts of the building with distinct functions. In doing this, the building also largely conforms to the Avoid a Change of Level strategy as, while a change of level is necessary to reach the galleries on the ground floor, it is at least conducted at the entrance to the building where clear directions may be given by gallery staff and signage. Visitors may therefore easily identify without ambiguity if a change of level is required and be reassured that they are making the correct decision. Following the change of level, all route decisions follow the straight bearing.

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[1] Pringle Richards Sharratt Architects

The Northern General Hospital could potentially follow the same design of 'stacked' Straight Bearing circulation accessed from a single point of vertical circulation near the entrance, achieving the same conformance to the Maintain a Straight Bearing and Avoid a Change of Level strategies that the Millennium Galleries achieves (Figure 6.08 & Figure 6.09). In order to ensure this works, the departments within the hospital would have to be planned to never be split across levels, so that once the change of level has been undertaken no further changes, once within a department, should be necessary. Although not as specifically described, this arrangement would also meet the recommendations in the NHS Estates guidelines on wayfinding (Stationery Office / NHS Estates, 1999)
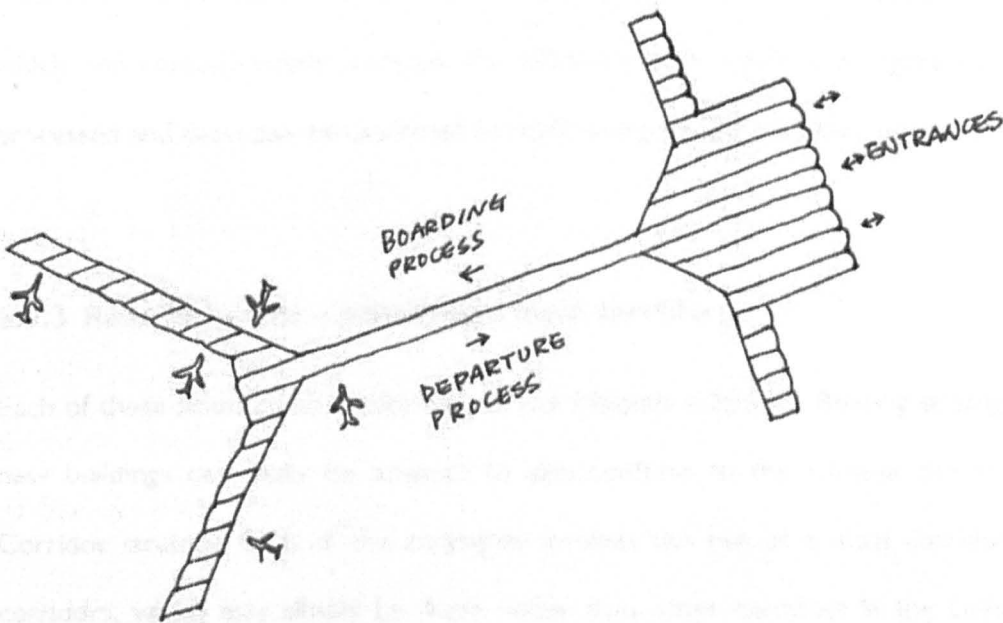
Figure 6.10 Sketch plan of Hong Kong's Chep Lap Kok Airport demonstrating how the building's use has informed a linear plan form. Source: author's drawing

Hong Kong's Chek Lap Kok airport Terminal 1 (Figure 6.10) features an architectural

concept derived from providing passengers with a logical progression through the building. The building's strictly linear form and internal layout utilise the unfamiliar visitors' likely behaviour to ensure that they reach the correct part of this very large terminal in the correct order. This is a particularly clear example of the function of the building informing the wayfinding design. The Maintain a Straight Bearing strategy was deliberately followed through faithfully in the design, providing reassurance to passengers by ensuring that all departure tasks are followed simply by walking in one direction in the building and all arrival tasks followed by walking in the other. If, as is often the case when catching a plane, there is spare time to be occupied, the passenger can wander the building but still pick up the wayfinding task of catching the plane at any point easily as there is little danger of walking in the wrong direction. This has many implications, reducing wayfinding errors and associated stress in unfamiliar users (who are likely to form a large proportion of the building's users), which will consequentially increase the efficiency with which passengers can be processed and decrease the workload for staff having to deal with lost users.

6.4.3 Refurbishment – providing a main corridor

Each of these solutions to conforming to the Maintain a Straight Bearing strategy in new buildings can easily be adapted to also conform to the Choose the Wider Corridor strategy. Each of the strategies involves the use of a main corridor or corridors, which may simply be made wider than other corridors in the building. However, in many circumstances this is not practical in refurbishment projects, typically due to existing structure. Instead of increasing the actual width of the corridor, the solution could be to increase its apparent width by annexing neighbouring spaces.

Of the two spaces in the Montreal Underground mall (Zacharias, 2002) that had positive results, one is of a path defined at its edges by columns. The path's width is emphasised by annexing the spaces beyond the columns. Likewise, many of the corridors in the St. George's Complex feature windows to one wall, thus 'borrowing' an impression of width from the building's external area.

At present, the main entrance level (Figure 6.11) of the Students Union building is experienced as a series of hubs – 3C (the back of the entrance lobby), 3J (at the centre of the shops), 3E (space serving the NatWest bank and STA Travel shop) and 3G (the top of the staircase down to the Interval café). The participants in the observational study appeared to treat these as a series of linearly linked spaces. A redevelopment of the Students' Union that employed an extension to this idea of interconnected hubs would appear to be viable, with further hubs serving University
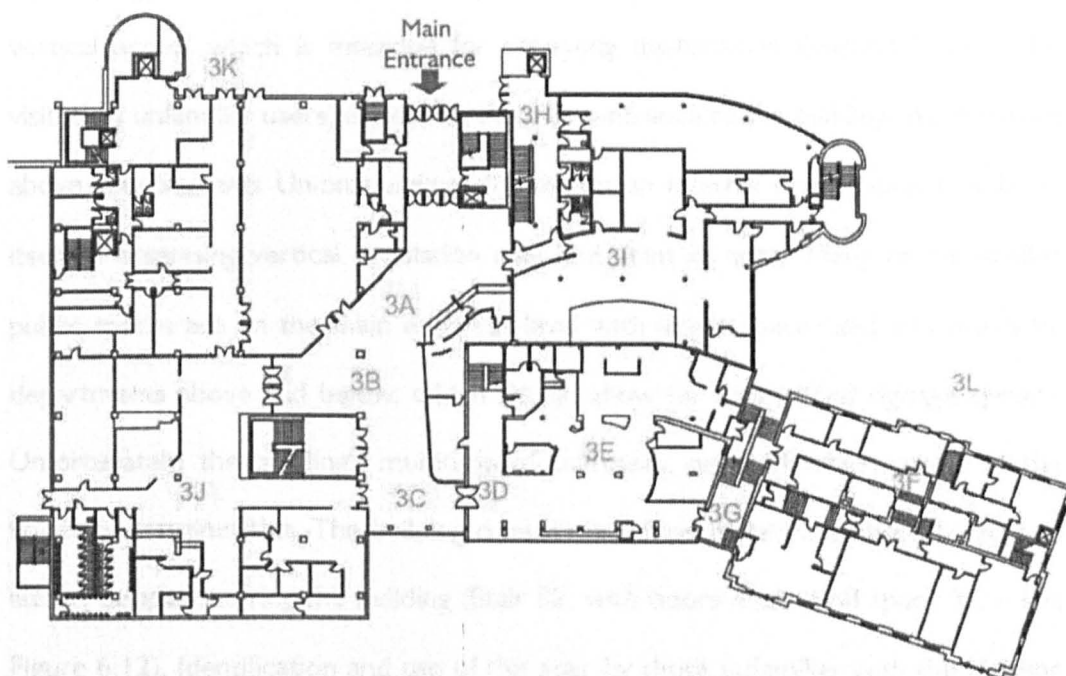
Figure 6.11 Level three of Students' Union showing main entrance and area codes. Source: Estates Department, University of Sheffield

House (the space beyond 3J) and the area currently occupied by the Ents corridor (3F), which would conform to the Maintain a Straight Bearing strategy.

6.4.4 Conformance when destinations are on multiple floors

The exploration for an alternative design for the Northern General Hospital in section 6.4.2 noted that many buildings inherently cannot conform strictly to the Avoid a Change of Level strategy. In this case it is due to the sloping site common to many of Sheffield's buildings, where public entrances into the building have to be on different floors. It may also be due to limited space on the ground floor for all the desired publicly-accessible destinations, or the unsuitability of the inclusion of certain destinations on the ground floor due to their architectural form.

In the alternative design for the Northern General Hospital and the existing Millennium Galleries design, the main vertical access within the building (i.e., the vertical access which is intended for accessing destinations deemed likely to be visited by unfamiliar users) is close to the main entrance to the building. As discussed above, the Students Union building already has an internal organisation that lends itself to organising vertical circulation near the point of entry. Many of the smaller public spaces are on the main entrance level with larger spaces and administrative departments above and below, which should allow for a simplified signage system. Unfortunately, the building's multitude of staircases, none of which serves all the floors, undermines this. The building does, in fact, have a staircase ideally located to attract people entering the building (Stair S2, with doors leading off space 3C – see Figure 6.12). Identification and use of this stair by those unfamiliar with the building should increase were it to be enclosed in glazed screens rather than solid walls.

Although it is fortunate that, in this case, a suitable staircase already exists for modification and that this is not necessarily the case in other buildings, it still demonstrates that relatively small and cheap changes, achievable within a refurbishment scheme, can potentially improve conformance to wayfinding strategies simply by improving the visual accessibility to the necessary parts of the building.
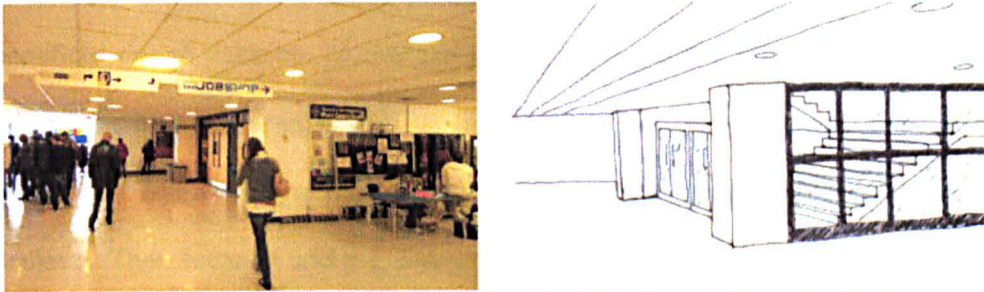
Figure 6.12 Sketches of a hypothetical refurbishment of the Students Union building partially conforming to the Avoid a Change of Level strategy (modifications to Stair 2). Source: author's photograph and drawing

6.4.5 Providing natural lighting for Brighter Space conformance

Conformance to the Walk Towards a Brighter Space strategy is likely to be achievable in most projects (refurbishment or new-build) by using artificial light. There may be complexities to achieving an appropriate lighting balance to draw visitors from decision point to decision point, particularly when aspects such as overheating, dazzling and providing unworkably low light levels are considered. At its most simplistic, however, it is a case of just adding or removing luminaires. When brighter lit spaces are required, the recommendation in this study is that there is artificial lighting provision to achieve the necessary brightness as the presence of artificial light is more reliable than daylight – most buildings will be used at some point following sunset. However, only providing artificial lighting when natural light could be available is rightfully considered wasteful. Additionally, natural light and the

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windows that bring it into buildings have further benefits that may be exploited. This section therefore concentrates on natural light as a means of increasing the light levels in a space, which is supplemented with artificial light for occasions when the daylight levels are too low to achieve the required brightness within the building.

The use of natural light in buildings is promoted to architects as an environmentally beneficial design decision. Numerous products are on the market to help designers bring light into buildings, including sun pipes and windows for unusual locations. These are often designed to be included in either new-build or refurbishment projects. Their location and the intensity of light captured are highly beneficial should they be adopted to meet the requirements of the Walk Towards a Brighter Space strategy. It is important that they are arranged such that areas that need to draw visitors, such as entrances to main destinations and decision points, receive the most

Figure 6.13 Comparison of two spaces in the St George's Complex, one naturally lit (on level D), another artificially lit (the same location in plan on level F). Source: author's photographs

light. The angling of sun pipes, for instance, could be adjusted so that a destination space receives direct daylight while surrounding spaces receive ambient daylight.

In both the St. George's Complex and the Students' Union Building, parts of the circulation that would otherwise be perceived as dead ends are illuminated with natural light. In both cases the point where a change of direction is necessary is illuminated. Also, in both cases, the change of direction is into a space lacking visual access (Figures 6.13). Of the paths used for the experiment in the Montreal Underground mall (Zacharias, 2002), one of those receiving negative results did because it appeared to terminate in a blank wall. On plan the layout at this change of direction would not be dissimilar to that in the St. George's Complex, with the exception that in the St. George's Complex the wall has external windows. In the St. George's Complex, the wayfinding task that took participants along this corridor was considered better (more comfortable, more confidence inspiring and less likely to leave an impression of disorientation) than the same route on a different floor in
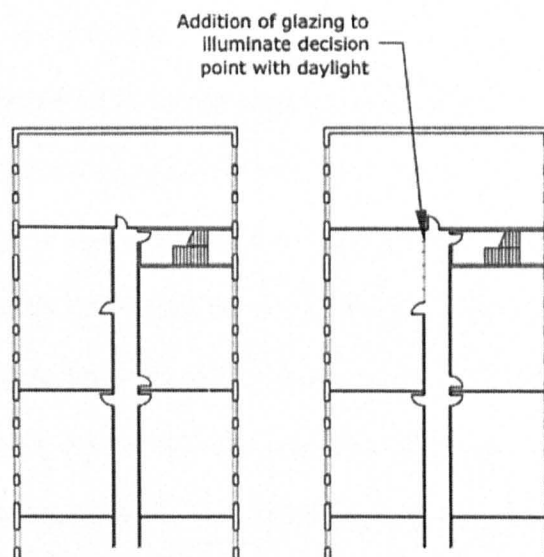
Figure 6.14 Example plans demonstrating meeting the Building Elements of natural light at junctions in refurbishment scenarios.

which the corridor was not glazed at this point.

Conformance to the Walk Towards a Brighter Space strategy using natural light in a refurbishment project would be partly influenced by the building's size. Fortunately, multi-storey buildings with very deep plans and rooms completely lacking natural light are rare, as it has for some time been a requirement that most workspaces are able to be naturally lit. Light could be borrowed to illuminate intersections and destinations by reorganising the use of rooms so that those at intersections can be given glazed walls allowing illumination of corridors from more sources than simply the corridor's own artificial lighting (Figure 6.14).

6.5   Summary

Within this chapter several designs were explored which would conform to the wayfinding strategies set out earlier in the thesis. These included the provision of a 'main corridor', linking the main entrance to each of the main destinations (or departments) within the building. There should be a straight bearing along this corridor from the main entrance to destinations / departments. The corridor may be curved, so long as the corridor is perceived to be one circulation space and visitors navigating along it do not feel they are deviating from their chosen path because of the curve, and should be the widest and most obvious route to take from the main entrance. Wherever possible, destinations likely to be of interest to visitors should be located on the ground floor and accessed from this main corridor, however in buildings consisting of departments or individual destinations across multiple floors, there may be multiple main corridors on different floors. In this case the vertical

circulation should be resolved early on, ideally near the main entrance.

In refurbishment projects, many of the wayfinding strategies could be most easily conformed to by a reorganisation of the destinations and departments that the circulation spaces serve, rather than altering the circulation spaces themselves. Larger buildings may be organised into clear departments with the department's main point of contact (for example, a General Enquiries office) located at the entrance to the department. It should be ensured that this departmental entrance is on a main route from the building's main entrance. Also, entrances to departments may be relocated, so that departments encompass the minor circulation spaces serving only them and are accessed directly off main circulation routes through the building.

Conformance to the Walk Towards a Brighter Space strategy would require control over the amount of light, both artificial and natural, at decision points in circulation spaces and destinations. This may be either an increase or decrease in natural light levels with increases concentrated at decision points and major destinations. Natural light may be borrowed 'through' spaces next to circulation spaces if the circulation space itself lacks external walls. On top floors of any building rooflights or sunpipes may be used, again with the light levels they produce controlled so that light levels at decision points and major destinations are always higher than along stretches of circulation spaces.

The designs explored are by no means an exhaustive list of those that will allow

conformance to the wayfinding strategies. These solutions should also not be considered in isolation. It was the intent of the discussion to provide examples that, with one design change, conformed to several of the wayfinding strategies. However, even if this is achieved within one space in a building, it can still be undermined by a lack of consideration of neighbouring spaces. The Northern General Hospital includes an existing example of this. Section 6.4.2 proposes main corridors as a means of conformance to the Maintain a Straight Bearing strategy. This design would also conform to both the Avoid a Change of Level and Choose the Wider Corridor strategies. The Northern General Hospital does, in fact, already feature a circulation space (the Vickers Corridor) which in itself largely conformes to the Maintain a Straight Bearing and Choose the Wider Corridor strategies, however these are undermined by the narrow and winding corridors and hidden vertical circulation that has to be navigated in order to reach either end of the corridor.

The designs, and the strategies themselves, should also not be considered in isolation of other wayfinding strategies not covered in this thesis. The wayfinding strategies explored here were chosen as they were found in previous research to have an influence on path choice during wayfinding, which the observation conducted in the Students' Union building supported. However, it is recognised that there are a wider range of wayfinding strategies and building design factors that influence wayfinding decisions than those explored here, each of which may have an influence on the design of buildings. These include the visual accessibility of spaces and architectural elements, which has been touched on in this chapter. Research into these may further refine the design examples given here.

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7

Conclusions

7.1   The focus of this study

The primary focus of this study is how to reduce the stress experienced by people finding their way around unfamiliar buildings. Such wayfinding tasks may have to be conducted at times which are already stressful, for example visiting a relative in an unfamiliar hospital, attending a job interview at an unfamiliar company office or catching a flight, and in these circumstances in particular the stress should not be compounded by the addition of wayfinding stresses imposed within these buildings. This research therefore investigates ways in which the visitor to an unfamiliar building may be reassured that they are following the correct route through the building and have made the correct path choice at decision points.

It was found, through the literature research documented in Chapter 2, observational study documented in Chapter 3 and Corridor Width experiment documented in Chapter 4, that several wayfinding strategies have an influence on wayfinding decisions. These strategies are typically used by people in unfamiliar environments and are related to the spatial design of buildings, and therefore are particularly relevant to this study. Other research into the use of the wayfinding tasks by people familiar and unfamiliar with the same space found those familiar with the

space made different path choice decisions. These decisions showed an apparent understanding of the building as a whole and therefore relied upon information held in the mind from previous experience of the building - the person's 'cognitive map' of the building. This is built up over time from the analysis of information observed in the environment. The more information that is known and understood, the more complete and reliable the cognitive map. By comparison, an unfamiliar user only has information they can observe in their immediate environment without the benefit of prior analysis or experience of the neighbouring spaces. This information may be too great or too scarce to make meaningful analysis of immediately. The wayfinding strategies are typically relied upon in such circumstances to inform decisions about path choice, particularly early on in the wayfinding task, and appear to be used as a means of reducing the errors that may occur as a consequence of misinterpreting the information available in the environment.

The review process culminated in a categorisation of previous wayfinding research into one of two Wayfinding Principles: research that studied the tools available to visitors when wayfinding (e.g. printed information such as signage and maps, information in the environment such as landmarks); and research that studied people's wayfinding behaviour and wayfinding strategies identified within this behaviour. It was proposed at this point that routes that may be completed by following the wayfinding strategies (i.e. the spatial design of the building along those routes complies with expected interactions predicted by the wayfinding strategies) result in easier and more intuitive wayfinding tasks, providing reassurance to unfamiliar visitors that they are following an appropriate route. As this study has focussed on the wayfinding strategies, it is the Reassurance principle which is

discussed throughout the thesis. The Wayfinding Principles have a further purpose – the Reassurance principle embodies the intent of the various wayfinding strategies, therefore if none of the strategies may be conformed to there may still be some benefit to wayfinding performance if some other form of tool or reassurance can be included in the design.

This study aimed to take this understanding of wayfinding strategies and use it to inform the spatial design of buildings. From the literature review it was found that little of the current research directly relates wayfinding performance back to the design of the environment (Conroy-Dalton, 2001). It was therefore proposed in this thesis that a building conforming to the wayfinding strategies would have destinations that would be more intuitive to find. This conformance would take the form of plan and section layouts and destination locations that would allow visitors to find destinations by following one or more of the wayfinding strategies. In the case of wayfinding strategies not used within a building design, the design should at least not directly conflict with a particular strategy. Conformance to the strategies within the design would mean that, at and between each decision point, the building's design would present to the visitor design attributes they would expect – for instance, when finding a primary public space within a building (a space considered a likely destination for an unfamiliar user), assuming this is not located next to the main entrance, the corridors leading to it are the wider corridors within the building. This should reassure visitors that they are on a route appropriate to the destination they are seeking, and thus reduce the stress of the wayfinding task. As already mentioned, it is also important to ensure that, at the very least, the building does not conflict with the wayfinding strategies. This would risk presenting the visitor with an element

of the building which may not be what they would expect and thus make them question their path choice decisions conducted to that point during the wayfinding task.

7.2   Findings augmenting the current body of knowledge

The observation documented in Chapter 3 was found to support the literature in Chapter 2. Of the four wayfinding strategies identified as having a particular influence on path choice, one was found to have had limited research devoted to it. The width of corridors was frequently mentioned by participants in a path choice preference test conducted by Zacharias (2002) as having an influence on their choice of paths within a building. This study did not isolate corridor width as a building factor, and whilst some studies including that by Gotts (1992) do, they are typically concerned with appropriate path widths (pedestrian or vehicular) for certain traffic levels. It was therefore considered that further study of this was essential if the consideration of corridor width was to be relied upon as a possible influence on path choice. Chapter 4 documents an experiment which isolates corridor width as the single variable and studies what path choices are made by the participants when presented with different corridor widths. The hypothesis of this experiment, based on Zacharias findings, was that participants would favour wider corridors when given the choice between two corridors of different widths.

One of the goals of this study was also to determine how the various wayfinding strategies work with each other. To date, the research about the strategies has either concentrated upon each strategy in isolation (such as the research into the Initial

Segment and Least Angle Strategies from which the Maintain Straight Bearing strategy is derived) or within an observation or test such as Zacharias' path choice studies within which it is difficult to determine, beyond the notes given by the participants, which wayfinding strategies are influencing the cognitive processes behind the path choices and to what extent their influence is. The opportunity was therefore taken, within the Corridor Width experiment, to study both path choices made when the only variable was corridor width, and path choices made when there was also a choice between maintaining a straight bearing and taking a 'side corridor' of greater width than the straight bearing corridor.

The results from the experiment supported the primary hypothesis that people have a preference for choosing wider corridors, however when this wider corridor would lead to a deviation from the straight bearing, maintaining the straight bearing appears to take precedence. The preference for maintaining a straight bearing is only overcome when the straight bearing corridor narrows at the decision point (in relation to the part of the corridor preceding the decision point, i.e. entrance corridor). An interpretation of this may therefore be that the overriding concern for people, given both variables, is that they do not deviate from the chosen path, even if the path appears to turn a corner. This assumes that participants were reading the narrowing straight bearing corridor as a deviation from this path. It is potentially valuable for building designers to know and understand this wayfinding behaviour as corridors with changes of direction are often more readily incorporated into buildings than corridors that perfectly conform to the Maintain a Straight Bearing strategy.

Parts of this work have been published in several conference proceedings (Chang, 2004a; 2004b; Chang & Fotios, 2008), in the journal Design Principles and Practices (Chang & Fotios, 2009) and in a Chinese journal 建築業導報 (Building Review) (Chang, 2006).

7.3   Findings augmenting the body of information used in architectural practice

Chapters 5 and 6 focus on the suitability of the four wayfinding strategies as the basis of guidelines on wayfinding designs. Chapter 5 documented a test conducted within a building in Sheffield University to determine whether the perceived difficulty of routes matched predicted difficulties, with predictions based upon whether the routes could be successfully navigated by following the wayfinding strategies. The results from this supported the hypothesis, and hence supported the idea that the ease with which a building may be navigated is related to how faithfully it conforms to the wayfinding strategies. This is considered a precursor to building designs which consider wayfinding ease from the outset. Chapter 6 expands upon this by discussing potential ways in which building designs may conform to the wayfinding strategies.

Chapter 6 does not go as far as to propose wayfinding guidelines. Rather, the chapter sets out to demonstrate the practicality of using the wayfinding strategies as the basis for design decisions. Although this material may not find its way directly into the recommendations put forward by wayfinding guidelines, this process would nevertheless be essential in determining that the guidelines offer practical advice to architects. If it was found by architects that wayfinding guidelines were too prescriptive, inflexible and / or impractical, it is likely that they will be overlooked.

Such wayfinding guidelines should therefore be flexible and not specifically tied to any particular type of building. They would not be intended as a replacement for those produced by bodies such as the NHS – the NHS's guidelines are aimed primarily at hospital managers and contain information about wayfinding within hospitals which may not be relevant or appropriate to other building types. Any wayfinding strategy-based guidelines could, however, be incorporated into the NHS guidelines as wayfinding strategies are still used by people when navigating hospitals. The NHS guidelines do explain wayfinding processes and advise simplifying hospital sites and buildings and improving visual accessibility – advice based on an understanding of wayfinding strategies could be a useful supplement to this.

7.4   Limitations and future research

Wayfinding is a broad area of research, covering multiple disciplines. Much of the research to date has concentrated on the complex information analysis and decision making processes conducted during the execution of a wayfinding task. Wayfinding stress and path choice reassurance are psychological studies. Additionally, this study has been conducted from an architectural point of view, with the consideration that those in practice may benefit from architectural guidelines that suggest ways in which buildings may be designed to be easier for unfamiliar users to wayfind within and dispel the notion that wayfinding 'problems' can be solved with just signage. This therefore has to be made with the practical and aesthetic considerations of architects in mind.

Given the broad area of study and the intention to consider wayfinding at the

architectural design level, which relied upon an analysis of the cognitive and psychological processes as a precursor, it was necessary to concentrate on a narrow selection of wayfinding behaviour (and hence strategies). For example, within the observation in the Students' Union, several trends across the participants' results were observed, any one of which may have warranted further investigation and potentially been identified as a new wayfinding strategy. However, these equally could have been trends specific to the layout and architectural design of the Students Union building, and would not be repeated by the same participants in a different environment. In order for them to be reliably studied further, additional observations and experiments, such as those conducted for the Choose the Wider Corridor strategy, would have to be undertaken. This would be a considerable undertaking for all possible trends and any others noted in studies of a broadly similar nature, such as that conducted by Zacharias (2002). The four strategies considered throughout this study were chosen on the basis that they have already been identified and studied in earlier research as not being environmentally-dependent and, particularly in the case of the Choose a Wider Corridor strategy, that they appeared to have a noticeable and consistent influence on wayfinding behaviour. Further research may concentrate on analysis of the other trends and possible identification of new wayfinding strategies and ideally should be tested for prevalence against the other wayfinding strategies as the Choose the Wider Corridor strategy was against the Maintain a Straight Bearing strategy. An understanding of further strategies would ultimately give architects further options for improving the ease with which their buildings may be used.

As well as studying other wayfinding trends, further research may also focus on

alternative ways in which the behaviours that the wayfinding strategies discussed in this study may be triggered. One of the findings from the Corridor Width experiment, for example, was that keeping to the same path appeared to take precedence over maintaining a straight bearing. It may be possible that other methods could be used to trigger the same behaviour, for example differences in décor, however further study is required to identify these alternatives and also determine the reliability with which they influence path choices.

Lastly, there are several limitations and issues that have been encountered as a consequence of studying the built environment. The very wide variety of buildings, building types and building elements potentially introduces a great number of variables within any study. Each of these adds to the complexity of the cognitive processes being undertaken as wayfinding tasks within buildings are executed. They also mean that the findings from a study in one building may not be applicable to another building. This study therefore uses two buildings rather than one as the focus of experiments. While it is accepted that both are educational buildings and may not be as frequently used by people in as stressful situations as catching a flight, they were considered to be suitable samples as neither is strongly distinctive in its architecture nor strongly task-led in its design (as is the case with the Chep Lap Kok airport, for example) and there is a different variety of building elements in each to test the wayfinding strategies against. However, it is recognised that there would be value to testing the findings from this research against a wider range of buildings.

The difficulty of changing the built environment has had a bearing on experiment methodology. The Students' Union study, for example, is limited to an observation as

such a large number of variables mean the results may be interpreted one of several ways. One way to isolate individual variables would be to repeat the study but with specific elements of the building altered, however this would be very costly.

This limitation led to the use of a virtual environment for the Corridor Width experiment within which the width of the corridors could be altered as the only variable. The methodology of this experiment was based on the methodology used by Taylor and Socov (1974) in their study of path choice based on brightness levels. A real environment was used for this, however changing the lighting level poses fewer practicality problems than changing the width of a corridor. As a means of further testing the findings from the Corridor Width experiment, further research using a purpose-constructed real environment such as that used by Taylor and Socov may be valuable. Although flexible, virtual environments have their own methodological problems and Taylor and Socov's study arguably distracted participants from the true focus of the experiment better than the Corridor Width experiment.

Advantages of the virtual environment used in the Corridor Width experiment, besides the flexibility of being able to make changes to the environment that are impractical in a real environment, were the possibility of gaining a comprehensive data set, obtaining multiple results per person and allowing participants to undertake the experiment in their own time. The interface used may present a barrier to participants as the actions it requires to confirm a path choice decision and the lack of freedom to explore are different to that experienced in real environments. More sophisticated tools, such as the virtual reality systems used by some wayfinding

researchers (e.g. Conroy-Dalton, 2003), would answer this to a degree.

7.5 Conclusion

It was noted that people find being lost stressful and rely upon wayfinding strategies when faced with an environment they are not familiar with. This thesis set out to identify how the spatial design of a building affects wayfinding for unfamiliar users. Four wayfinding strategies were examined: walking towards the brighter lit of a set of route options (Walk Towards a Brighter Space strategy); choosing the wider of a set of route options (Choose the Wider Corridor strategy); avoiding changes of level (Avoid a Change of Level strategy) and avoiding changes of direction (Maintain a Straight Bearing strategy). These strategies tend to be employed when information directly relating to their destination is lacking.

Each of the wayfinding strategies has received varying levels of attention in previous studies by other researchers. A range of strategies was identified in the literature and an observational study was conducted to observe whether these strategies were apparent in the wayfinding behaviour of unfamiliar users in a building known to the researcher. The four strategies that formed the focus of this research were chosen through this procedure.

Three of these strategies were supported by earlier experiments by other researchers demonstrating how they were used during wayfinding tasks. However, the wider corridor strategy only had support from the observation and verbal feedback given in a wider-ranging experiment on path choice. This verbal feedback

was high on the list of path choice reasons recorded and explained a large number of the path choice decisions made by the participants in the observation. The Corridor Width Experiment was therefore conducted to formally investigate the influence of corridor width on path choice.

The findings of the St George's study demonstrated that wayfinding difficulty could be predicted by analysing routes for conformance or confliction with the various wayfinding strategies at each decision. By extension, this implies that wayfinding problems can be reduced by careful design of buildings by considering how particular junction and route designs will perform when the wayfinding strategies are used as the basis for decision making.

In the Introduction chapter the present lack of *general wayfinding design guidelines* for architects was considered. It is proposed that such guidelines could be based around this understanding of wayfinding strategies. The intent would be that architects can design major junctions along routes to common destinations such that the correct exit is the one that would be chosen if the wayfinding strategies are employed. This should reassure people that they are on the correct route, make the building more intuitive to navigate and lead to a less serious impact on wayfinding performance if the person who is wayfinding is distracted from the wayfinding task.

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A

Appendix A: Supporting information for the Observational Study – Union Study

Appendix A includes supporting information for the observational study conducted in the University of Sheffield's Students' Union building. A.1 shows the instructions giving to the participant at the beginning of the test and A.2 shows routes taken by each of the participants.

A.1   Instructions to participants

Below are instructions given verbally to participants (notes in square brackets explain the point at which these were mentioned in the experiment).

[Start at the main entrance foyer facing the Box Office]

Thank you for participating in this experiment.

I wish to find out how unfamiliar users like yourself will explore and find your way around a building.

I would like you to walk around the building and while you do this, please point out to me anything that you pick out as landmarks. These can be anything you can see, whether it is a part of the building or an object, for example something placed in the corridor.

[Following the participant and map the route]

I will now take you round the building again, but this time, please follow my directions and start and stop when I ask.

[Go back to Common Room to complete questionnaire and a sketch map]

A.2 Routes taken by participants

Figures A.01 ~ Figure A.24 show the routes taken by participants during the observational test. During the test the participants were followed by the researcher and the routes they took recorded on copies of the Students' Union building floor plans.
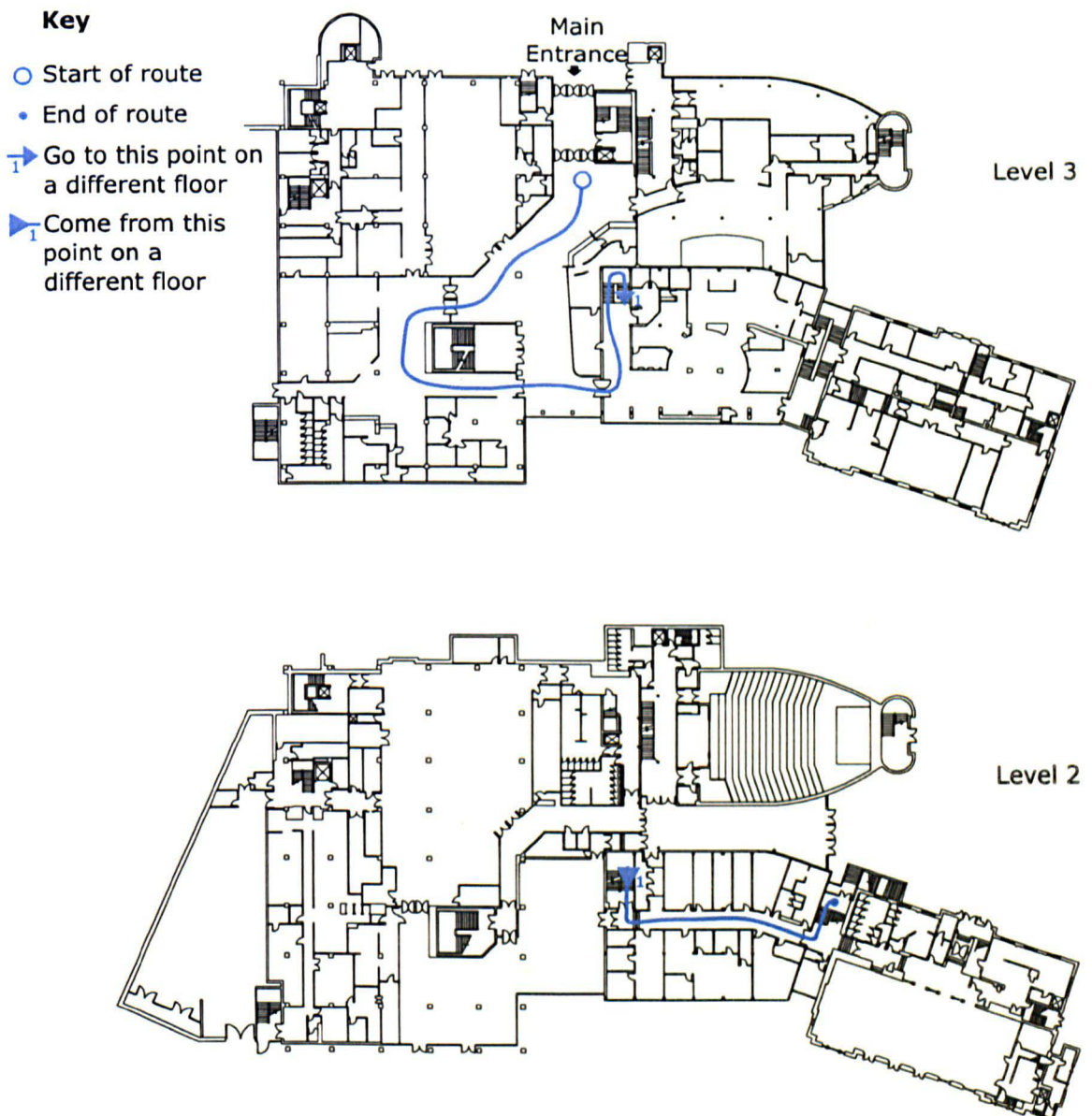
Figure A.01 Union Study : Route taken by Participant 1

Main Entrance

Level 3

Level 2
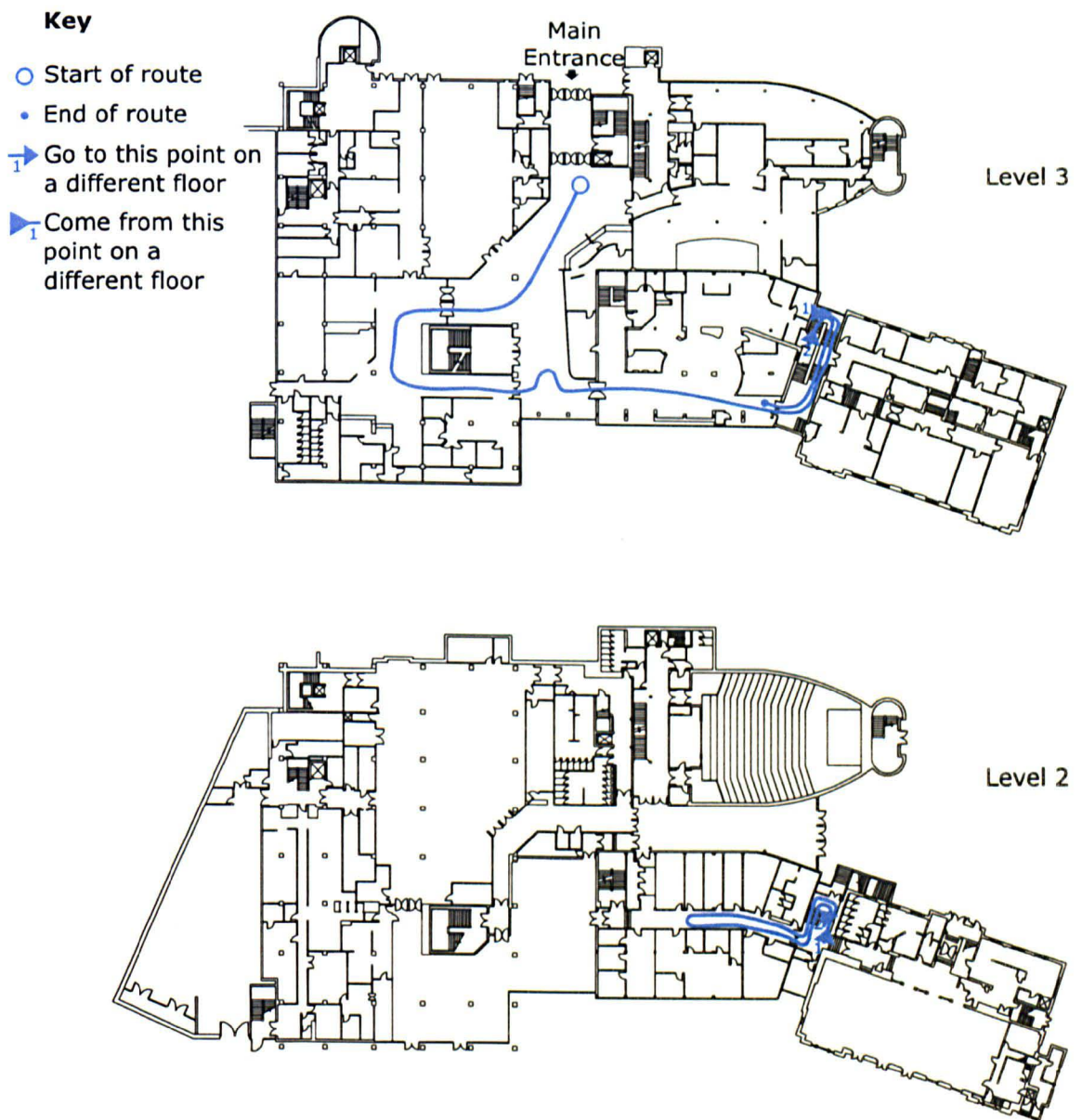
Figure A.02 Union Study : Route taken by Participant 2
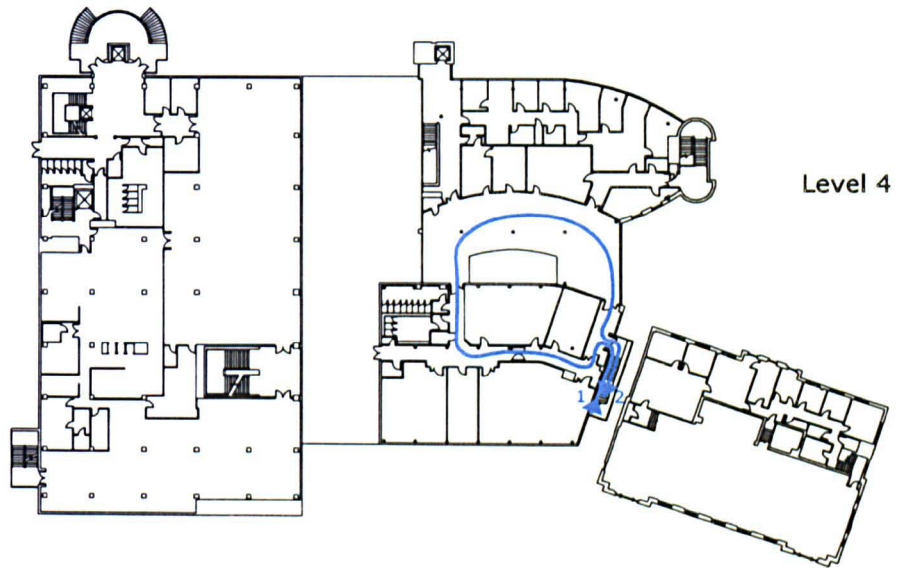
Level 4

Level 3

Key

○ Start of route

• End of route

Go to this point on a different floor

Come from this point on a different floor

Main Entrance
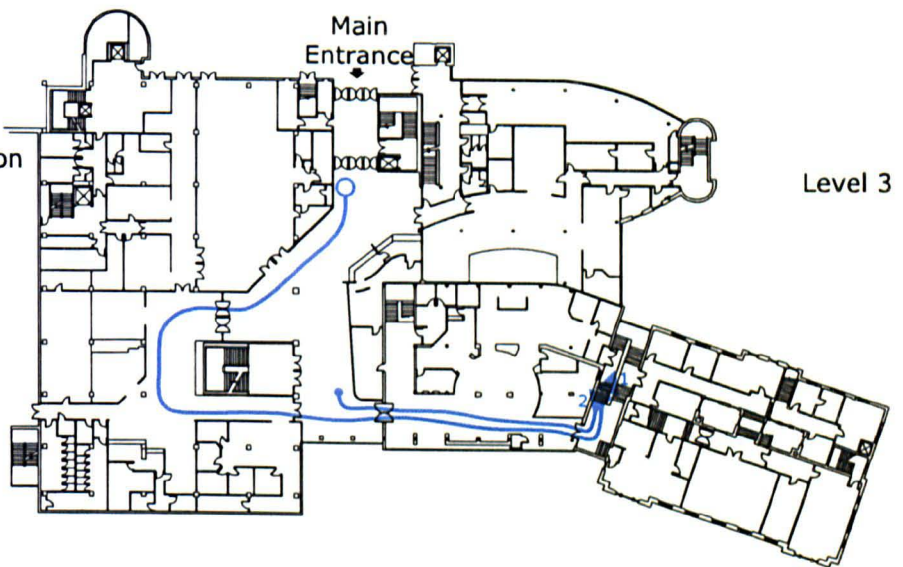
Figure A.03 Union Study : Route taken by Participant 3

Key

○ Start of route

• End of route

→ Go to this point on a different floor
  1

▶ Come from this
  1 point on a different floor

Main Entrance

Level 3
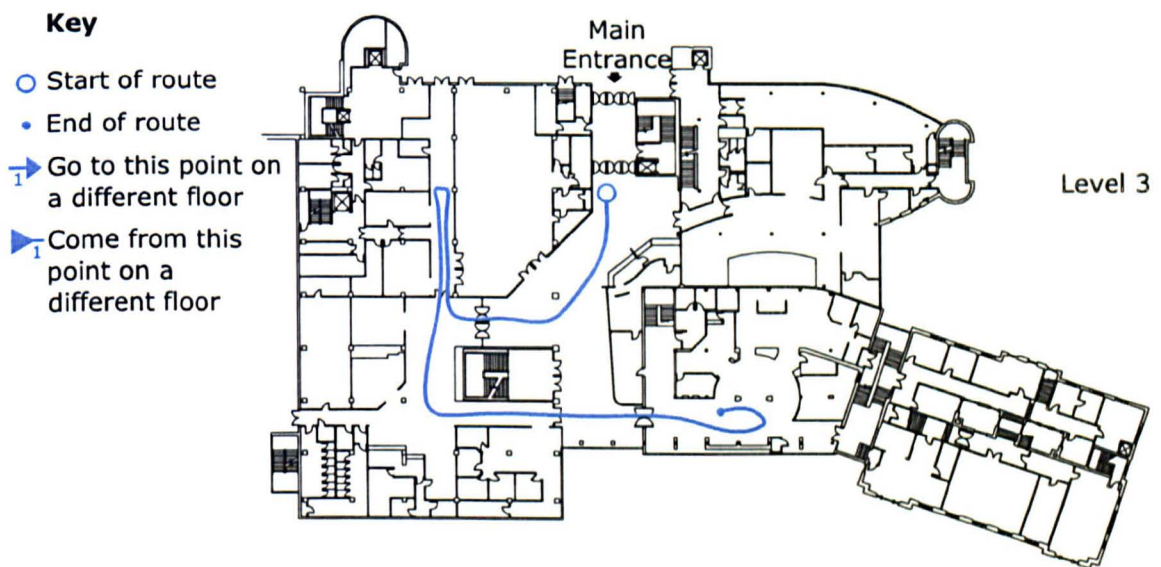
Figure A.04 Union Study : Route taken by Participant 4

Level 4

Key

○ Start of route

• End of route

▶ Go to this point on a different floor

▶ Come from this point on a different floor

Main Entrance

Level 3
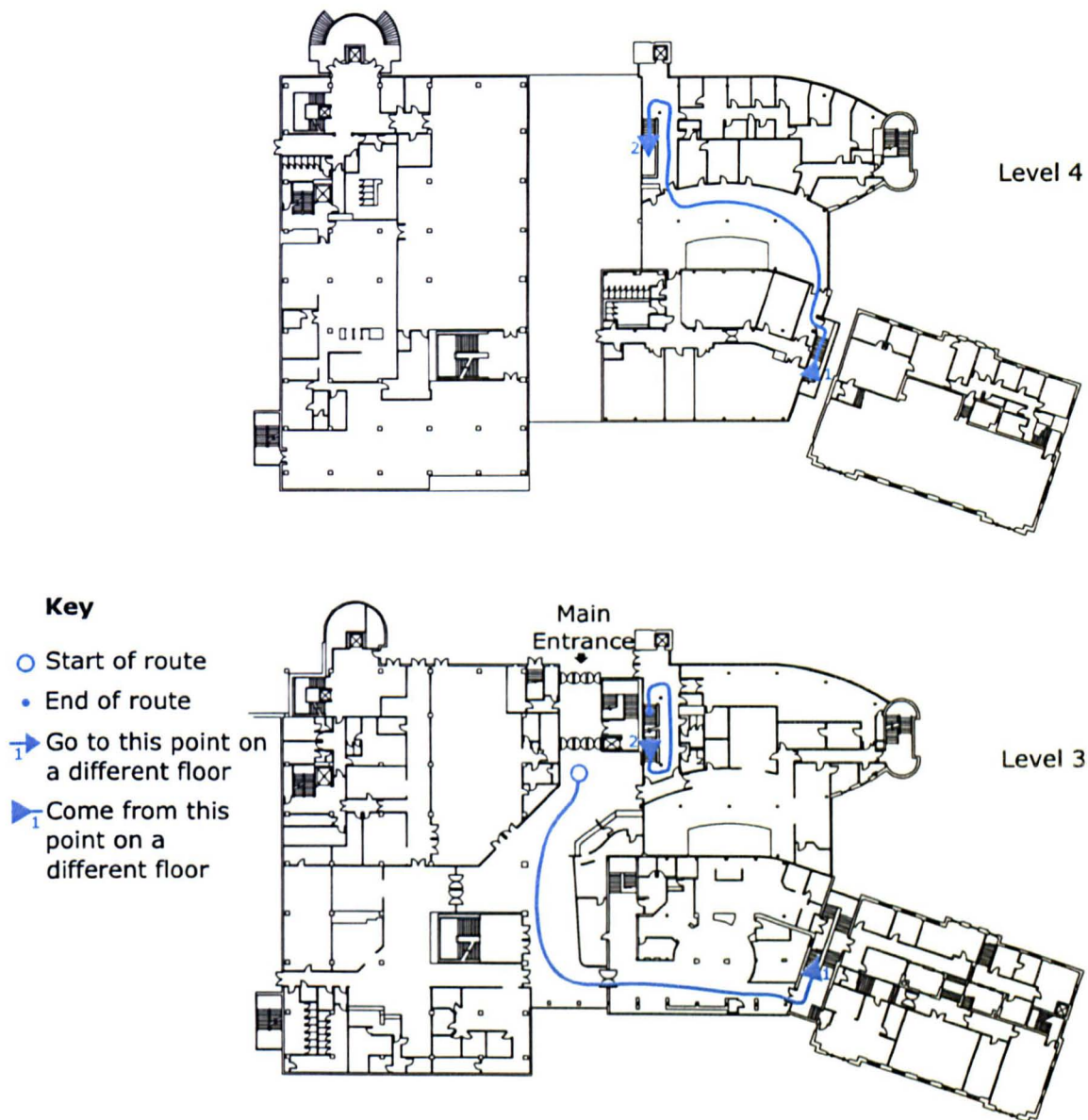
Figure A.05 Union Study : Route taken by Participant 5

Key

○ Start of route

• End of route

▶ Go to this point on
a different floor

▶ Come from this
point on a
different floor

Main
Entrance

Level 3

Key

○ Start of route

• End of route

➡ Go to this point on a different floor

▶ Come from this point on a different floor

Main Entrance

Level 3

Level 2
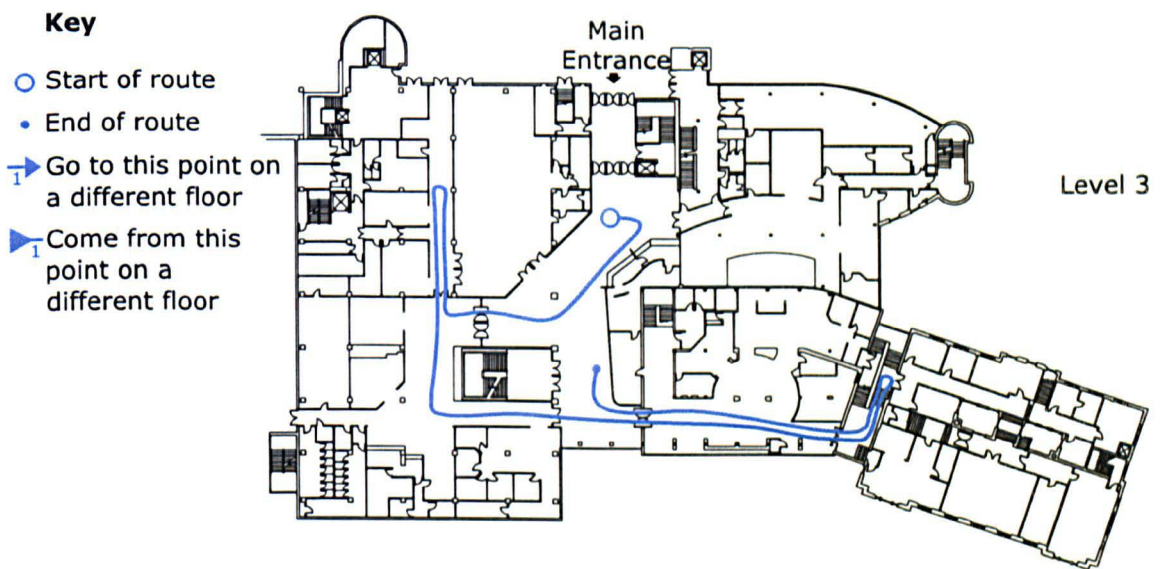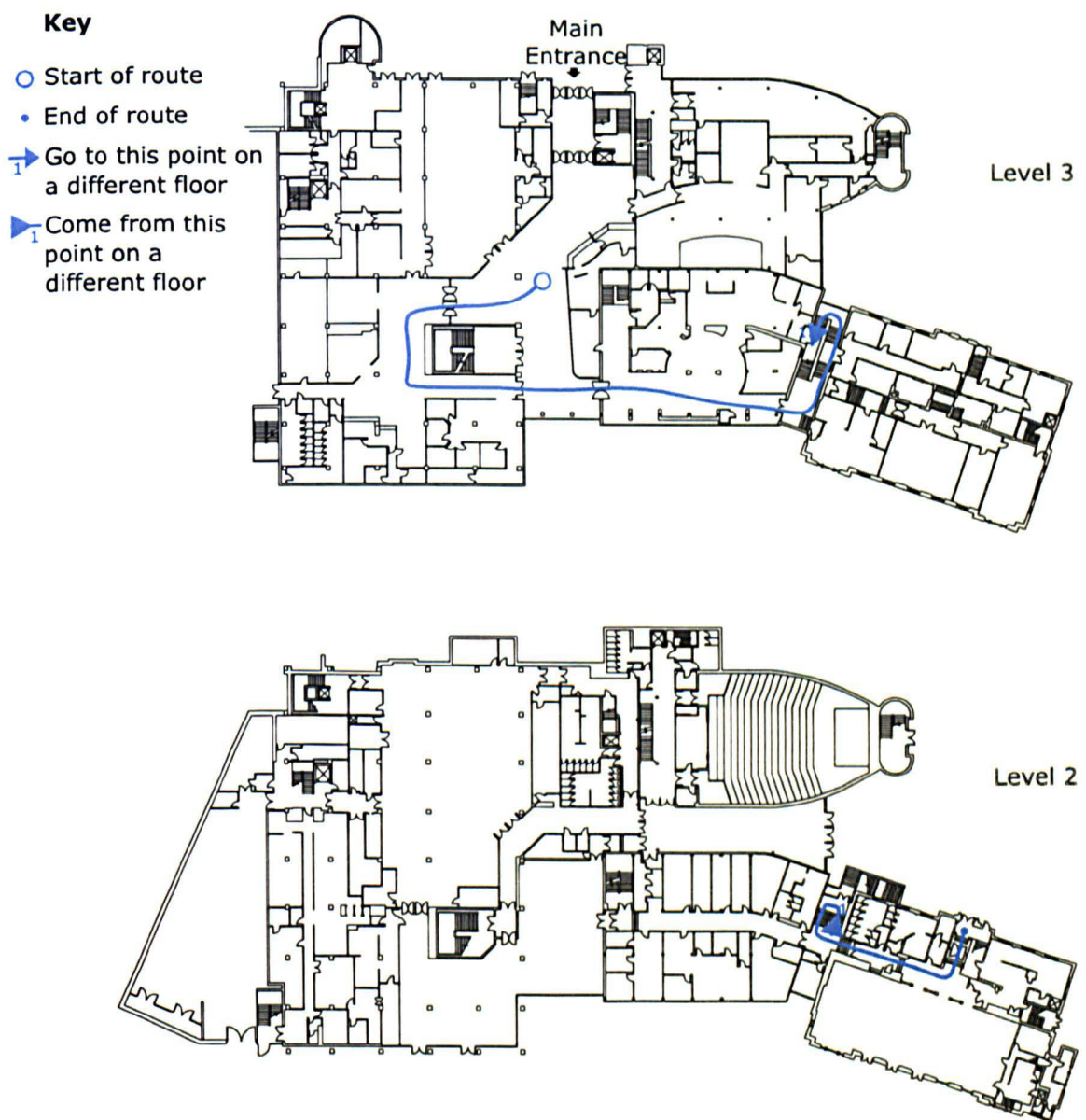
Figure A.07 Union Study : Route taken by Participant 7

254

Key

○ Start of route

• End of route

◄ Go to this point on a different floor

◄ Come from this point on a different floor

Main Entrance

Level 3

Level 2
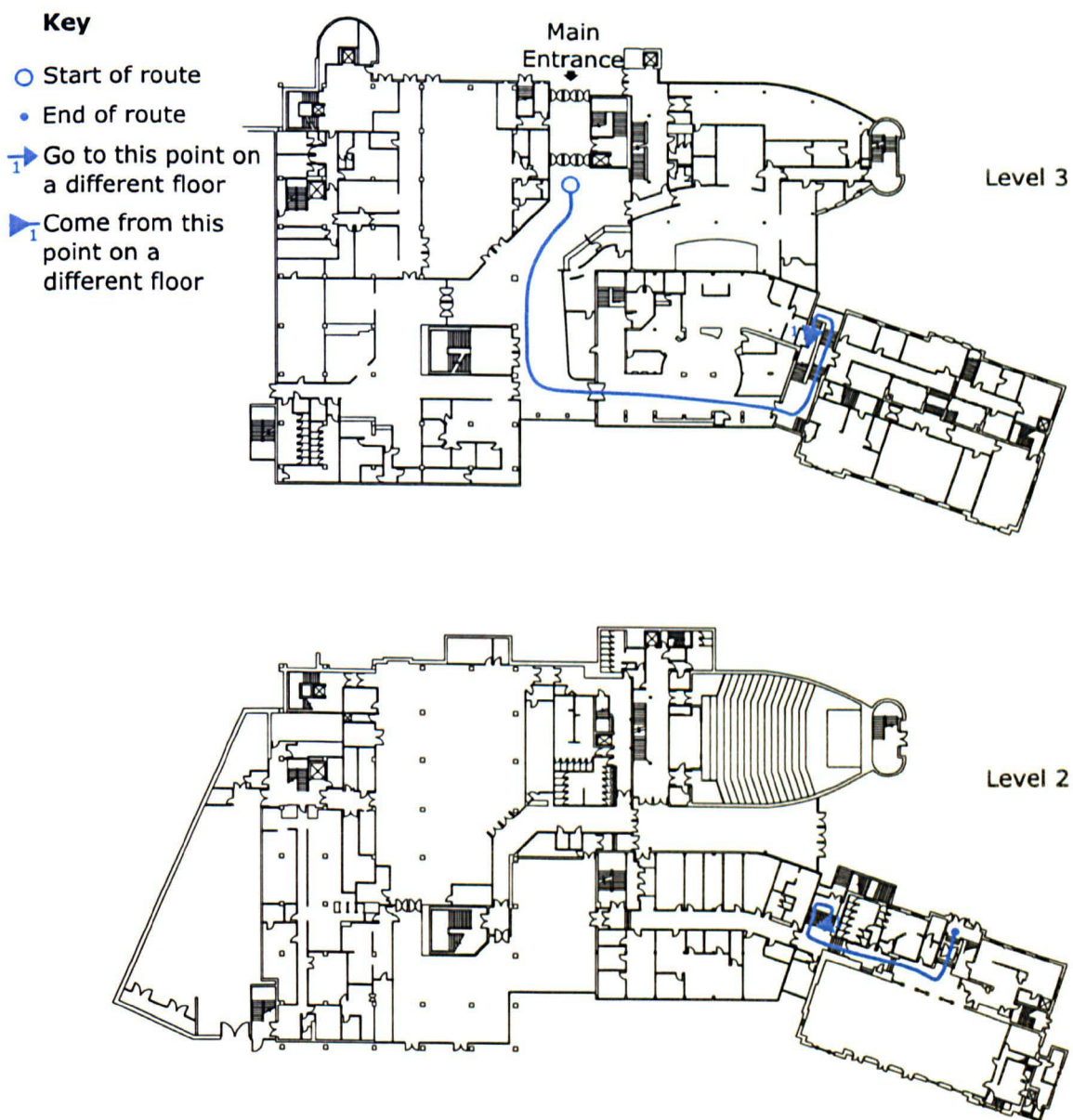
Figure A.08 Union Study : Route taken by Participant 8

255

Key

○ Start of route

• End of route

➤ Go to this point on
  1 a different floor

◄ Come from this
  1 point on a
     different floor

Main
Entrance

Level 3
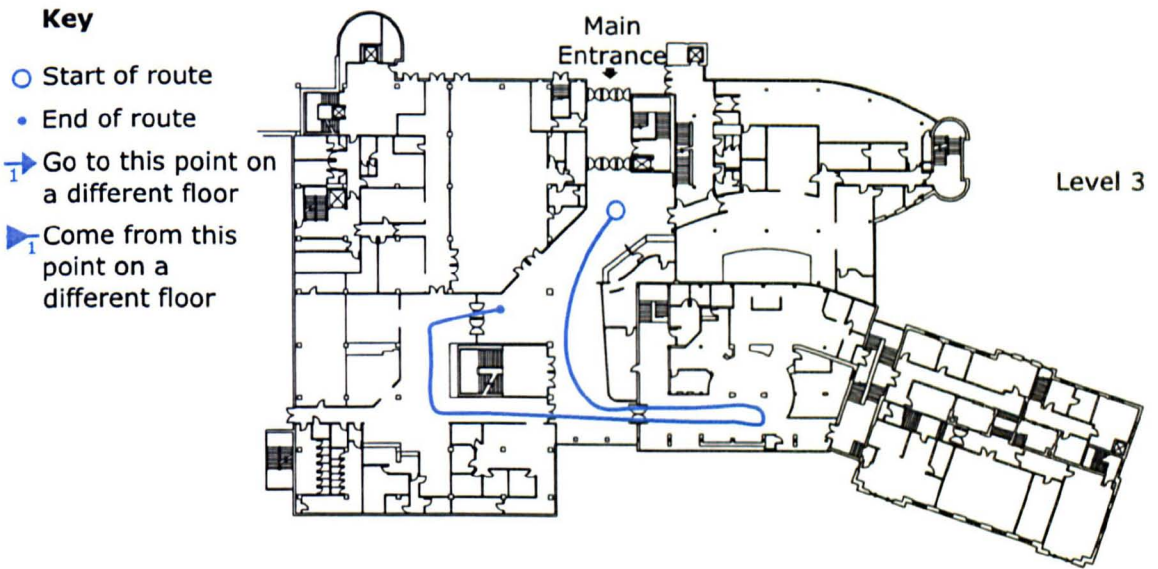
Figure A.09 Union Study : Route taken by Participant 9

Level 4

Level 3

Key

○ Start of route

• End of route

→▶ Go to this point on
   a different floor
¹

▶─ Come from this
¹ point on a
   different floor

Main
Entrance
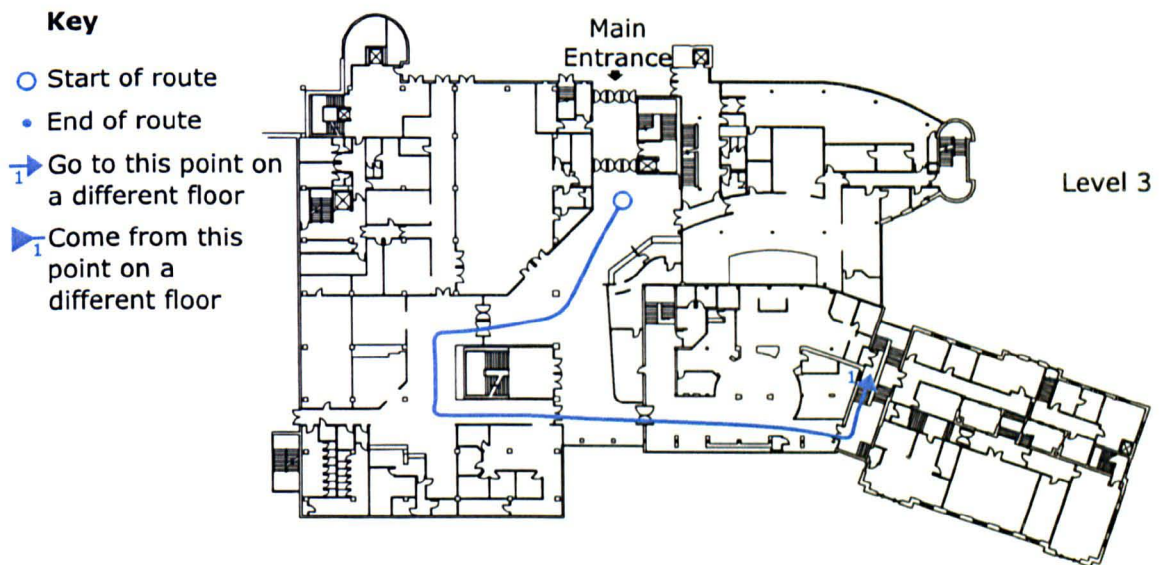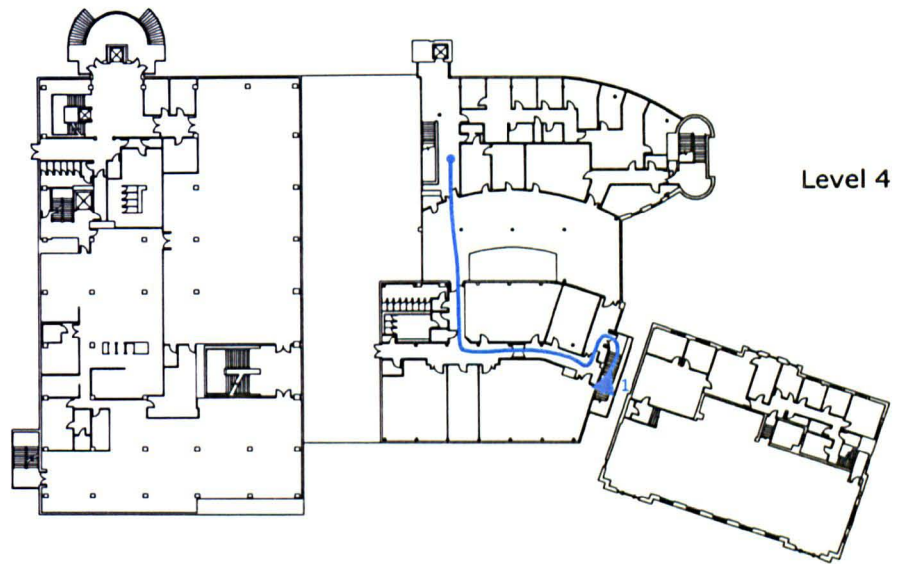
Figure A.10 Union Study : Route taken by Participant 10

257

Key

○ Start of route

• End of route

▶ Go to this point on a different floor

▶ Come from this point on a different floor

Main Entrance

Level 3

Level 2
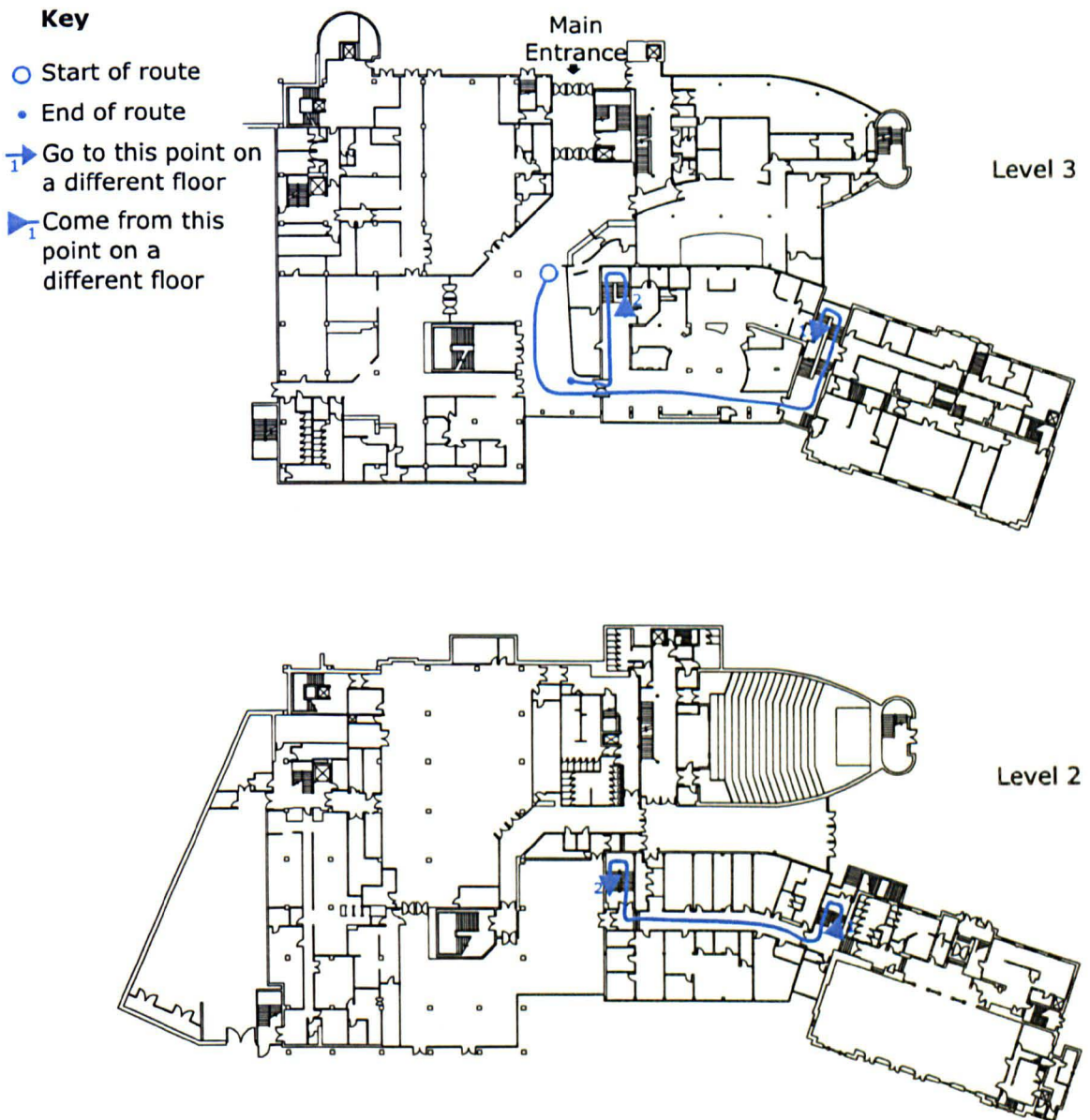
Figure A.11 Union Study : Route taken by Participant 11

258

Key

○ Start of route

• End of route

→ Go to this point on a different floor
1

▶ Come from this point on a different floor
1

Main Entrance

Level 3

Level 2
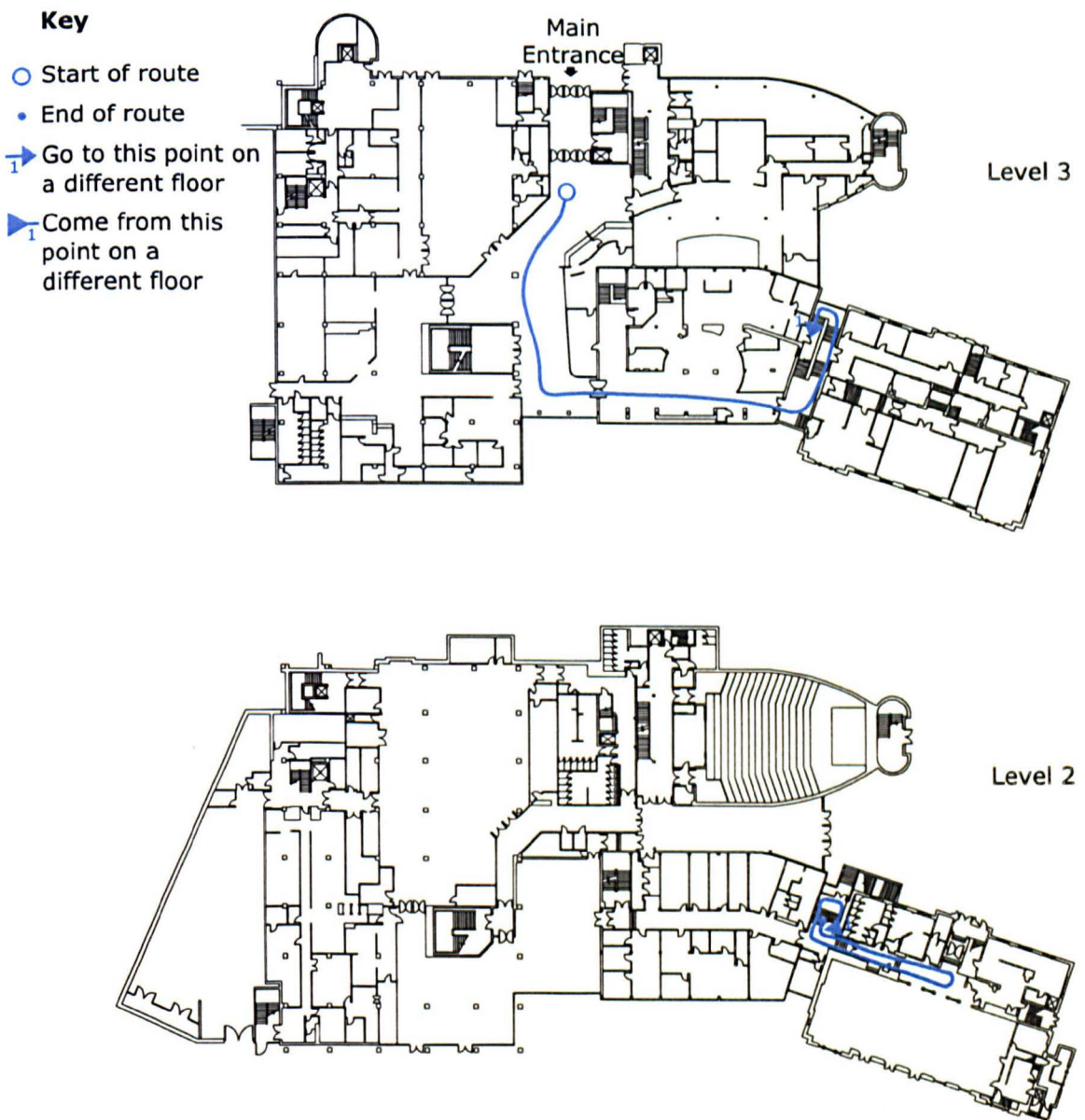
Figure A.12 Union Study : Route taken by Participant 12

259

Level 4

Key

○ Start of route
• End of route
▶ Go to this point on a different floor
◀ Come from this point on a different floor

Main Entrance

Level 3
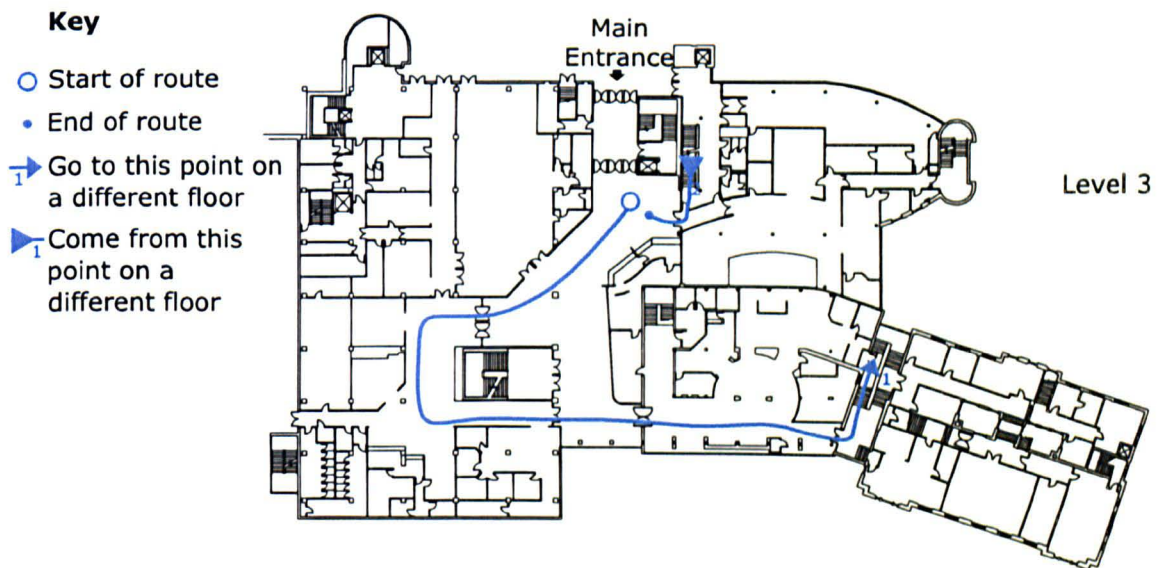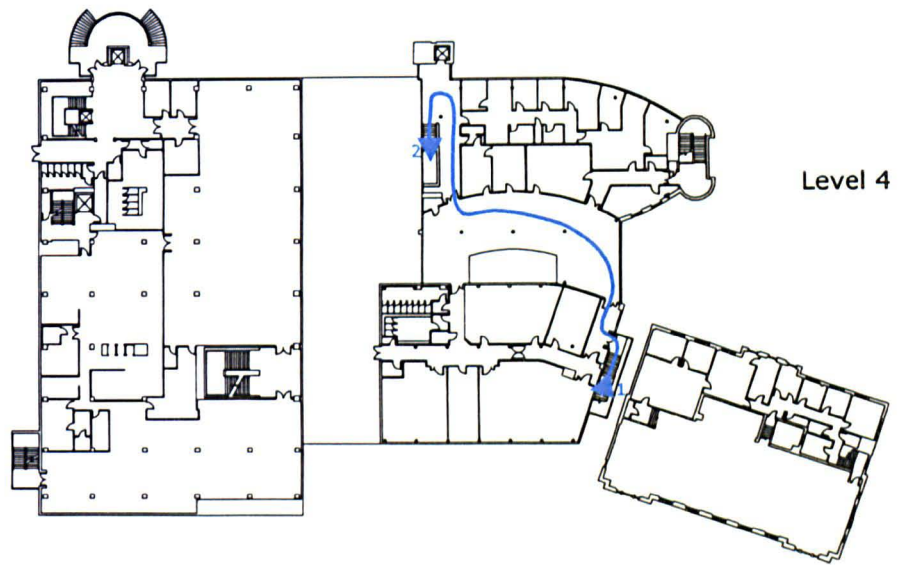
Figure A.13 Union Study : Route taken by Participant 13

260

Key

○ Start of route

• End of route

→₁ Go to this point on a different floor

▶₁ Come from this point on a different floor

Main Entrance

Level 3
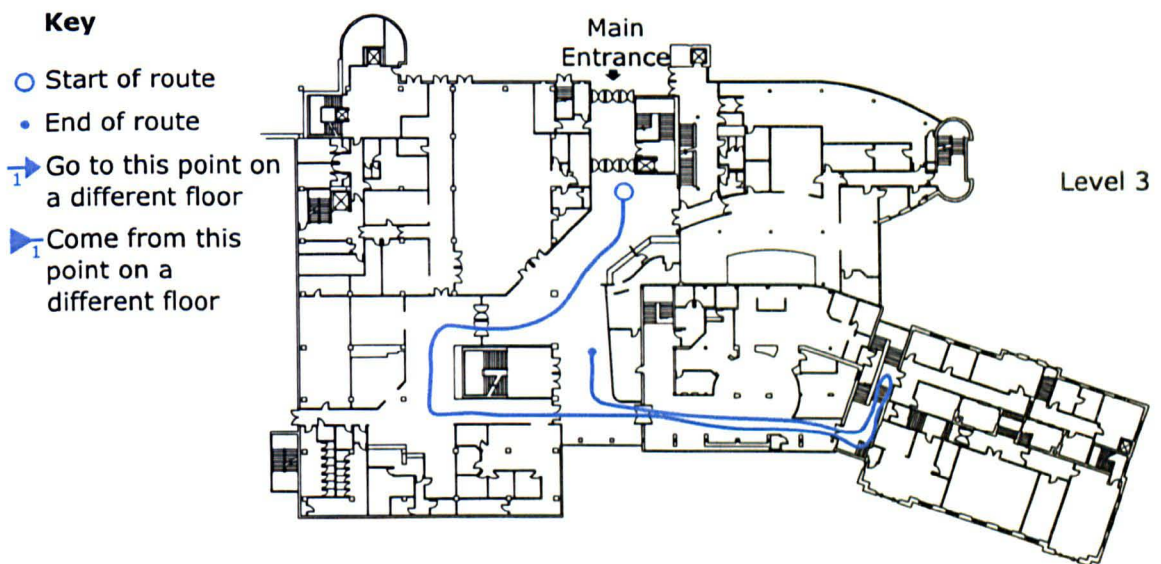
Figure A.14 Union Study : Route taken by Participant 14
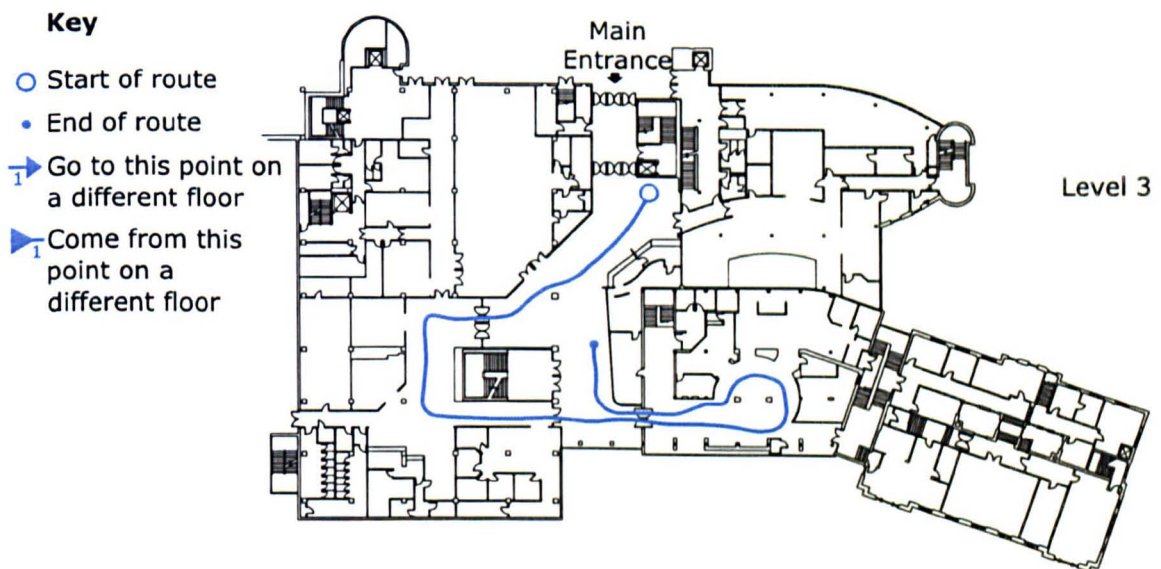
Figure A.15 Union Study : Route taken by Participant 15

Key

○ Start of route

• End of route

➤₁ Go to this point on a different floor

►₁ Come from this point on a different floor

Main Entrance

Level 3

Level 2
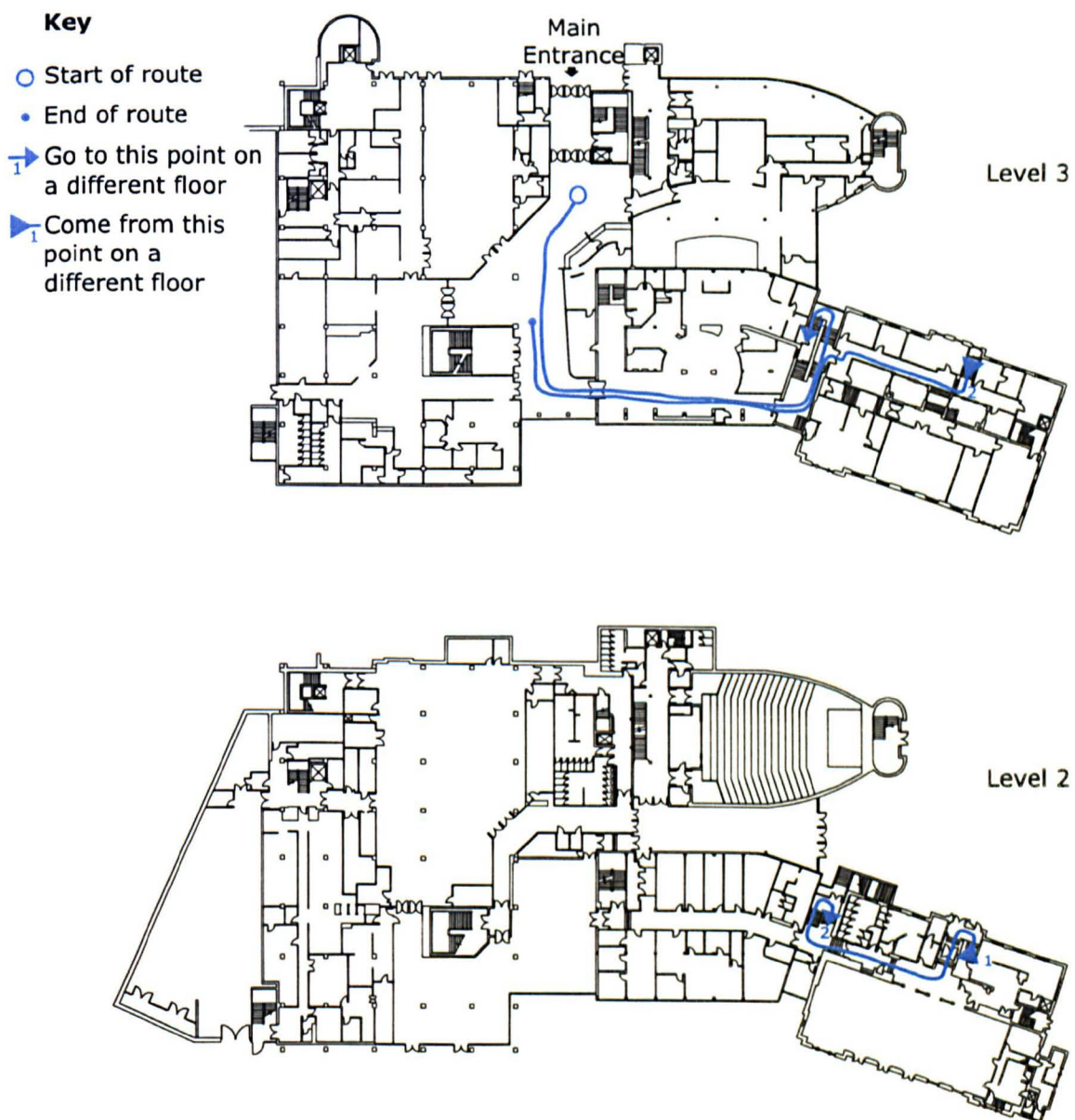
Figure A.16 Union Study : Route taken by Participant 16

263

Key

○ Start of route

• End of route

▶₁ Go to this point on a different floor

▶₁ Come from this point on a different floor

Main Entrance

Level 3

Level 2
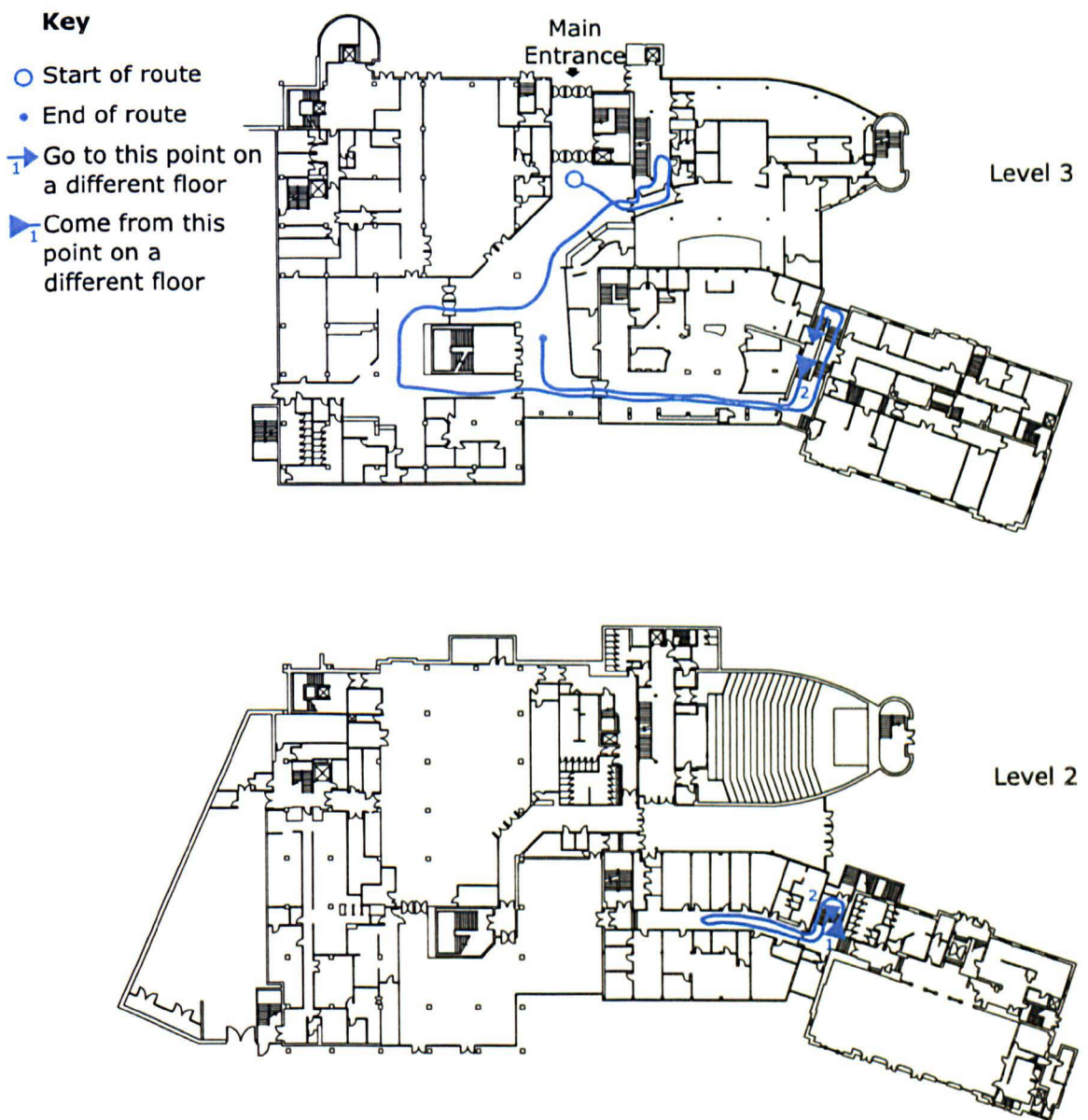
Figure A.17 Union Study : Route taken by Participant 17
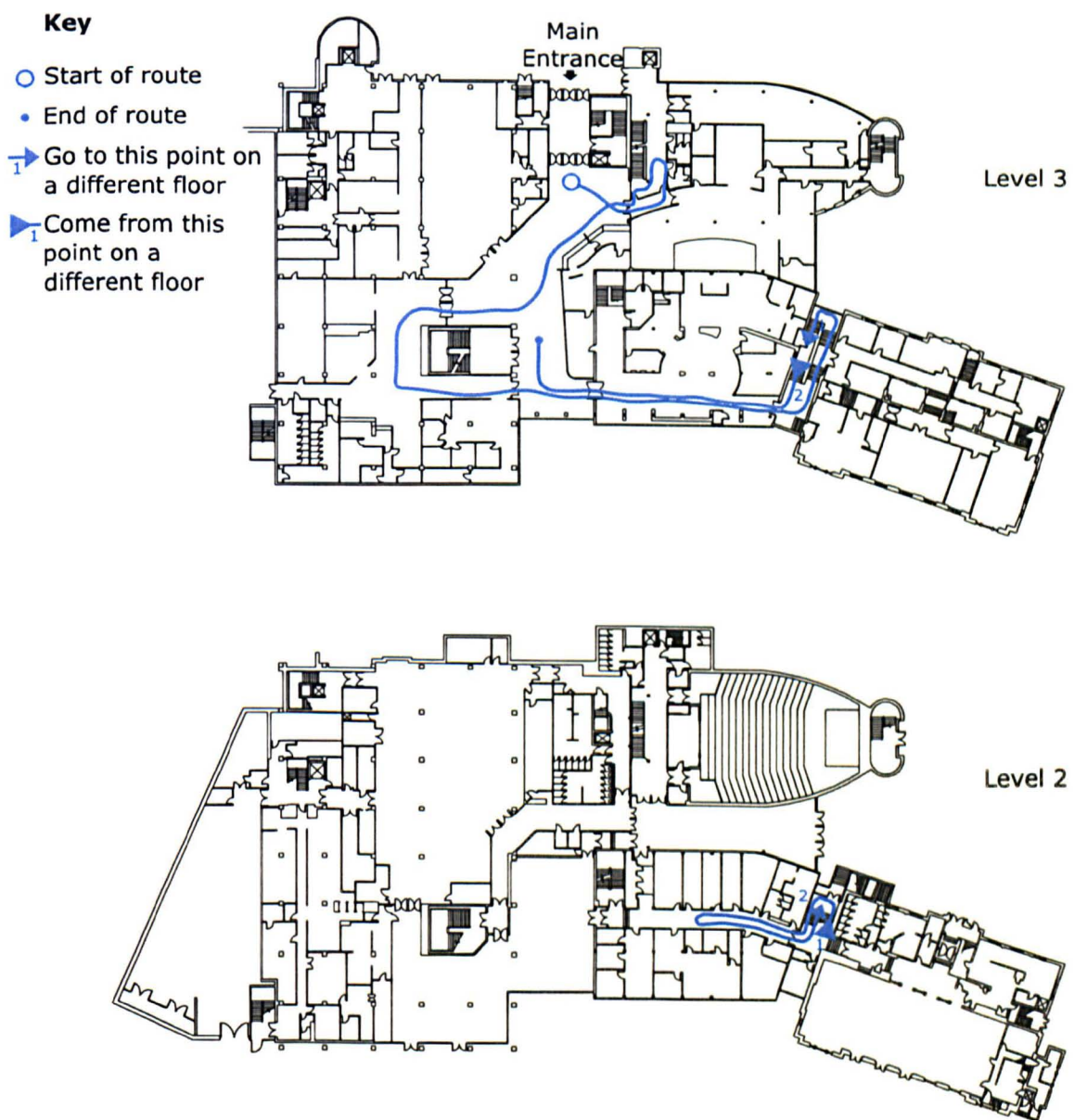
Figure A.18 Union Study : Route taken by Participant 18

Key

○ Start of route

• End of route

▶1 Go to this point on a different floor

▶1 Come from this point on a different floor

Main Entrance

Level 3

Level 2
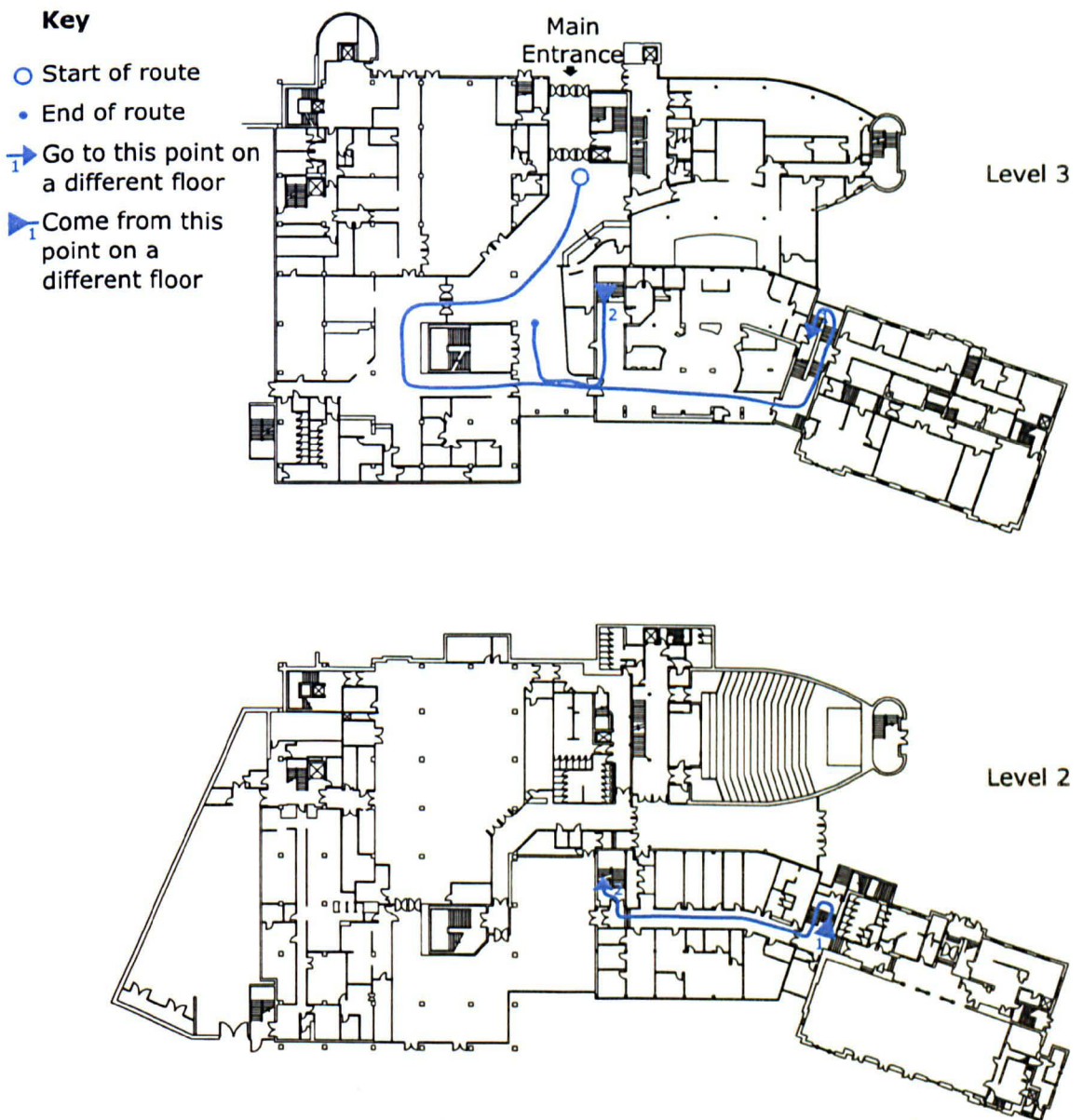
Figure A.19 Union Study : Route taken by Participant 19

266

Level 4

Level 3

Key

○ Start of route

• End of route

▶ Go to this point on a different floor
1

▶ Come from this point on a different floor
1

Main Entrance
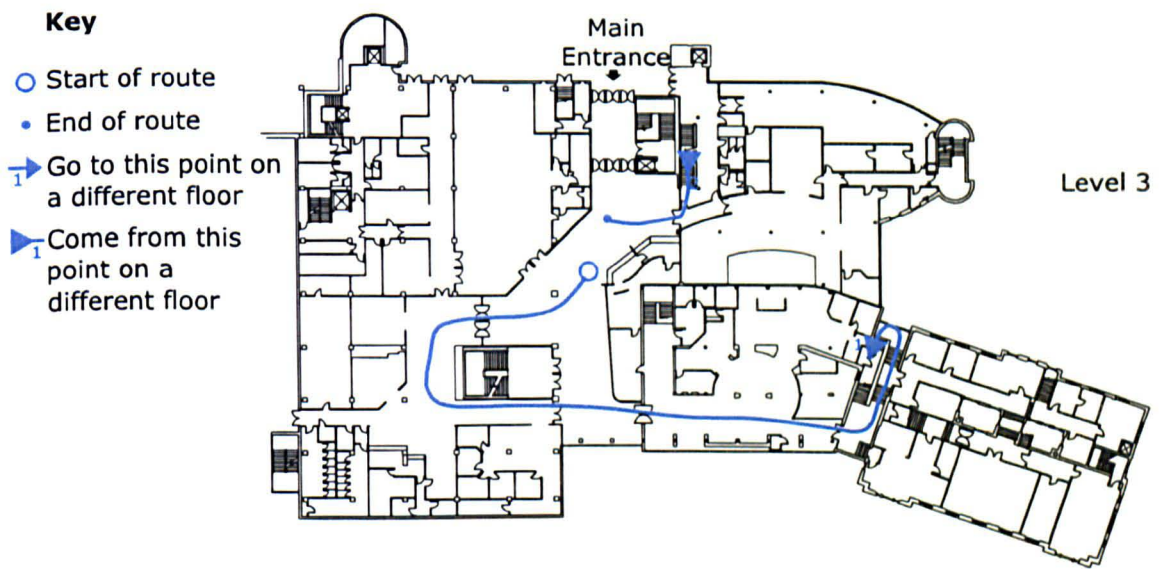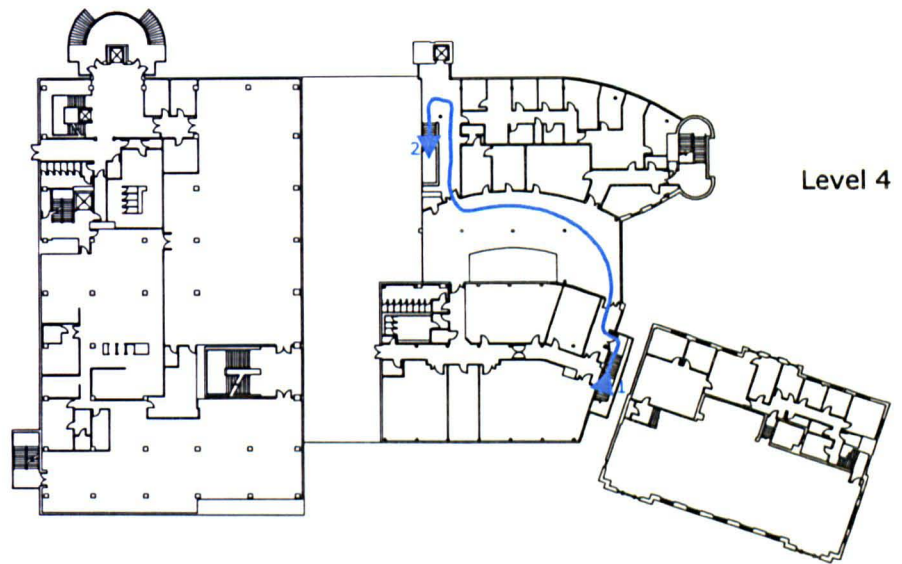
Figure A.20 Union Study : Route taken by Participant 20

267

Key

○ Start of route

• End of route

⇒₁ Go to this point on a different floor

▶₁ Come from this point on a different floor

Main Entrance

Level 3

Level 2
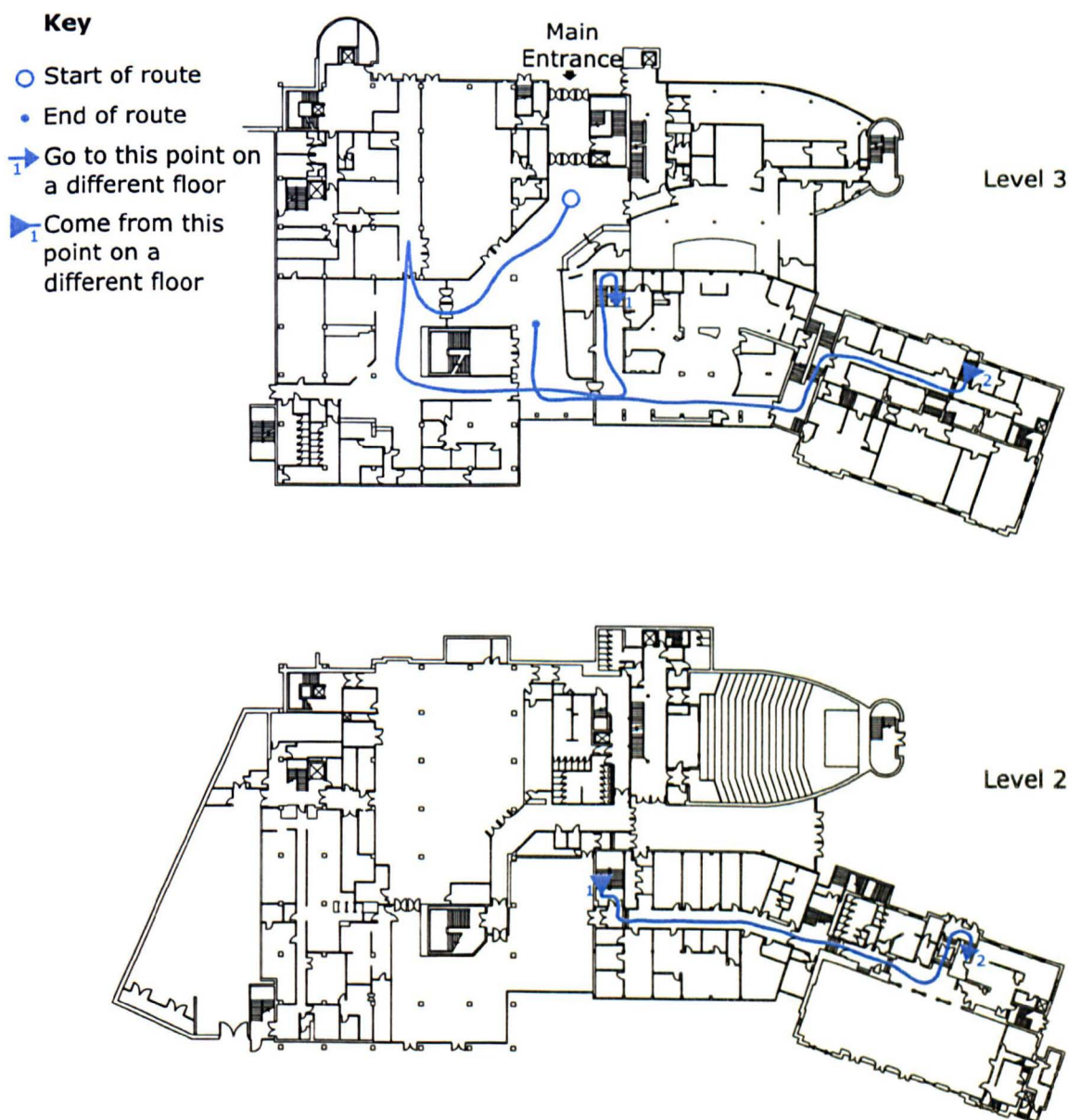
Figure A.21 Union Study : Route taken by Participant 21

Key

○ Start of route

• End of route

▶ Go to this point on
  a different floor

▶ Come from this
  point on a
  different floor

Main
Entrance

Level 3

Level 2
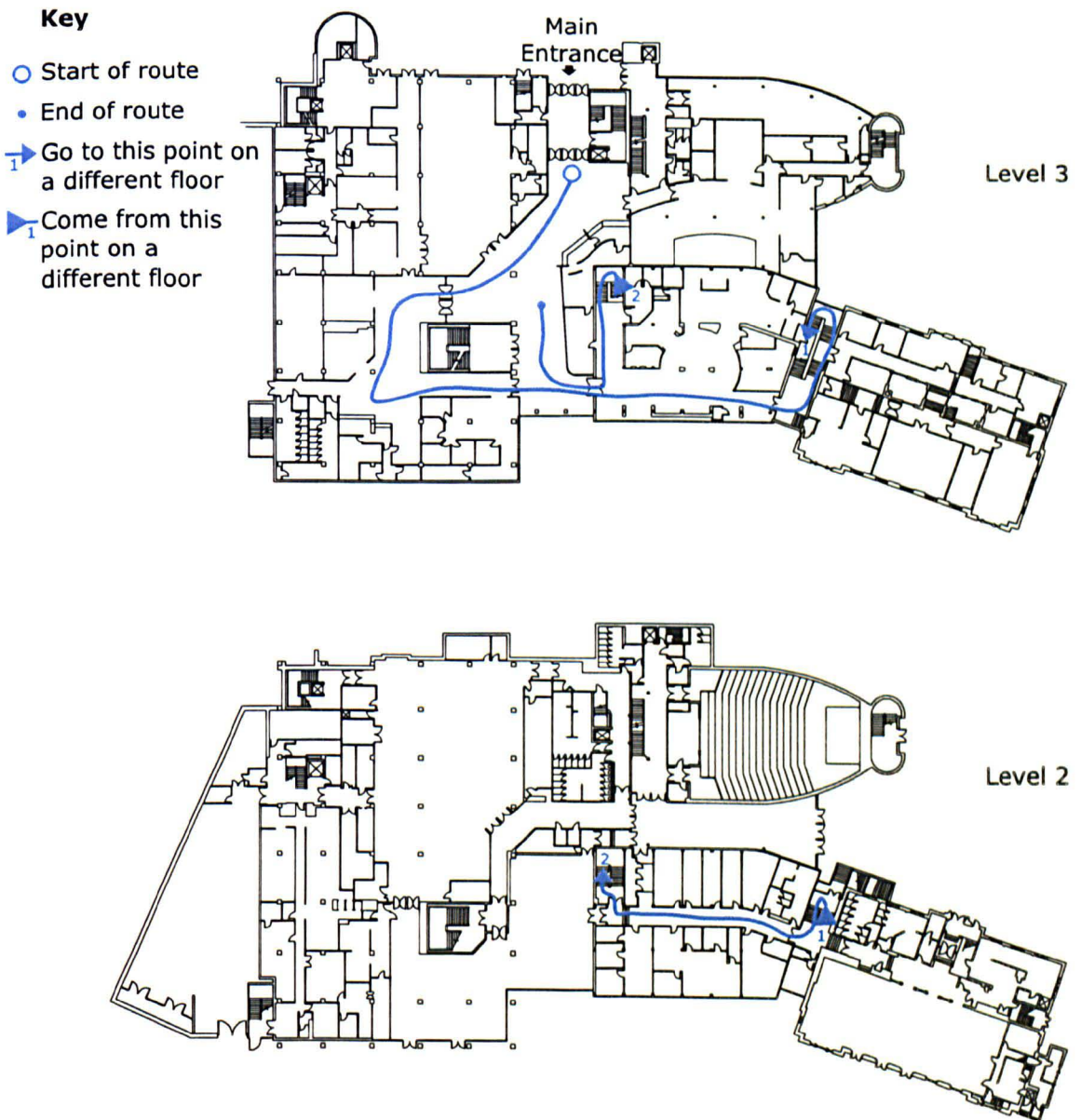
Figure A.22 Union Study : Route taken by Participant 22

269

Key

○ Start of route

• End of route

▷₁ Go to this point on a different floor

▶₁ Come from this point on a different floor

Main Entrance

Level 3

Level 2
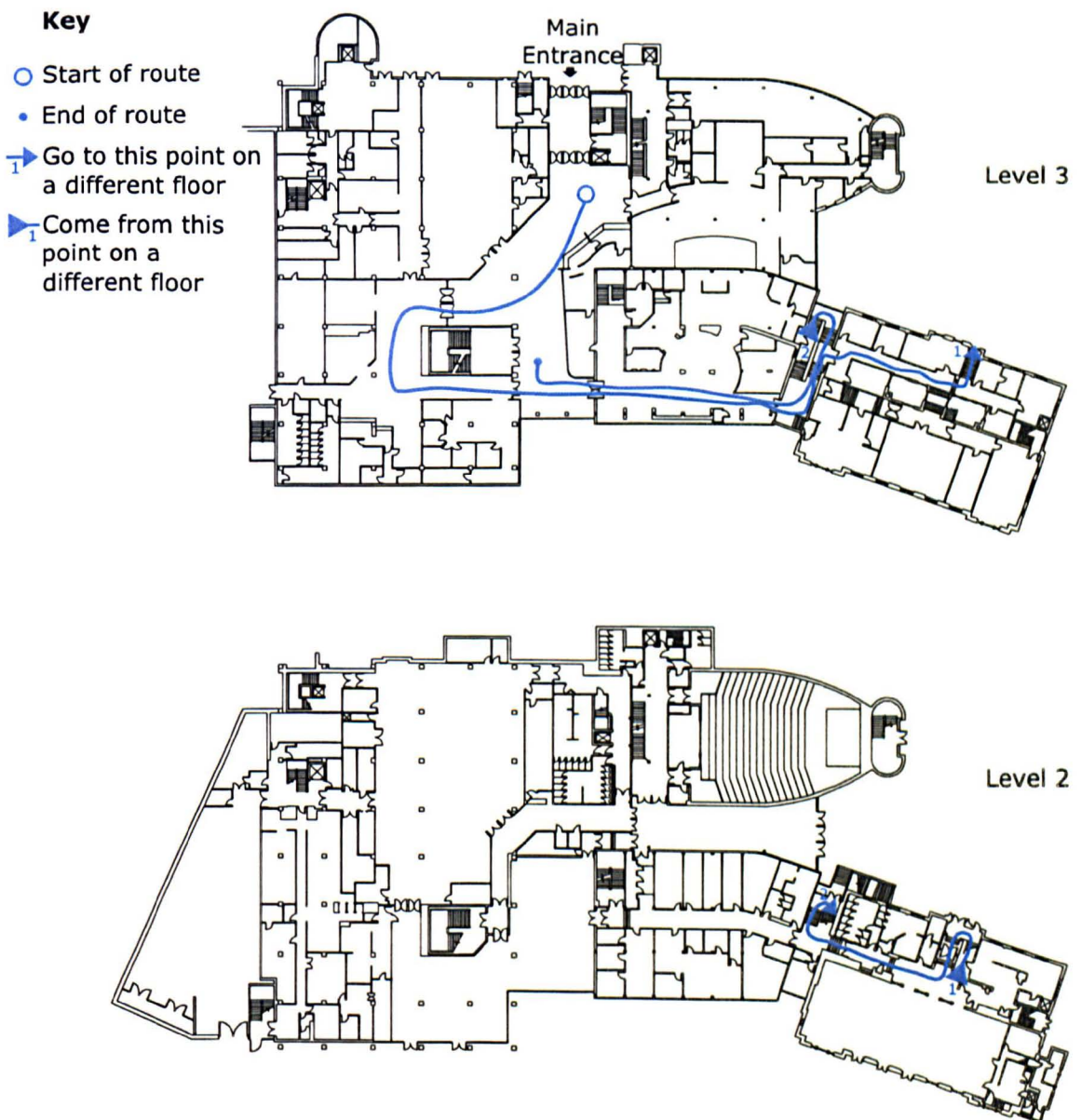
Figure A.23 Union Study : Route taken by Participant 23

270

Key

○ Start of route

• End of route

▶ Go to this point on a different floor
  ₁

▶ Come from this point on a different floor
  ₁

Main Entrance

Level 3

Level 2
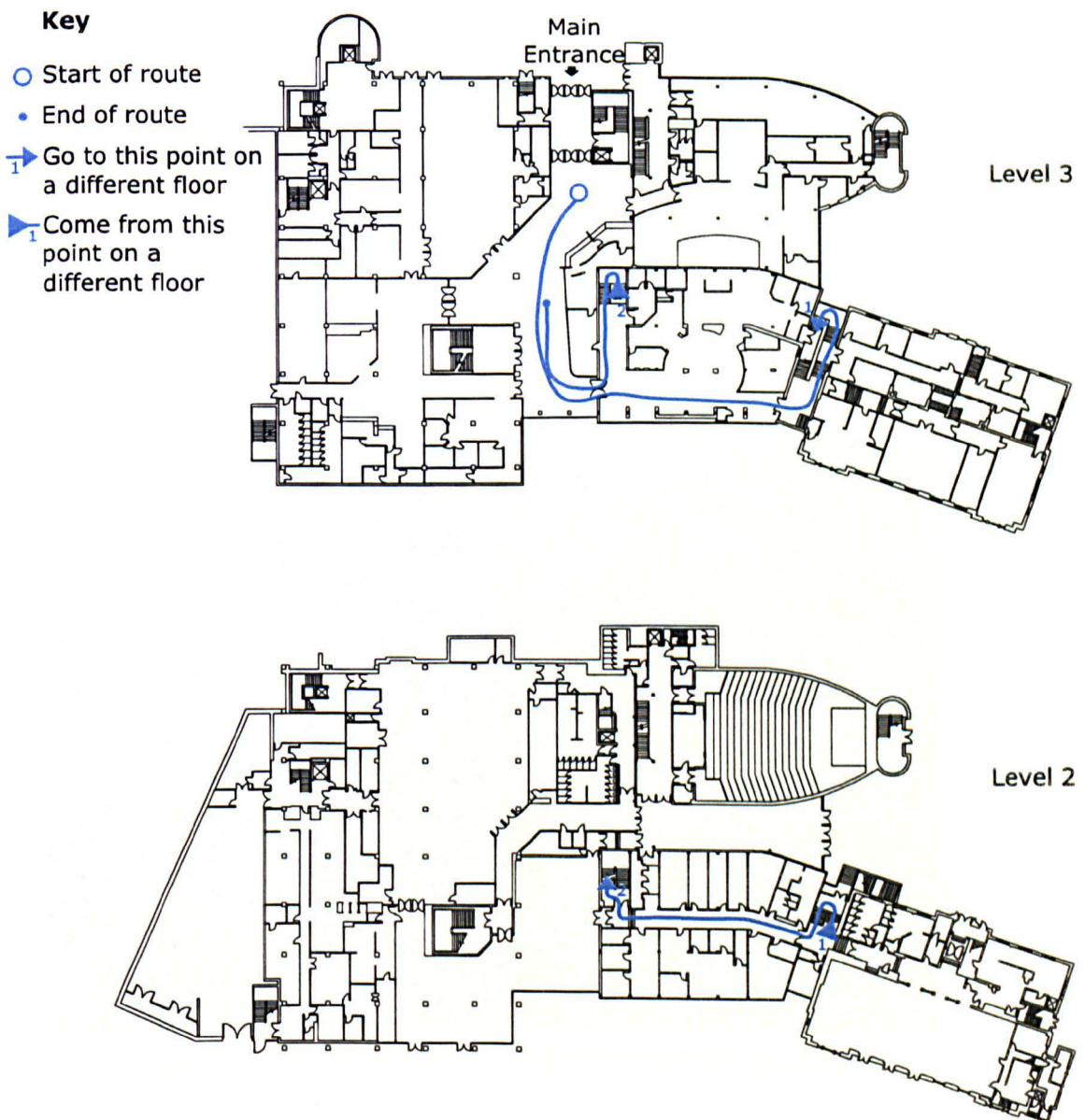
Figure A.24 Union Study : Route taken by Participant 24

271

B

Appendix B: Supporting information for the Corridor Width Experiment

Appendix B contains supporting information relating to the Corridor Width Experiment

documented in Chapter 4.

B.1 Screenshots of the test website

Figures B.01~ Figure B.09 show the screenshots from the Corridor Width Experiment

website (http://experiment.chinglan.com) showing the introductory pages, instructions and

two example test images.
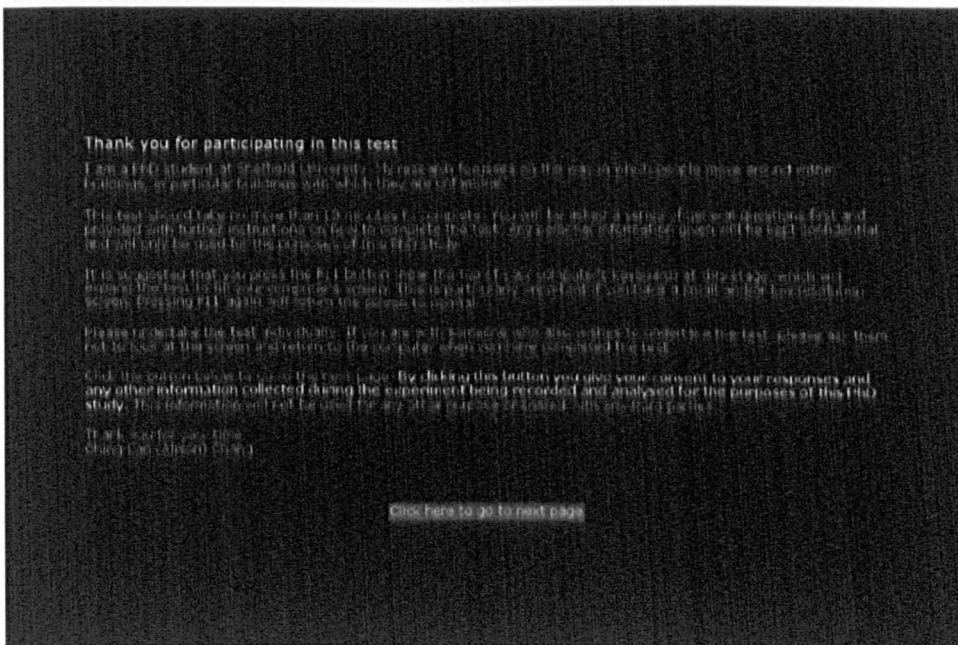
Figure B.01: Screenshot of page 1 from the experiment site showing
introduction to participants
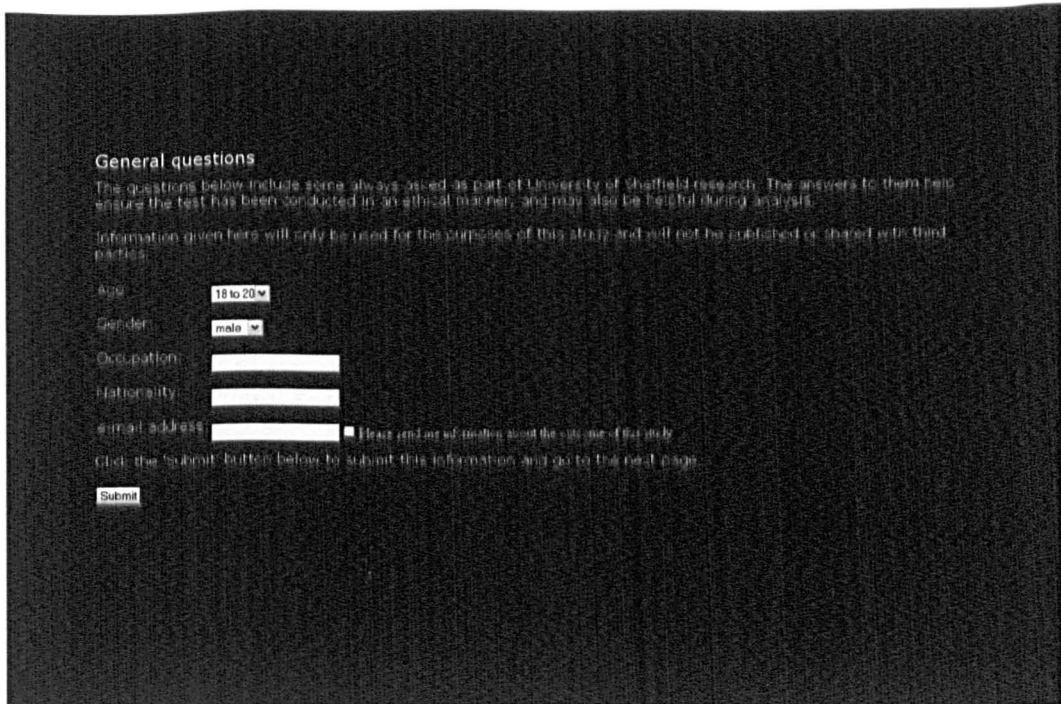
Figure B.02: Screenshot of page 2 asking for general information
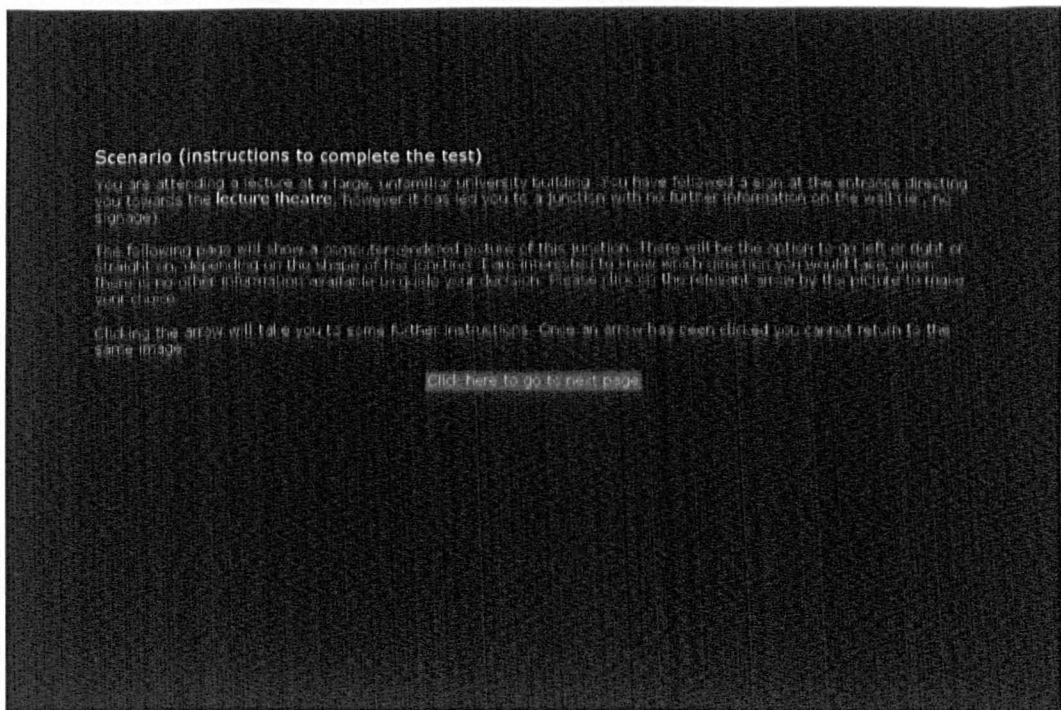
Figure B.03: Screenshot of page 3 showing test instructions (scenario)

Figure B.04: Screenshot of page 4
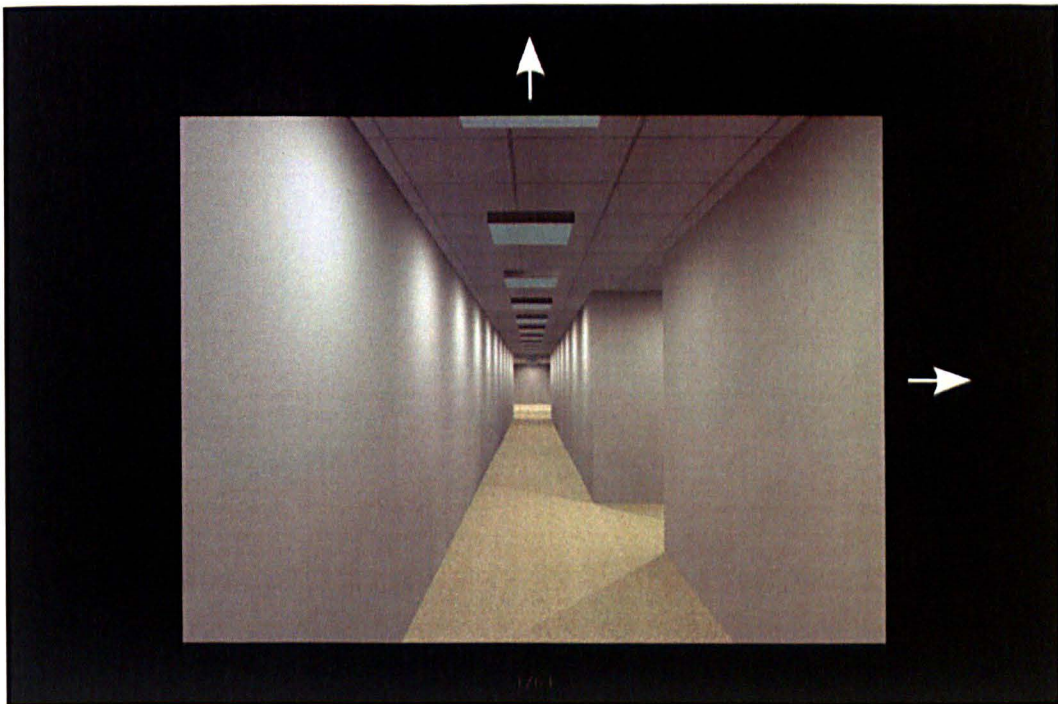
Figure B.05: Screenshot of page 5 showing 1st test image (randomly chosen by the website software)
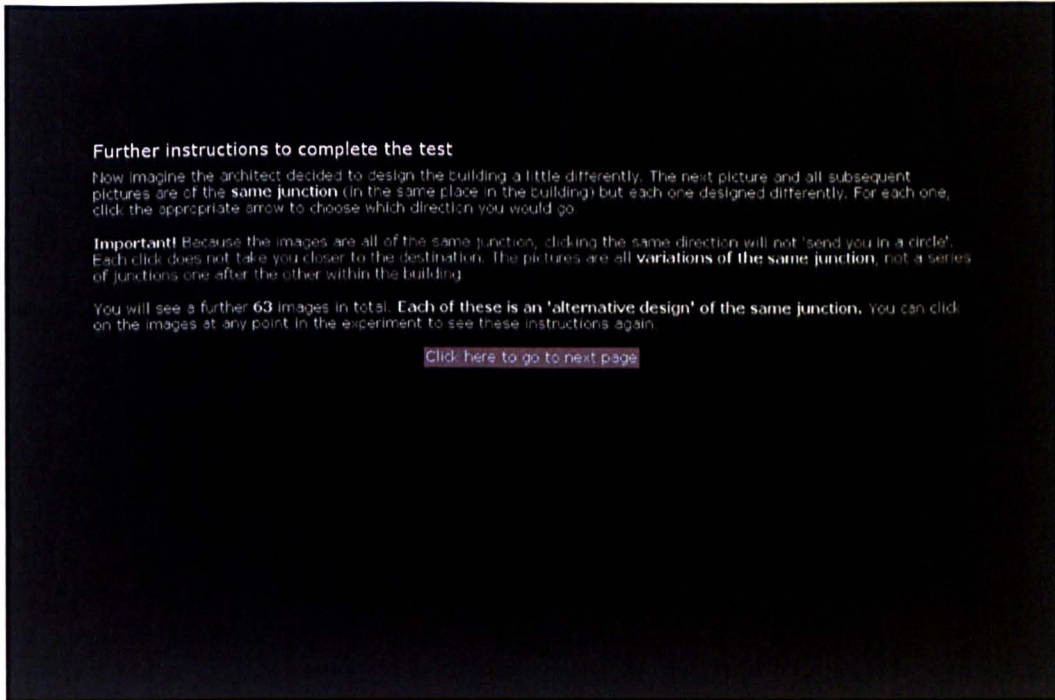
Figure B.06: Screenshot of page 6 showing further instructions to complete the test after the 1st test image
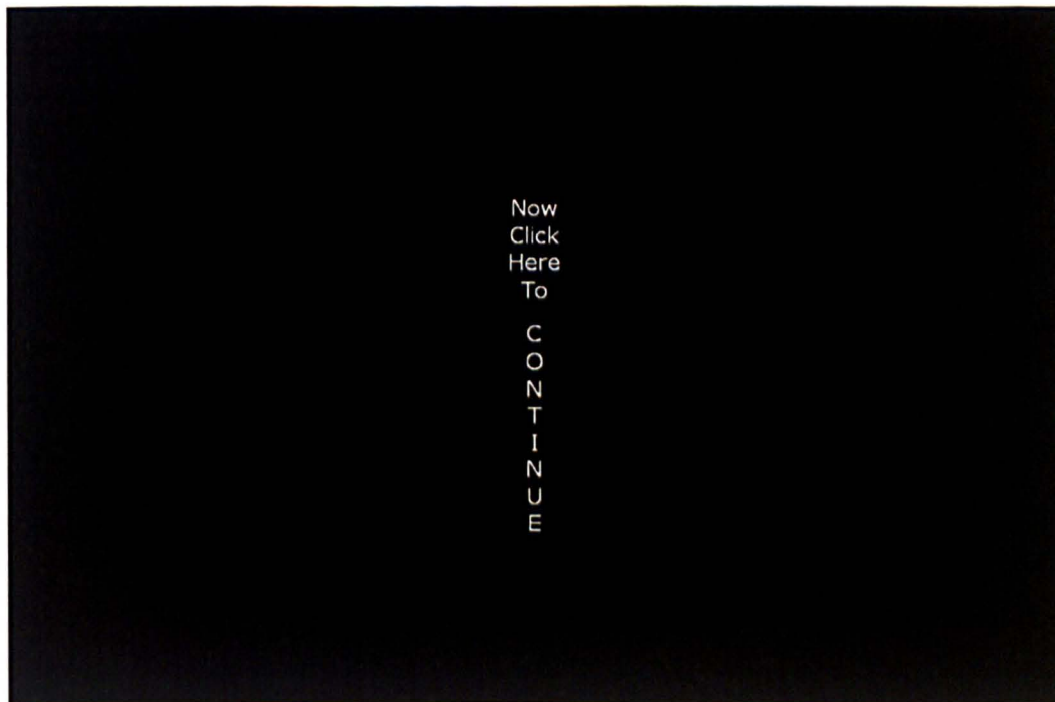
Figure B.07: Screenshot of page 7

Figure B.08: Screenshot of page 8 showing 2nd test image (randomly chosen by the website software)
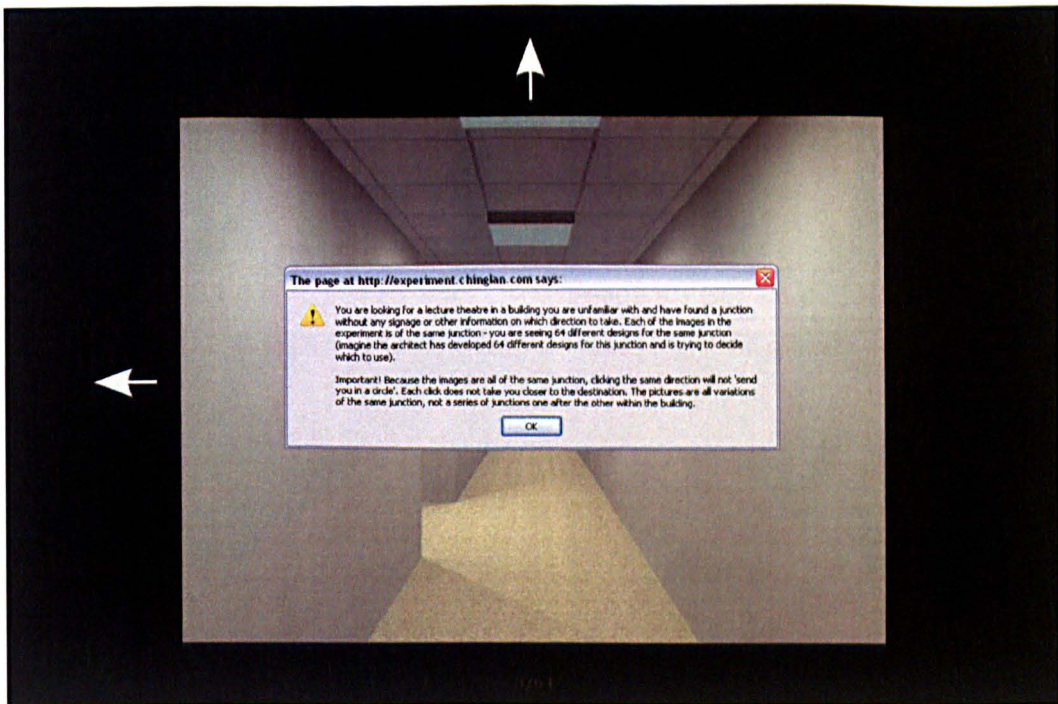
Figure B.09: Screenshot with test instructions (this can be shown by clicking the test image at anytime during the test)

B.2 Test images used in the main experiment

Figure B.10 lists all 32 test images in the test showing type of junction and ratio of corridor for each image.

Image 1 - Set A : L: 1.0 R: 1.0	Image 2 - Set A : L: 1.122 R: 1.0
Image 3 - Set A : L: 1.259 R: 1.0	Image 4 - Set A : L: 1.413 R: 1.0
Image 5 - Set A : L: 1.0 R: 1.0	Image 6 - Set A : L: 1.0 R: 1.122
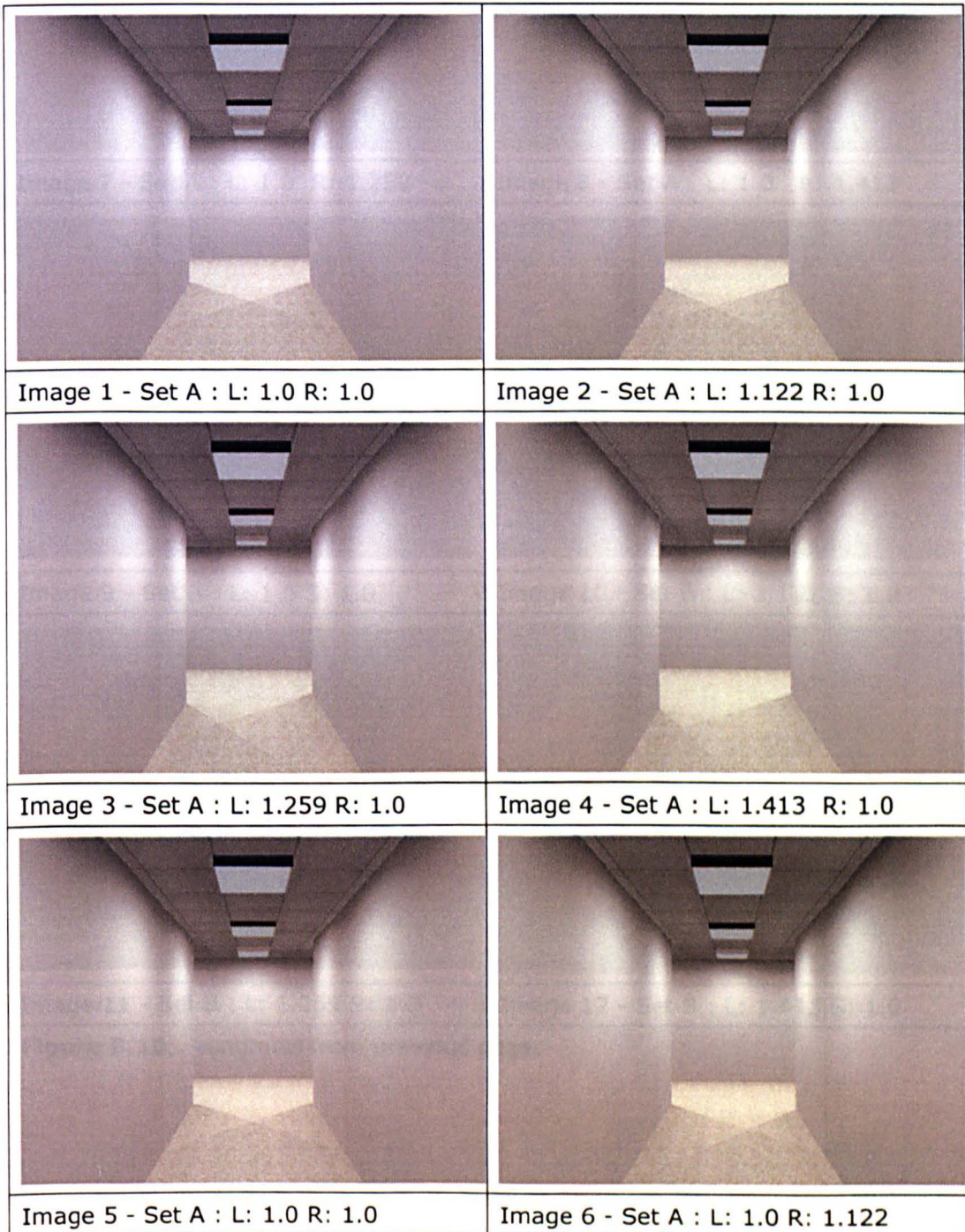
Figure B.10 All 32 test images in the test showing type of junction and ratio of corridor for each image.

Image 7 - Set A : L: 1.0 R: 1.259

Image 8 - Set A : L: 1.0   R: 1.413

Image 9 - Set B : L: 1.0 S: 1.0

Image 10 - Set B : L: 1.122 S: 1.0

Image 11 - Set B : L: 1.259 S: 1.0

Image 12 - Set B : L: 1.413 S: 1.0

Figure B.10... continues from previous page

Image 13 - Set B : L: 1.585 S: 1.0	Image 14 - Set B : L: 1.778 S: 1.0
Image 15 - Set B : R: 1.0 S: 1.0	Image 16 - Set B : R:1.122 S: 1.0
Image 17 - Set B : R: 1.259 S: 1.0	Image 18 - Set B : R: 1.413 S: 1.0
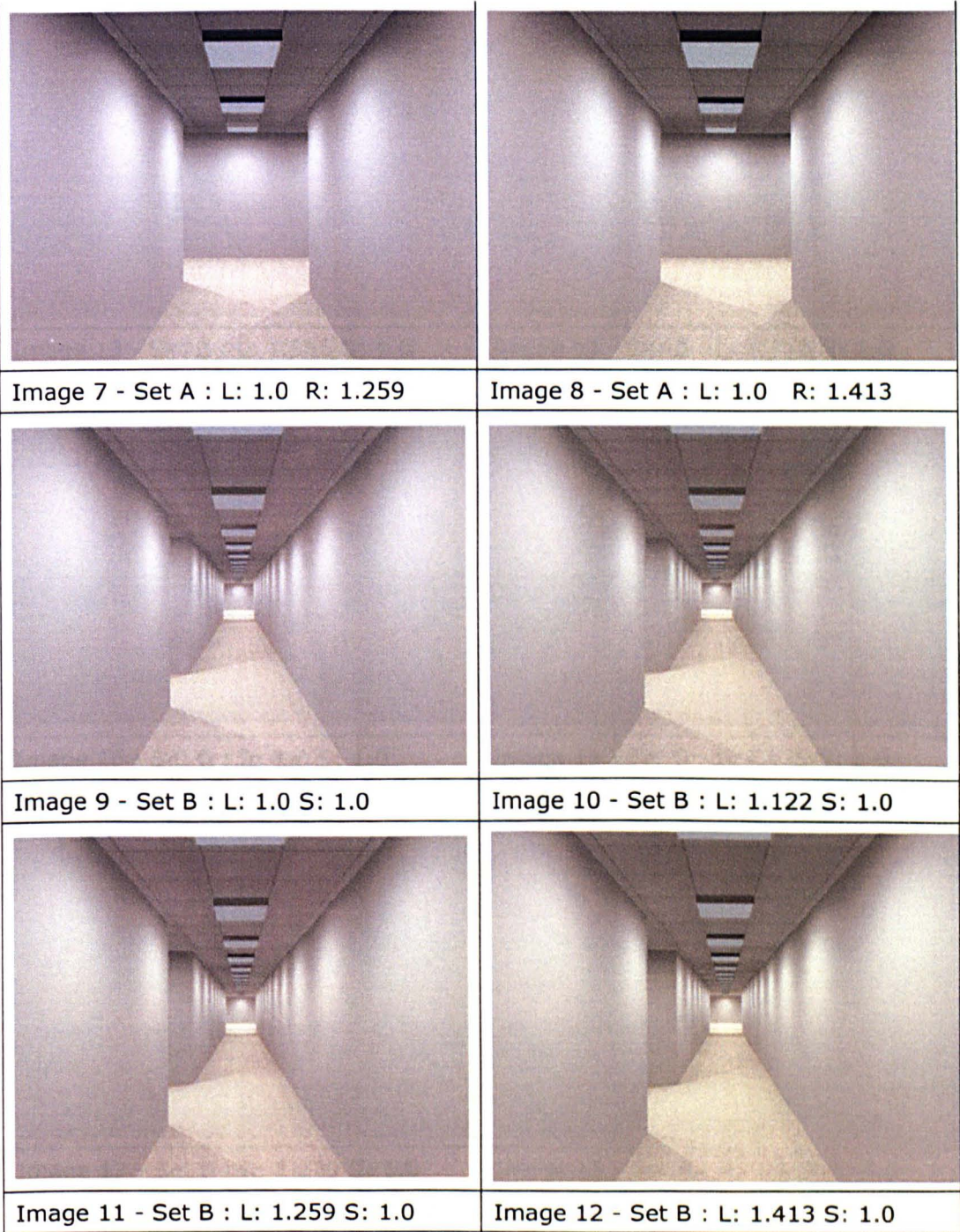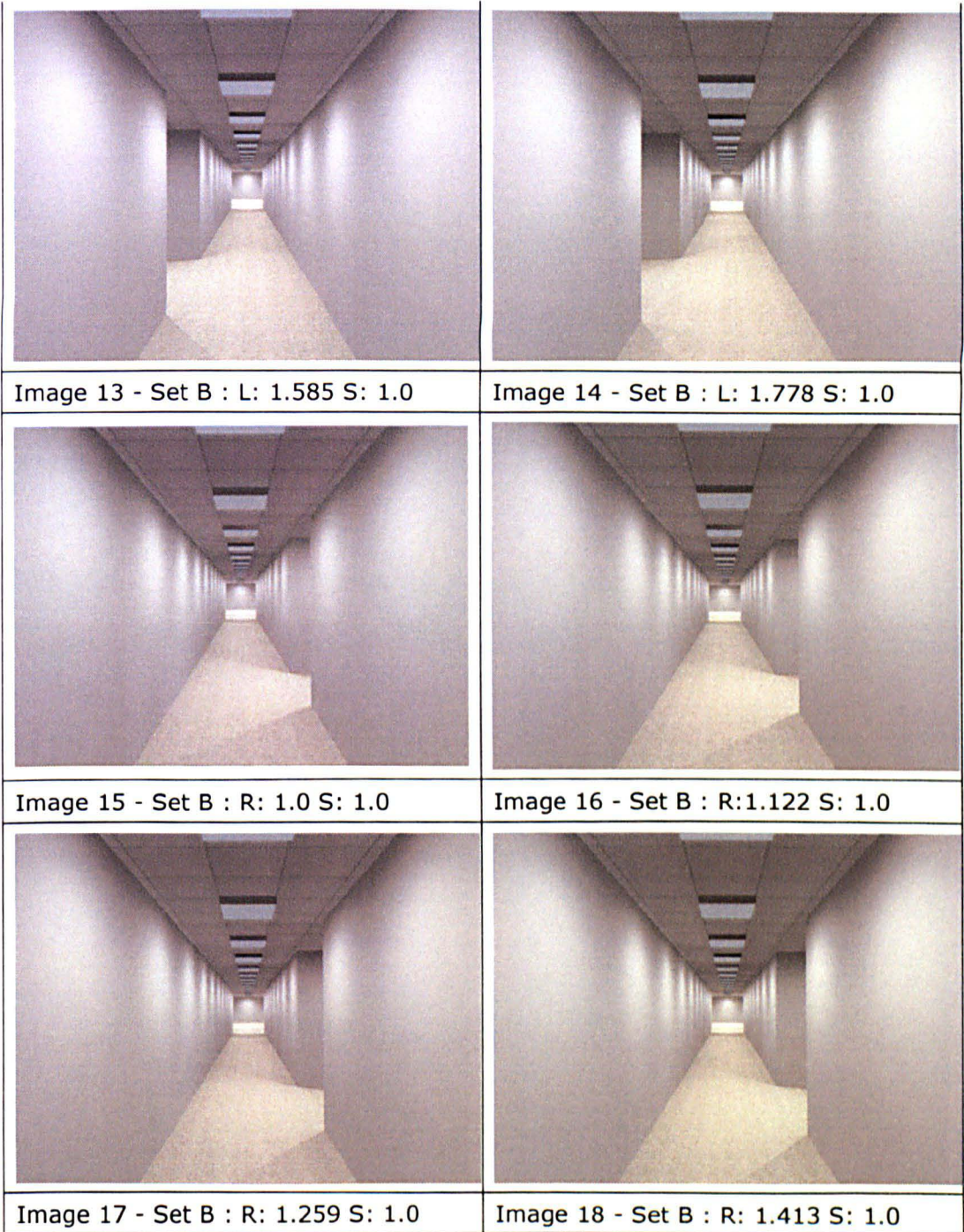
Figure B.10... continues from previous page
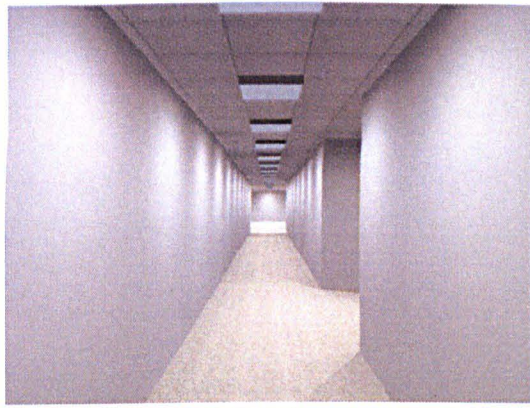
Image 19 - Set B : R: 1.585 S: 1.0	Image 20 - Set B : R: 1.778 S: 1.0
Image 21 - Set C : L: 1.0 S: 0.708	Image 22 - Set C : L: 1.0 S: 0.794
Image 23 - Set C : L: 1.0 S: 0.891	Image 24 - Set C : L: 1.0 S: 1.0
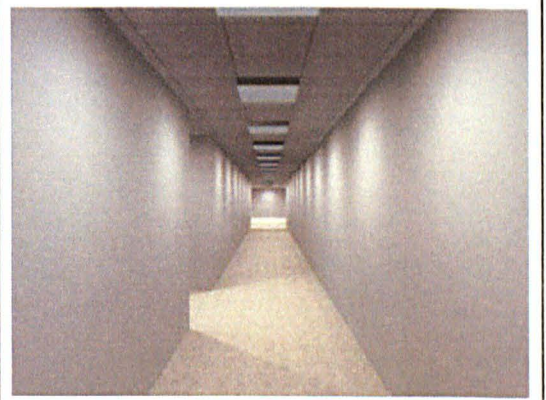
Figure B.10... continues from previous page

Image 25 - Set C : R: 1.0 S: 0.708

Image 26 - Set C : R: 1.0 S: 0.794
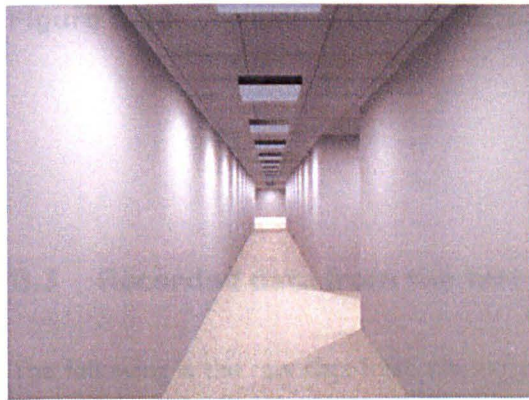
Image 27 - Set C : R: 1.0 S: 0.891
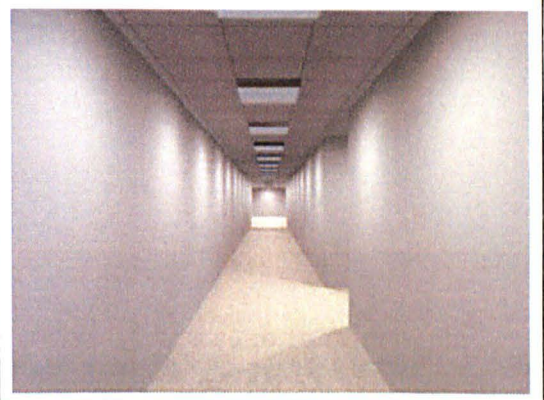
Image 28 - Set C : R: 1.0 S: 1.0

Image 29 - Set C : L: 1.122 S: 0.891

Image 30 - Set C : L: 1.259 S: 0.794

Figure B.10... continues from previous page
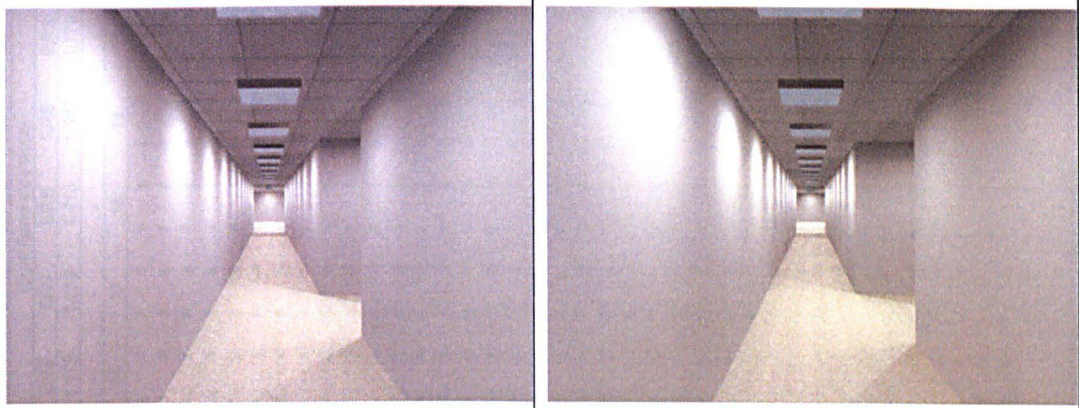
| Image 31 - Set C : R: 1.122 S: 0.891 | Image 32 - Set C : R: 1.259 S: 0.794 |

Figure B.10 ... continues from previous page

B.3 Recorded data from the test

The following is the raw data from the experiment, showing each participant and the path choices they made at each ratio, handing and *plan layout*. Table B.01 shows the recorded data for Set A and Set B. Data for Set C and Set D is shown in Table B.02. Comments from participants are documented at the end of this section (Table B.03).

	Set A - T Junction								Set B - side exit varies, straight on same as entrance corridor											
	E=2, L=2*a, R=2				E=2, R=2*a, L=2				E=2, L=2*a, S=2						E=2, R=2*a, S=2					
	null	Left hand side wider			null	Right hand side wider			null	Left hand side wider					null	Right hand side wider				
	ELR	ELR	ELR	ELR	ERL	ERL	ERL	ERL	ELS	ELS	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ERS	ERS
Ratio of corridor	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1.585	1.778	1	1.122	1.259	1.413	1.585	1.778
Image no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p1	r r	r r	l l	l l	r l	r r	r r	r r	l l	l l	l l	l l	l l	s l	r r	r r	r r	r r	r r	r r
p2	r r	l r	l l	l l	l r	l l	r r	l r	s l	l s	l s	l s	l l	s l	r s	r s	r s	r r	r r	r r
p3	l l	l l	l l	r l	r l	l l	l l	l l	s l	s l	s s	s s	s s	l s	s r	s r	s s	r r	s s	s s
p4	r r	l l	l l	l l	l l	r r	r r	r r	s s	s s	l s	s l	s l	s l	s s	s s	s s	s r	r r	r r
p5	r r	r r	l l	l r	l r	r r	r r	r r	s s	s s	s s	s l	s s	s s	r s	r s	s s	r s	s s	r r
p6	r r	l l	l l	l l	r r	r r	r r	r r	l s	s s	l l	l l	l s	l l	s s	r s	r r	s r	r r	r r
p7	l l	l r	l r	l l	l l	l l	r r	l r	s s	l s	l l	l l	l l	l s	s s	s s	s s	r r	s r	r r
p8	l r	l r	l l	l l	r r	r r	r l	l r	l l	l l	l l	l l	l l	l l	r r	r r	r r	r r	r r	r r
p9	r l	r l	r l	l l	r r	r r	r r	r r	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p10	l r	l r	l l	l l	l l	r r	r r	r r	s s	s s	s l	s s	s l	l l	s s	s s	s l	s r	s s	s s
p11	l l	l l	l l	l l	l l	l l	l l	l l	l l	s l	l l	l l	l l	s s	r s	r r	s s	s s	r r	r r
p12	r l	l l	l l	l l	l l	r r	r r	r r	s s	l s	l s	s l	l l	l l	s s	s s	s s	s s	r s	r r
p13	l l	l l	l l	l l	l l	l r	l l	l r	s s	s s	s l	l l	l l	l l	s s	s s	s r	r r	r r	r r
p14	l l	l r	l l	l l	r r	l l	l l	l r	l l	l s	s s	l l	l l	l s	s s	s s	s s	s s	s s	s r
p15	r l	r l	l r	l l	r r	l l	r r	l l	s s	s s	s s	s s	l s	s s	r r	s s	s s	r s	s r	r s
p16	r r	l l	l l	l l	l l	r r	r r	l r	s s	s l	l s	s s	s s	s s	s s	s s	s s	s s	r r	s s
p17	r l	r l	l l	l l	r l	l l	r r	l r	s s	s l	s l	l l	s l	l l	r s	s s	s s	r s	s s	s r
p18	l r	r r	l l	l r	r r	r r	r r	r l	s l	l s	s s	l l	l s	s l	r r	r s	s s	s r	s r	s r
p19	l r	l l	l l	l l	r r	r r	r r	r r	l l	s l	s s	s s	s l	l l	r r	s s	s s	r s	s r	r r
p20	r r	l l	l l	l l	r r	l l	r r	r r	s l	s l	s l	l l	l l	l l	s s	s s	r s	r s	s s	s s
p21	r r	r r	l l	l l	r r	l l	r r	r r	s l	s l	s s	s s	s s	l l	s s	s s	s r	r r	s s	s s
p22	l l	l l	l l	l l	l l	r l	l l	l l	l l	l l	l l	l l	l l	s l	r r	r r	r r	r r	r r	s r
p23	l r	l r	r r	r r	r r	r r	r r	r r	s s	s s	s s	s s	s s	s s	r r	s s	r r	s r	r s	r r
p24	l r	l r	l l	l l	r r	r r	r r	r r	s s	l s	l l	l l	l l	l l	r s	s r	s r	r r	r r	r r
p25	r r	r r	l l	l r	l l	r r	r r	r r	l s	s s	s s	s s	s s	s s	s r	s r	s r	r s	r s	s r
p26	l r	l r	l l	l l	r l	r r	r r	r r	s s	s l	l s	l s	l s	l l	s r	r r	r s	s s	s r	s r
p27	l r	l r	l l	l l	r l	r l	l r	l r	l l	l s	s s	l l	l s	s s	s r	r s	s r	s s	r s	s s
p28	r l	r r	l l	l l	r l	r r	r r	r r	s l	s s	l s	l l	l l	l l	s r	s s	s r	s s	r r	r r
p29	l l	l l	l l	l l	l l	r r	r r	r r	s s	l s	s s	l l	s l	l l	s s	r s	r s	r r	s r	r r
p30	r r	r r	r r	l r	r r	r r	l r	r r	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s r
p31	l l	l l	l r	l l	l l	r r	r r	r r	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s r	r s
p32	r l	l l	l l	l l	r r	r r	r r	r r	l s	l s	s l	s l	l l	l l	r s	r s	s r	s r	s r	r r
p33	r l	l l	l l	l l	r r	l r	r r	r r	s s	l l	s l	l s	l l	s l	s r	s s	s r	r r	r r	r r
p34	r r	l l	r l	l l	r r	r r	r r	r r	l s	l s	l l	s s	s s	s s	s s	s s	s r	s r	s r	s r
p35	l l	l l	r l	r l	l l	l l	l l	l l	s l	s l	s l	l l	l l	l l	r r	r r	r r	r r	r r	r r
p36	r l	l l	l r	r r	r l	l l	r r	l r	l l	l l	l l	l l	l l	l l	r r	r r	r r	r r	r r	r r
p37	r l	r l	r r	r r	r l	r l	r r	r r	l s	l l	l l	l l	s s	s l	r s	r s	r r	s r	r r	r s
p38	l r	r r	r r	r r	r r	r r	r r	r r	s s	s s	s s	l s	s s	s s	s s	s s	s r	s s	s s	r s
p39	r r	r r	r r	r r	r r	r r	r r	r r	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s

Table B.01 (1/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set A - T Junction								Set B - side exit varies, straight on same as entrance corridor												
	E=2, L=2*a, R=2				E=2, R=2*a, L=2				E=2, L=2*a, S=2						E=2, R=2*a, S=2					
	null	Left hand side wider			null	Right hand side wider			null	Left hand side wider					null	Right hand side wider				
	ELR	ELR	ELR	ELR	ERL	ERL	ERL	ERL	ELS	ELS	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ERS	ERS
Ratio of corridor	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1.585	1.778	1	1.122	1.259	1.413	1.585	1.778
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Image no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p40	l	l	r	r	r	r	l	r	s	s	s	s	r	s	r	s	s	r	s	s
p41	l	l	l	l	l	l	l	l	l	s	s	s	l	l	l	s	l	s	l	s
p42	r	r	l	l	r	l	l	l	l	s	l	l	l	l	l	l	l	l	l	l
p43	l	l	l	l	r	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p44	l	l	l	l	l	l	l	l	s	s	s	s	s	s	l	l	l	l	l	l
p45	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p46	r	r	l	l	l	l	l	r	l	l	l	l	s	l	l	l	s	s	s	s
p47	l	r	r	l	l	l	l	l	s	s	s	s	l	s	s	s	l	l	s	l
p48	r	r	l	l	l	l	l	l	s	s	s	s	s	s	s	l	l	l	l	l
p49	r	r	l	l	l	l	l	l	s	s	s	s	s	s	l	l	l	l	l	l
p50	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p51	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p52	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p53	l	l	l	r	l	r	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p54	r	r	r	r	r	r	r	l	s	s	s	s	s	s	s	s	s	s	s	s
p55	r	r	r	r	r	r	r	r	s	s	s	s	l	s	s	l	s	l	s	l
p56	l	l	r	l	l	l	l	l	l	s	s	l	l	l	l	l	l	l	l	l
p57	r	r	r	l	l	l	l	l	s	s	l	s	l	l	l	l	l	l	l	l
p58	r	r	r	l	l	l	l	l	l	l	s	l	l	s	l	s	l	l	l	l
p59	r	r	r	l	l	l	l	l	l	s	l	s	l	l	l	l	l	l	l	s
p60	l	l	r	l	l	l	l	l	s	s	s	s	s	s	s	l	s	s	l	s
p61	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	l	s	l
p62	r	r	r	r	r	r	r	r	l	l	s	s	l	l	l	l	l	l	l	l
p63	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p64	l	r	r	r	r	r	l	l	l	l	l	s	l	l	l	l	l	l	l	l
p65	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p66	r	r	l	l	l	l	r	l	l	l	l	l	l	l	l	l	l	l	l	l
p67	l	l	l	l	l	l	l	l	l	s	s	l	l	l	l	l	l	l	l	l
p68	l	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p69	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l
p70	r	r	r	l	l	l	l	l	l	s	l	l	s	l	l	s	l	s	l	s
p71	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p72	l	l	l	l	l	r	r	r	l	l	s	s	s	s	s	s	s	s	s	s
p73	r	l	l	l	l	l	l	r	s	l	l	l	s	l	l	l	s	l	l	l
p74	l	r	l	l	l	l	r	l	l	s	s	s	s	s	s	s	s	l	s	l
p75	l	l	r	r	r	l	l	l	l	l	l	s	l	l	l	l	l	l	l	l
p76	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p77	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l
p78	r	r	l	l	l	l	l	l	s	s	l	l	s	s	l	l	l	l	l	l

Table B.01 (2/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

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	Set A - T Junction								Set B - side exit varies, straight on same as entrance corridor												
	E=2, L=2*a, R=2				E=2, R=2*a, L=2				E=2, L=2*a, S=2						E=2, R=2*a, S=2					
	null	Left hand side wider			null	Right hand side wider			null	Left hand side wider					null	Right hand side wider				
	ELR	ELR	ELR	ELR	ERL	ERL	ERL	ERL	ELS	ELS	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ERS	ERS
Ratio of corridor	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1.585	1.778	1	1.122	1.259	1.413	1.585	1.778
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Image no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p79	r	r	r	r	r	r	r	r	s	s	l	l	s	s	l	l	s	s	s	l
p80	r	r	l	l	l	l	l	l	s	s	l	s	l	l	l	l	l	l	l	l
p81	l	l	l	l	l	l	l	r	l	s	s	s	l	s	l	s	s	s	s	s
p82	r	r	r	r	l	l	r	r	s	s	s	s	l	s	s	s	s	s	s	s
p83	r	r	r	r	r	r	r	l	r	r	r	r	r	r	r	r	r	r	r	r
p84	l	r	l	l	l	l	r	r	s	l	l	s	s	s	s	l	s	s	s	s
p85	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	l
p86	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	l
p87	r	r	r	r	l	r	r	r	s	s	s	s	s	s	s	s	s	s	s	l
p88	r	l	r	r	r	r	r	l	l	l	l	l	l	l	l	l	l	s	l	l
p89	l	l	r	l	l	l	l	l	s	s	s	l	s	l	l	l	l	l	l	l
p90	l	l	r	l	l	l	l	l	s	s	l	l	l	s	l	s	l	s	l	l
p91	l	l	l	l	l	l	l	l	s	s	s	l	s	s	l	s	s	s	l	s
p92	r	l	l	l	l	l	l	l	s	s	l	l	l	l	l	l	l	l	l	l
p93	r	l	l	l	l	l	l	r	l	s	l	l	l	l	l	l	l	s	l	l
p94	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p95	l	l	r	l	r	r	l	l	l	s	s	l	s	s	s	s	l	s	s	s
p96	l	r	l	l	l	l	l	l	s	s	l	s	s	l	s	l	s	l	l	l
p97	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	s	s	s
p98	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l
p99	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	l	s	s	s	l
p100	r	r	r	r	r	l	l	l	s	s	s	l	s	l	l	l	l	s	s	s
p101	r	r	l	l	l	l	l	l	l	s	l	s	s	s	l	s	s	s	l	s
p102	r	l	l	l	l	l	l	l	l	s	l	l	l	l	l	l	l	l	l	l
p103	r	r	r	r	r	r	r	r	l	s	l	s	s	s	s	s	s	s	s	l
p104	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	l	l	l	l	l
p105	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p106	r	l	l	l	l	l	r	l	s	s	s	s	s	s	s	s	s	s	s	s
p107	r	l	r	r	r	r	r	r	l	s	l	s	s	s	s	s	l	l	s	l
p108	l	l	r	r	r	r	r	r	l	l	l	l	l	s	l	l	l	l	l	l
p109	l	l	l	l	l	l	l	l	s	s	s	l	s	s	s	s	s	s	l	s
p110	r	r	r	r	r	r	r	r	s	l	s	s	s	s	s	s	s	l	s	s
p111	l	r	l	l	r	l	l	l	l	l	l	l	l	l	l	s	l	l	l	l
p112	r	r	r	l	r	l	l	l	l	s	s	s	s	l	s	l	l	l	l	l
p113	r	r	r	r	l	l	r	r	s	l	s	s	l	s	l	s	s	s	l	s
p114	r	r	r	r	r	r	l	r	s	s	s	l	l	l	l	s	l	s	s	s
p115	l	r	r	l	l	l	l	l	l	s	l	l	l	l	l	l	l	l	l	l
p116	r	r	l	l	l	l	l	l	s	s	l	s	l	l	l	l	l	l	l	l
p117	r	r	r	l	l	r	l	l	l	l	l	l	l	l	l	l	l	l	l	l

Table B.01 (3/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set A - T Junction								Set B - side exit varies, straight on same as entrance corridor												
	E=2, L=2*a, R=2				E=2, R=2*a, L=2				E=2, L=2*a, S=2						E=2, R=2*a, S=2					
	null	Left hand side wider			null	Right hand side wider			null	Left hand side wider					null	Right hand side wider				
	ELR	ELR	ELR	ELR	ERL	ERL	ERL	ERL	ELS	ELS	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ERS	ERS
Ratio of corridor	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1	1.122	1.259	1.413	1.585	1.778	1	1.122	1.259	1.413	1.585	1.778
Image no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p118	l	l	l	l	l	r	r	r	s	s	l	l	l	l	s	r	r	s	r	r
p119	r	r	r	l	r	r	l	r	l	l	l	s	l	s	r	s	s	r	r	r
p120	r	l	l	r	l	l	l	l	s	s	l	s	l	l	s	s	r	s	r	s
p121	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	r	s	r	s	r
p122	r	r	r	l	l	l	l	l	l	s	l	s	l	s	s	r	r	r	s	r
p123	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	r	r	s	r	r
p124	l	l	l	l	l	l	l	l	l	l	l	l	l	l	r	s	r	r	r	r
p125	r	r	l	l	l	l	r	r	l	s	s	l	l	s	s	r	s	s	s	s
p126	r	r	l	l	l	l	l	l	l	l	l	l	l	l	r	r	r	r	r	r
p127	r	r	r	r	r	r	r	r	l	s	s	s	l	s	r	s	r	r	r	r
p128	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p129	l	l	r	l	l	l	l	l	l	l	l	l	s	l	s	s	r	s	s	s
p130	r	l	r	l	l	l	r	l	s	l	s	s	l	s	r	r	r	s	r	s
p131	r	r	l	l	r	l	r	l	l	s	l	s	s	l	r	r	s	r	s	r
p132	r	l	l	l	l	l	l	l	l	l	l	s	s	s	s	s	r	s	s	s
p133	r	r	r	r	r	r	r	r	s	s	s	s	l	s	s	s	r	s	r	r
p134	r	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	r	s	s
p135	r	r	r	r	r	r	r	r	s	s	s	s	s	s	r	r	r	r	r	r
p136	l	l	l	l	l	l	l	l	s	s	s	s	l	l	s	s	r	s	r	s
p137	r	r	r	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p138	l	r	r	l	r	r	l	l	s	s	l	l	l	l	s	s	r	r	r	r
p139	r	r	r	r	r	r	r	r	s	s	s	s	s	s	r	r	r	r	r	r
p140	l	r	r	r	l	l	r	l	s	s	s	s	s	s	s	s	s	s	s	s
p141	l	l	l	r	l	l	r	l	l	l	l	l	s	l	r	r	r	r	r	r
p142	l	l	l	l	l	l	l	l	s	s	s	s	l	s	s	s	s	s	s	s
p143	l	l	l	l	l	l	r	l	l	l	l	l	l	s	r	r	s	r	r	r
p144	l	l	l	l	l	l	l	l	l	l	l	l	s	l	r	r	s	r	r	s
p145	l	l	l	l	l	r	l	l	l	l	s	s	s	s	s	s	r	r	r	r
p146	l	l	l	l	l	l	r	l	l	l	l	l	l	l	r	r	r	r	s	r
p147	r	r	r	r	r	r	r	r	s	s	s	s	s	s	r	r	r	r	s	r
p148	r	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p149	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p150	r	r	l	l	l	r	l	r	s	s	s	s	l	l	r	r	r	s	r	r
p151	r	r	r	r	r	l	l	r	s	s	s	s	s	l	r	r	s	r	r	r
p152	l	r	l	l	l	l	r	l	s	s	s	s	s	s	s	s	s	s	s	s
p153	r	r	r	r	r	r	r	r	l	l	l	l	l	l	r	r	r	r	r	r
p154	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p155	l	l	l	l	l	l	l	l	l	l	s	s	s	s	s	s	r	s	s	r
p156	r	l	l	l	l	l	l	l	s	s	s	s	l	l	r	s	s	s	r	s

Table B.01 (4/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set A - T Junction								Set B - side exit varies, straight on same as entrance corridor												
	E=2, L=2*a, R=2				E=2, R=2*a, L=2				E=2, L=2*a, S=2						E=2, R=2*a, S=2					
	null	Left hand side wider			null	Right hand side wider			null	Left hand side wider					null	Right hand side wider				
	ELR	ELR	ELR	ELR	ERL	ERL	ERL	ERL	ELS	ELS	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ERS	ERS
Ratio of corridor	1 -	1.122 -	1.259 -	1.413 -	1 -	1.122 -	1.259 -	1.413 -	1 -	1.122 -	1.259 -	1.413 -	1.585 -	1.778 -	1 -	1.122 -	1.259 -	1.413 -	1.585 -	1.778 -
Image no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p157	r	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	r
p158	r	r	r	r	l	l	l	l	l	s	l	s	s	s	s	r	s	r	r	r
p159	l	l	l	l	l	l	l	l	l	l	l	l	l	l	s	s	r	s	r	r
p160	r	r	r	r	r	r	r	l	l	l	l	l	l	l	r	r	r	r	r	r
p161	l	l	l	l	r	l	l	l	s	s	l	l	l	s	s	s	r	r	s	r
p162	l	r	r	l	r	l	l	l	s	s	s	s	s	s	r	r	r	r	s	r
p163	r	r	r	l	r	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p164	r	l	l	r	r	l	l	l	s	l	l	s	s	l	r	s	r	s	s	s
p165	l	l	r	l	r	r	r	r	l	l	l	l	l	l	r	r	r	r	r	r
p166	r	l	r	l	r	l	l	l	s	s	s	s	s	s	s	s	s	s	r	s
p167	l	l	r	l	l	l	l	r	s	s	s	s	l	l	s	s	s	r	s	r
p168	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	r	r
p169	l	l	l	l	r	l	r	l	s	s	l	s	s	s	r	s	s	s	r	r
p170	l	l	l	l	l	l	l	l	s	s	s	s	l	l	r	s	s	s	r	r
p171	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p172	l	r	l	l	l	l	l	l	s	s	l	l	l	s	s	s	s	r	r	r
p173	l	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	r	s
p174	r	r	r	r	l	l	l	l	l	s	l	s	s	l	s	r	r	r	s	s
p175	r	r	l	r	l	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p176	l	r	l	l	l	l	l	l	s	s	s	l	l	l	r	r	r	s	r	r
p177	r	r	l	l	l	l	l	l	l	l	l	l	l	l	r	r	r	r	r	r
p178	r	r	r	l	l	r	l	l	s	l	l	l	s	s	s	r	s	r	r	r
p179	l	r	l	r	r	r	r	l	l	l	l	s	s	s	r	r	r	r	r	r
p180	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p181	l	r	l	l	l	l	l	l	s	s	s	l	s	s	s	s	r	r	s	r
p182	l	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p183	l	r	l	l	l	l	l	l	l	s	l	s	l	s	s	r	s	r	r	s
p184	l	l	l	r	l	l	r	l	s	s	s	s	s	s	s	r	s	r	s	s
p185	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	r	r
p186	r	r	r	r	r	r	r	l	s	s	s	s	s	s	r	r	s	r	s	r
p187	l	l	l	l	l	l	l	l	s	s	s	s	s	s	r	r	r	r	r	r
p188	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p189	l	l	l	l	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p190	l	l	l	l	l	l	l	r	s	s	l	s	l	l	r	r	s	r	s	r
p191	r	r	r	l	l	l	l	l	l	s	l	s	l	s	r	r	r	s	r	r
p192	r	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p193	l	l	r	l	r	r	l	l	s	s	s	s	l	s	r	s	s	r	s	r
p194	r	r	r	r	l	l	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p195	r	r	r	l	r	l	l	l	s	s	s	s	l	s	r	s	r	s	s	s

Table B.01 (5/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

Set A - T Junction / **Set B - side exit varies, straight on same as entrance corridor**

Image no.	ELR 1	ELR 1.122	ELR 1.259	ELR 1.413	ERL 1	ERL 1.122	ERL 1.259	ERL 1.413	ELS 1	ELS 1.122	ELS 1.259	ELS 1.413	ELS 1.585	ELS 1.778	ERS 1	ERS 1.122	ERS 1.259	ERS 1.413	ERS 1.585	ERS 1.778
(col)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p196	r	r	l	r	r	r	r	r	l	l	l	l	l	l	r	r	r	r	r	r
p197	r	r	l	r	r	r	r	l	l	s	l	l	l	s	s	s	s	r	s	s
p198	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p199	r	l	l	l	l	l	l	l	s	s	s	l	l	l	r	r	s	r	r	r
p200	r	l	r	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p201	r	l	r	l	l	l	r	r	s	l	s	l	s	s	s	r	s	s	r	r
p202	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p203	r	r	r	r	r	r	l	r	s	s	s	s	s	s	s	s	s	s	s	s
p204	r	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p205	r	r	r	r	r	r	l	r	l	l	l	l	l	l	r	r	r	r	r	r
p206	r	r	l	r	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p207	r	r	r	l	r	r	l	r	s	s	s	s	s	l	s	s	r	s	r	s
p208	l	r	r	l	r	r	r	r	s	s	s	s	s	s	s	s	r	r	r	s
p209	r	r	r	l	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s
p210	l	l	l	l	l	l	r	l	l	s	l	l	l	l	r	r	r	s	r	s
p211	r	r	r	l	l	l	l	l	l	l	l	l	l	l	r	r	r	r	r	r
p212	r	r	r	r	l	l	l	r	s	s	s	l	s	s	s	s	s	s	s	r
p213	r	r	l	l	r	r	l	l	l	l	l	l	l	l	r	r	r	r	r	r
p214	r	l	r	r	l	r	s	r	l	s	l	l	s	l	s	s	r	s	s	r
p215	r	r	r	r	l	l	r	l	l	s	s	s	s	s	r	s	s	r	s	s
p216	r	r	r	r	r	r	r	r	s	s	l	s	s	l	s	r	r	s	s	r
p217	r	r	l	l	l	l	l	l	l	s	s	s	l	l	r	r	s	s	r	r
p218	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p219	r	r	r	r	r	r	r	l	s	s	s	s	s	s	s	s	s	s	s	s
p220	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p221	l	r	l	l	l	l	l	l	s	l	s	s	s	l	s	r	r	r	r	s
p222	l	l	l	l	l	l	l	l	l	s	l	l	l	l	r	r	r	r	r	r
p223	l	l	l	r	l	r	l	l	s	s	s	s	s	s	r	r	s	s	s	r
p224	r	r	l	l	l	r	r	l	s	l	s	l	s	s	s	s	s	s	s	s
p225	r	r	l	l	l	r	r	l	s	s	l	s	l	s	s	s	r	s	r	s
p226	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s	s
p227	l	l	l	l	l	l	l	l	l	s	s	s	s	s	s	s	s	s	s	s
p228	l	l	l	l	l	l	l	l	s	l	l	s	l	l	r	s	r	s	r	r
p229	r	r	l	l	l	l	l	l	l	s	s	s	s	s	r	s	r	r	r	r
p230	r	r	r	r	r	r	l	l	l	s	s	l	s	l	s	s	r	r	r	r
p231	r	r	l	l	l	l	l	l	l	l	l	l	l	l	s	s	r	r	s	r
p232	r	l	r	r	l	l	l	l	s	s	l	l	s	s	r	r	s	s	s	r
p233	l	r	l	l	l	l	l	l	s	s	s	s	s	s	s	s	r	s	r	s
p234	l	l	l	l	r	r	l	r	s	s	s	s	s	s	s	s	s	s	s	s

Table B.01 (6/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

Table B.01 (7/7): Set A and Set B raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set A - T Junction																Set B - side exit varies, straight on same as entrance corridor																								
	E=2, L=2*a, R=2								E=2, R=2*a, L=2								E=2, L=2*a, S=2												E=2, R=2*a, S=2											
	null		Left hand side wider						null		Right hand side wider						null		Left hand side wider										null		Right hand side wider									
	ELR		ELR		ELR		ELR		ERL		ERL		ERL		ERL		ELS		ELS		ELS		ELS		ELS		ELS		ERS		ERS		ERS		ERS		ERS		ERS	
Ratio of corridor	1		1.122		1.259		1.413		1		1.122		1.259		1.413		1		1.122		1.259		1.413		1.585		1.778		1		1.122		1.259		1.413		1.585		1.778	
Image no.	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
p235	l	l	r	l	l	r	r	l	l	l	r	l	l	r	l	l	s	l	s	s	s	s	s	s	s	s	s	s	s	s	s	s	r	s	r	s	s	s	r	s
p236	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p237	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	r	r	r	r
p238	l	r	r	r	r	r	l	r	r	r	l	r	l	l	l	r	l	l	l	l	l	s	s	s	s	s	l	l	s	s	s	s	r	r	r	r	s	r	r	r
p239	r	r	r	l	l	r	l	l	r	r	r	r	r	l	r	l	l	l	l	l	l	l	l	s	l	l	l	l	r	r	r	r	r	s	r	r	r	r	s	s
p240	r	r	l	l	l	l	l	l	r	r	r	r	r	r	r	r	s	s	l	l	l	l	l	l	l	l	l	l	s	r	r	s	r	r	r	r	r	r	r	r
p241	r	r	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	s	s	s	s	l	s	l	s	l	l	s	r	r	s	s	s	s	r	s	r	s	r	s
p242	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	s	s	s	l	s	l	l	l	l	s	s	s	r	r	r	r	r	r	r	r	s	r	r	r
p243	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	l	s	s	s	l	s	l	l	l	l	s	s	s	r	r	r	r	s	r	r	r	s	r	r	r
p244	r	l	l	l	l	l	l	l	r	l	r	r	r	r	l	r	s	s	l	l	s	s	l	s	s	l	l	l	r	r	r	s	s	r	r	r	r	s	s	r
p245	r	r	l	l	l	l	l	l	r	r	r	r	r	r	r	r	s	s	l	l	l	s	l	s	l	l	l	l	s	s	s	s	s	r	r	r	s	r	r	r
p246	r	r	l	l	l	l	l	l	r	r	r	r	r	r	r	r	s	l	l	l	l	l	l	s	s	l	l	l	r	s	r	s	s	r	r	s	s	r	s	s
p247	l	l	l	l	l	l	l	l	l	l	l	l	l	r	r	r	s	s	l	l	l	l	l	s	l	s	l	l	s	r	s	s	s	s	r	r	r	r	r	r
p248	r	l	r	l	l	r	l	r	l	l	l	l	l	l	r	r	l	l	s	l	s	s	l	l	s	s	l	s	r	r	s	r	r	r	s	r	r	s	r	r
p249	l	r	l	l	l	r	l	r	r	r	r	l	l	r	l	r	s	s	l	l	l	s	s	s	l	s	s	s	r	s	r	s	r	s	r	s	r	s	r	s
p250	l	r	r	l	r	r	r	l	r	l	r	r	l	l	l	r	s	s	l	s	s	s	s	s	s	s	s	s	r	r	r	s	r	s	s	s	r	s	s	r
r=	135	136	116	98	91	78	86	70	145	138	169	180	179	198	184	197	0	0	0	0	0	0	0	0	0	0	0	0	99	91	101	86	108	120	120	113	131	130	132	149
l=	115	114	134	152	159	172	164	180	105	112	81	70	71	52	66	53	89	71	98	91	95	93	116	116	109	114	126	131	0	0	0	0	0	0	0	0	0	0	0	0
s=	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	161	179	152	159	155	157	134	134	141	136	124	119	151	159	149	164	142	130	130	137	119	120	118	101
sum	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
L%=	46	46	54	61	64	69	66	72	42	44.8	32	28	28	21	26	21	36	28	39	36	38	37	46	46	44	46	50	52	0	0	0	0	0	0	0	0	0	0	0	0
R%=	54	54	46	39	36	31	34	28	58	55.2	68	72	72	79	74	79	0	0	0	0	0	0	0	0	0	0	0	0	40	36	40	34	43	48	48	45	52	52	53	60
S%=	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	72	61	64	62	63	54	54	56	54	50	48	60	64	60	66	57	52	52	55	48	48	47	40

Set C - straight on varies, side exit same as entrance corridor

- E=2, L=2, S=2*b — Straight narrower (ELS, ELS, ELS) | null (ELS)
- E=2, R=2, S=2*b — Straight narrower (ERS, ERS, ERS) | null (ERS)

Set D - both straight on and side exit vary

- E=2, L=2*a, S=2*b — Straight narrower, LHS wider (ELS, ELS)
- E=2, R=2*a, S=2*b — Straight narrower, RHS wider (ERS, ERS)

	21		22		23		24		25		26		27		28		29		30		31		32	
Ratio of corridor	0.708		0.794		0.891		1		0.708		0.794		0.891		1		0.891		0.794		0.891		0.794	
	1		1		1		1		1		1		1		1		1.122		1.259		1.122		1.259	
p1	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p2	l	l	l	l	l	s	s	s	r	r	s	r	r	r	r	s	l	l	l	l	r	r	r	r
p3	s	l	s	l	s	s	s	l	r	r	r	s	s	s	s	r	l	l	l	l	s	r	s	r
p4	l	l	l	s	s	s	s	s	r	r	s	r	r	r	s	s	s	l	l	l	s	r	r	r
p5	s	s	s	s	s	s	s	s	s	r	s	r	s	r	r	r	s	s	s	s	s	s	s	s
p6	l	l	l	l	l	l	l	s	r	r	r	r	r	r	s	s	l	l	l	l	r	s	r	r
p7	l	l	l	l	l	l	s	s	r	r	r	s	s	s	r	s	l	l	l	l	s	r	r	r
p8	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p9	l	l	s	s	s	s	s	s	r	s	s	s	r	s	s	s	s	s	s	s	s	s	s	s
p10	s	l	l	l	s	l	s	s	r	r	r	r	s	r	s	s	l	l	l	l	s	r	r	r
p11	l	l	l	s	s	l	l	s	r	r	r	r	r	s	s	s	l	s	s	l	r	r	s	s
p12	l	l	l	l	s	l	l	l	r	r	s	r	r	s	s	s	l	l	l	l	r	r	r	r
p13	l	s	l	l	s	s	s	s	r	r	r	r	s	s	s	s	s	s	s	l	r	s	r	r
p14	s	l	s	l	s	s	s	s	r	s	r	s	r	s	r	s	s	s	l	l	s	s	s	s
p15	s	s	s	s	s	s	s	l	s	s	s	s	s	s	r	s	l	s	s	s	s	s	s	s
p16	s	l	s	l	s	s	s	s	r	s	s	s	s	s	s	s	s	s	l	s	r	s	r	r
p17	l	l	l	l	l	s	l	s	r	r	r	r	r	s	r	s	l	l	l	l	r	r	r	r
p18	l	s	s	l	l	s	l	s	s	r	r	r	r	s	r	s	s	l	l	l	r	s	r	r
p19	l	l	l	l	s	l	s	s	s	r	r	r	r	s	s	s	s	l	l	l	r	r	s	r
p20	l	l	l	l	s	l	l	l	r	r	r	s	r	r	s	s	l	l	l	l	r	r	r	r
p21	l	l	s	l	s	l	s	s	r	r	r	s	s	r	s	r	l	s	l	s	r	r	s	r
p22	l	l	l	l	l	l	l	l	s	r	r	r	s	r	r	r	l	l	l	l	s	r	r	r
p23	s	s	s	s	s	l	s	s	r	r	r	r	r	s	s	s	s	s	s	s	s	s	s	r
p24	l	l	l	s	l	s	l	s	r	r	s	s	s	s	r	s	s	l	l	s	r	r	r	r
p25	s	s	s	s	s	s	l	s	s	s	r	r	r	r	s	r	s	s	s	s	r	s	s	r
p26	s	s	l	s	s	s	s	s	r	r	s	s	r	r	r	s	s	l	l	l	s	s	r	s
p27	l	s	l	l	s	l	l	l	s	r	s	s	s	r	r	r	l	l	s	s	r	r	s	s
p28	l	l	l	l	l	s	s	s	r	r	s	r	r	s	s	s	l	s	l	l	r	s	r	r
p29	l	l	l	l	l	l	l	s	r	r	r	r	r	r	r	s	l	l	l	l	r	r	r	r
p30	s	s	s	s	l	s	s	s	s	s	s	s	s	r	s	s	s	s	s	s	s	s	s	r
p31	l	l	s	l	l	l	s	s	r	r	r	r	s	r	s	s	l	l	l	l	r	r	r	r
p32	l	l	l	s	l	s	l	s	r	r	r	r	r	s	r	r	l	l	l	l	r	s	r	s
p33	l	l	l	l	s	l	l	s	s	r	r	r	r	r	s	s	l	l	l	l	s	r	r	r
p34	l	l	l	s	s	l	s	s	r	r	r	s	s	s	s	s	l	l	l	s	r	s	r	r
p35	l	l	l	l	s	l	l	l	s	r	r	r	r	r	r	r	s	l	s	l	r	r	r	r
p36	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p37	l	l	l	l	l	l	l	l	r	r	s	r	s	s	r	s	l	l	l	l	r	r	r	r
p38	l	s	s	s	s	s	s	s	s	r	r	r	r	r	r	s	s	l	l	l	s	s	r	r
p39	s	s	s	s	s	s	s	s	s	s	s	s	s	s	r	s	s	s	s	s	s	s	s	s

Table B.02 (1/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set C - straight on varies, side exit same as entrance corridor																Set D - both straight on and side exit vary							
	E=2, L=2, S=2*b								E=2, R=2, S=2*b								E=2, L=2*a, S=2*b				E=2, R=2*a, S=2*b			
	Straight narrower						null		Straight narrower						null		Straight narrower, LHS wider				Straight narrower, RHS wider			
	ELS		ELS		ELS		ELS		ERS		ERS		ERS		ERS		ELS		ELS		ERS		ERS	
Ratio of	0.708		0.794		0.891		1		0.708		0.794		0.891		1		0.891		0.794		0.891		0.794	
corridor	1		1		1		1		1		1		1		1		1.122		1.259		1.122		1.259	
Image no.	21		22		23		24		25		26		27		28		29		30		31		32	
p40	s	s	s	s	s	s	s	s	s	s	r	s	s	s	s	s	s	s	s	s	s	s	s	s
p41	l	l	s	s	s	s	s	l	s	r	s	s	s	s	s	l	s	s	s	l	s	s	r	r
p42	l	l	l	s	l	l	s	l	r	r	r	s	r	r	s	s	l	l	l	l	s	r	r	r
p43	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p44	s	l	s	s	s	s	s	s	r	r	s	s	s	s	s	s	s	s	s	l	s	s	s	s
p45	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p46	l	l	l	l	l	l	l	l	s	r	r	r	s	r	r	s	l	s	l	s	s	r	s	r
p47	l	l	l	l	s	l	s	s	r	r	r	r	s	r	s	s	s	l	l	l	r	r	r	r
p48	l	l	l	l	l	l	s	s	r	r	s	r	r	r	s	s	s	s	l	l	r	r	r	r
p49	l	l	s	s	s	s	s	s	r	r	r	r	r	s	s	s	l	l	l	l	r	r	r	r
p50	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p51	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p52	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p53	l	l	s	l	s	l	s	s	r	r	r	r	s	s	s	s	s	s	s	s	s	s	r	r
p54	s	l	s	s	s	s	s	s	s	s	s	s	r	s	s	r	s	s	s	s	r	r	s	r
p55	l	l	l	l	s	s	s	l	r	r	s	s	s	s	r	r	l	s	l	l	s	s	r	r
p56	l	l	l	l	l	l	s	s	r	r	r	r	r	s	r	s	l	l	l	l	r	r	r	r
p57	l	l	l	l	l	l	s	l	r	r	r	r	r	r	s	s	l	l	l	l	r	r	r	r
p58	l	l	s	l	s	s	s	s	s	r	s	r	s	r	s	s	s	l	l	l	r	s	s	r
p59	l	l	l	l	l	l	l	s	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p60	l	l	l	l	s	s	s	s	r	s	s	r	s	s	s	s	s	s	l	l	s	s	r	r
p61	s	s	s	s	s	s	s	s	r	r	r	s	r	s	r	s	s	s	s	l	s	s	r	r
p62	l	l	l	l	s	l	s	s	r	r	s	r	r	r	r	s	s	l	l	l	r	r	r	r
p63	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p64	l	l	l	l	l	l	s	s	r	r	r	r	r	r	s	r	l	l	l	l	r	r	r	r
p65	l	l	l	l	l	l	s	s	r	r	r	r	r	r	s	s	s	s	l	l	r	r	r	r
p66	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p67	l	l	l	l	l	s	l	l	r	r	r	r	r	r	s	r	l	l	l	l	r	r	r	r
p68	l	s	s	s	s	s	s	s	r	r	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p69	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p70	s	s	s	s	s	s	s	s	s	s	s	s	r	s	r	r	l	l	l	s	s	r	r	r
p71	l	l	s	l	s	s	s	s	r	r	r	r	s	s	s	s	s	s	s	l	s	s	r	r
p72	l	l	s	l	s	l	l	s	r	r	r	s	r	s	s	r	l	l	l	l	r	r	s	r
p73	l	l	l	l	s	s	s	l	r	r	r	r	r	r	s	r	l	l	l	l	s	r	s	r
p74	l	l	l	l	l	l	s	s	r	r	r	r	s	r	s	s	s	s	l	l	s	r	r	r
p75	l	s	l	s	l	l	l	l	r	s	s	s	r	r	r	r	l	l	l	l	r	r	r	r
p76	s	s	l	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p77	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p78	l	l	l	l	s	l	l	l	r	r	s	r	s	s	s	s	l	l	l	l	r	r	r	r

Table B.02 (2/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set C - straight on varies, side exit same as entrance corridor								Set D - both straight on and side exit vary			
	E=2, L=2, S=2*b				E=2, R=2, S=2*b				E=2, L=2*a, S=2*b		E=2, R=2*a, S=2*b	
	Straight narrower			null	Straight narrower			null	Straight narrower, LHS wider		Straight narrower, RHS wider	
	ELS	ELS	ELS	ELS	ERS	ERS	ERS	ERS	ELS	ELS	ERS	ERS
Ratio of	0.708	0.794	0.891	1	0.708	0.794	0.891	1	0.891	0.794	0.891	0.794
corridor	1	1	1	1	1	1	1	1	1.122	1.259	1.122	1.259
Image no.	21	22	23	24	25	26	27	28	29	30	31	32
p79	l l	l l	l l	s s	r s	r r	s r	s s	l l	s l	s s	r r
p80	l l	l l	s l	s s	r r	r r	r r	s s	l l	s l	r r	r r
p81	l s	l s	l l	l s	r s	s s	s s	s s	l s	l l	r s	s s
p82	s s	s s	s s	l s	s s	s r	s r	s r	s s	s l	s r	r s
p83	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	r r
p84	l s	l s	l l	s s	s s	s r	s s	s s	s l	s s	s s	s r
p85	s s	s s	l s	s s	r r	s s	r r	r s	s s	s s	s r	s s
p86	s s	s s	s s	s s	s s	r s	s s	s s	s s	s s	s s	s s
p87	l l	s l	l s	s s	r r	r r	r r	s s	s s	s l	s s	s r
p88	s l	s l	l l	s l	r r	r r	s r	s s	l l	l l	r r	s r
p89	s s	s s	s s	s s	s s	s s	s s	s r	s l	l s	s r	s s
p90	l l	s l	l s	l l	r r	s r	r r	s r	l s	s l	s s	r s
p91	l l	l s	l l	s s	r r	s r	s s	s s	s l	l l	s r	s r
p92	l l	l l	l l	s l	r r	r s	r s	s r	l l	l l	s r	r r
p93	l l	l l	l s	l l	r r	r r	r r	r s	s s	l l	r r	r r
p94	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p95	s l	l l	s l	l l	s r	r r	r s	r r	s l	l l	r r	r r
p96	l l	s l	s l	s s	r r	r r	r r	s s	s l	l l	r r	s r
p97	l l	l l	l l	l l	r r	s s	r r	r s	s l	l l	s r	r s
p98	l l	l l	l l	l l	s r	r r	r r	r r	l l	l l	r r	r r
p99	l l	s l	s l	s s	r r	r r	s r	s s	l l	l s	s r	r r
p100	s s	s s	s s	s l	r r	s s	s r	r r	s s	s l	s s	r r
p101	l l	s l	l l	s s	r r	r r	r r	s s	l l	l l	r r	r r
p102	s s	s s	l s	l s	s s	r s	s s	r s	l l	s l	s r	s r
p103	s s	l s	l s	l s	r s	r s	s s	r r	l l	s s	r s	s s
p104	l l	l l	l s	s s	r r	r r	s r	s s	s l	l l	r r	s r
p105	l l	s s	s s	s s	s r	s s	r s	s s	s s	l s	r s	s s
p106	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p107	s s	s l	l s	s s	r r	s s	s s	r s	s s	l l	s r	s s
p108	l l	l l	l l	l l	s s	s r	s s	r s	l l	l l	s s	s s
p109	l s	s l	s l	s s	r s	r s	s s	s s	s l	l s	s s	r s
p110	s s	s s	s s	s s	s s	s r	s s	s s	s s	s s	s s	s r
p111	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	r r
p112	s l	s l	l l	s s	r r	r s	s s	s s	l l	l l	s r	r r
p113	l s	l s	s l	s s	r r	s s	s r	s r	s s	s l	s r	s s
p114	l s	l l	l l	l l	r r	r r	s r	r s	l l	l l	r r	r r
p115	l l	l l	l l	l l	s r	s s	s s	s s	l l	l l	s s	s r
p116	l l	l l	s s	s l	r r	r r	s r	r r	s l	s l	r r	r r
p117	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	r r

Table B.02 (3/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

Table B.02 (4/7)

	Set C - straight on varies, side exit same as entrance corridor																Set D - both straight on and side exit vary							
	E=2, L=2, S=2*b								E=2, R=2, S=2*b								E=2, L=2*a, S=2*b				E=2, R=2*a, S=2*b			
	Straight narrower						null		Straight narrower						null		Straight narrower, LHS wider				Straight narrower, RHS wider			
	ELS		ELS		ELS		ELS		ERS		ERS		ERS		ERS		ELS		ELS		ERS		ERS	
Ratio of	0.708		0.794		0.891		1		0.708		0.794		0.891		1		0.891		0.794		0.891		0.794	
corridor	1		1		1		1		1		1		1		1		1.122		1.259		1.122		1.259	
Image no.	21		22		23		24		25		26		27		28		29		30		31		32	
p118	l	l	l	l	s	l	s	l	r	r	r	r	r	r	s	s	s	l	l	l	r	r	r	r
p119	s	s	l	s	l	s	s	l	r	r	r	r	s	r	r	s	s	l	s	s	r	s	r	r
p120	s	s	s	l	s	l	s	s	r	r	r	r	s	s	r	s	l	s	s	l	r	r	r	r
p121	l	l	l	l	l	l	s	s	r	r	r	r	s	r	s	s	l	l	l	l	s	r	r	r
p122	l	s	s	s	s	s	s	s	r	s	s	s	s	s	s	r	l	l	l	s	s	r	r	s
p123	s	s	s	s	s	s	s	s	r	r	r	r	r	s	s	s	s	s	s	s	r	r	r	r
p124	l	l	l	l	l	l	l	l	r	r	r	r	s	r	r	r	l	l	l	l	r	r	r	r
p125	s	s	s	s	s	l	l	s	s	r	s	s	r	r	r	r	l	s	l	s	s	r	r	s
p126	s	l	s	l	l	l	l	l	r	s	r	r	r	r	r	r	l	l	l	l	s	r	s	s
p127	l	s	l	l	s	s	l	l	r	r	s	r	r	r	r	r	l	s	l	s	r	r	r	r
p128	l	l	s	l	s	s	s	s	r	r	r	s	s	s	s	s	s	s	l	l	r	s	r	r
p129	s	s	s	s	s	l	s	s	r	s	s	s	s	s	s	s	s	s	s	s	r	s	r	s
p130	s	s	l	l	l	l	l	l	r	s	s	r	s	r	r	s	s	l	l	s	r	r	r	r
p131	l	l	l	l	s	l	s	s	r	r	r	r	s	s	r	l	s	l	l	l	s	r	r	s
p132	l	l	s	l	s	s	s	s	r	r	s	r	s	s	s	s	l	l	l	l	r	r	r	s
p133	l	l	s	l	s	s	s	s	r	r	r	s	s	r	s	s	s	l	l	l	s	s	r	r
p134	l	l	s	l	l	s	s	s	s	r	s	r	s	s	s	s	s	s	l	l	r	r	r	r
p135	s	s	s	s	s	s	s	s	r	r	r	r	r	s	r	r	s	s	s	s	s	s	s	s
p136	s	l	s	s	l	l	s	s	r	s	s	r	r	s	s	s	s	l	l	l	s	r	r	r
p137	l	l	s	s	l	s	s	s	s	r	s	r	s	s	s	s	s	l	l	l	s	s	r	s
p138	s	l	l	l	l	l	s	l	s	r	r	r	r	r	r	s	s	s	l	l	r	r	s	r
p139	s	s	s	s	s	s	s	s	r	r	r	r	r	r	r	r	s	s	s	s	r	r	s	r
p140	l	l	l	l	s	s	s	s	r	r	s	r	s	s	s	s	s	s	s	l	s	s	r	r
p141	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p142	l	l	s	s	s	s	s	s	r	r	s	s	s	s	s	s	s	s	l	s	s	s	s	s
p143	l	l	l	l	s	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	s	r	r	r
p144	l	l	l	l	s	l	l	l	r	r	r	r	r	r	s	r	l	s	l	l	s	r	r	r
p145	l	l	s	s	l	l	s	s	r	r	r	r	s	r	s	s	s	s	s	l	s	s	r	r
p146	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p147	s	s	s	s	s	s	s	s	r	r	s	r	s	r	r	r	l	s	s	s	s	s	s	s
p148	s	s	s	s	s	s	s	s	r	s	s	r	s	s	s	s	s	s	s	s	s	s	s	s
p149	s	s	s	s	s	s	s	l	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p150	l	l	l	l	l	l	s	s	s	r	r	r	r	r	s	s	s	l	l	l	r	r	r	r
p151	l	l	s	l	s	s	l	l	s	r	r	r	r	s	r	r	l	l	l	s	r	s	r	r
p152	s	l	l	l	s	s	s	s	r	r	s	r	s	s	s	s	s	s	l	l	s	r	s	s
p153	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p154	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p155	l	l	l	l	l	s	s	l	r	r	r	r	r	s	s	s	l	l	l	l	s	r	r	r
p156	l	s	s	s	l	s	s	s	s	s	s	s	s	s	s	s	l	s	s	s	s	s	r	s

Table B.02 (4/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

Table B.02 (5/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set C - straight on varies, side exit same as entrance corridor																Set D - both straight on and side exit vary							
	E=2, L=2, S=2*b								E=2, R=2, S=2*b								E=2, L=2*a, S=2*b				E=2, R=2*a, S=2*b			
	Straight narrower						null		Straight narrower						null		Straight narrower, LHS wider				Straight narrower, RHS wider			
	ELS		ELS		ELS		ELS		ERS		ERS		ERS		ERS		ELS		ELS		ERS		ERS	
Ratio of	0.708		0.794		0.891		1		0.708		0.794		0.891		1		0.891		0.794		0.891		0.794	
corridor	1		1		1		1		1		1		1		1		1.122		1.259		1.122		1.259	
Image no.	21		22		23		24		25		26		27		28		29		30		31		32	
p157	l	l	l	l	l	s	s	s	r	r	r	r	s	s	s	s	l	l	l	l	s	s	r	r
p158	l	l	l	l	l	s	s	s	r	r	r	r	r	s	s	s	s	s	l	l	r	r	s	r
p159	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p160	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p161	l	l	l	s	l	s	l	s	r	r	r	s	s	s	s	s	s	l	l	l	s	s	r	r
p162	s	l	l	l	s	l	s	s	s	r	r	r	r	r	s	r	l	s	l	l	r	r	r	r
p163	l	l	s	s	s	s	s	s	r	r	s	s	s	s	s	s	s	s	l	l	s	s	s	r
p164	s	l	s	s	s	s	s	l	s	r	s	s	s	r	r	r	l	s	l	s	s	s	s	s
p165	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p166	l	l	l	l	s	l	s	s	s	r	s	r	r	r	s	s	s	l	s	l	s	r	s	r
p167	l	s	s	s	s	s	l	s	s	s	s	s	s	s	s	s	s	l	l	l	r	s	r	r
p168	l	l	s	l	s	l	s	s	s	r	r	r	s	r	s	s	l	l	s	l	s	s	s	r
p169	s	s	l	s	s	s	s	s	r	r	s	s	r	s	s	s	l	s	s	s	r	s	r	r
p170	l	l	l	l	l	l	s	s	r	r	r	r	r	s	s	s	l	l	l	l	r	r	r	r
p171	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p172	l	l	l	l	s	l	s	s	r	r	r	r	r	r	r	s	l	l	s	l	r	r	r	r
p173	l	l	l	s	l	l	l	s	r	r	r	r	r	s	r	s	s	s	l	l	r	s	r	r
p174	s	s	l	l	s	s	s	s	r	r	r	r	r	r	s	r	s	l	l	l	r	r	r	r
p175	s	s	s	s	s	s	s	s	r	r	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p176	l	l	l	l	l	l	l	l	r	r	r	r	r	r	s	l	s	l	l	l	r	r	r	r
p177	l	l	l	l	l	l	l	l	r	r	r	s	r	r	r	r	l	l	l	l	r	r	r	r
p178	s	l	l	l	s	l	s	s	r	r	r	r	r	r	r	r	l	s	l	l	s	s	r	r
p179	l	l	l	l	l	l	l	s	r	r	r	r	s	r	r	r	s	l	l	l	s	r	r	r
p180	s	s	s	s	s	s	s	s	s	s	s	r	s	r	s	s	s	s	s	s	s	s	s	s
p181	l	l	l	l	l	s	s	s	r	r	r	r	r	r	s	s	s	s	s	l	s	r	r	r
p182	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p183	s	l	s	l	l	l	l	l	s	s	r	r	s	r	r	r	l	l	l	l	r	s	r	r
p184	l	s	l	s	l	s	s	s	r	s	s	s	s	s	s	s	s	s	l	s	s	s	r	s
p185	l	l	l	l	l	s	s	s	r	r	s	r	s	s	s	s	l	s	l	l	r	s	r	r
p186	l	s	s	l	s	s	s	s	r	r	r	r	r	r	r	r	s	s	s	s	r	r	r	r
p187	s	l	l	l	s	s	s	s	r	r	r	r	r	r	r	r	s	s	s	l	r	r	r	r
p188	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p189	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
p190	l	l	l	l	l	s	l	l	r	r	r	r	r	r	s	s	l	l	l	s	r	r	r	r
p191	l	l	l	l	l	s	l	s	r	r	r	r	r	r	r	s	l	s	l	l	s	r	r	r
p192	l	l	l	l	s	l	s	s	r	r	r	r	s	s	s	s	s	s	l	l	s	r	r	r
p193	l	l	l	l	s	s	s	s	r	r	s	r	s	r	r	s	s	s	s	l	s	s	r	r
p194	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	r
p195	l	s	l	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	l	s	r	s	r	s

Set C - straight on varies, side exit same as entrance corridor (Images 21–28)   **Set D - both straight on and side exit vary** (Images 29–32)

- Set C, E=2, L=2, S=2*b — Straight narrower: images 21, 22, 23 (ELS); null: image 24 (ELS)
- Set C, E=2, R=2, S=2*b — Straight narrower: images 25, 26, 27 (ERS); null: image 28 (ERS)
- Set D, E=2, L=2*a, S=2*b — Straight narrower, LHS wider: images 29, 30 (ELS)
- Set D, E=2, R=2*a, S=2*b — Straight narrower, RHS wider: images 31, 32 (ERS)

	21	22	23	24	25	26	27	28	29	30	31	32
Ratio of corridor	0.708	0.794	0.891	1	0.708	0.794	0.891	1	0.891	0.794	0.891	0.794
	1	1	1	1	1	1	1	1	1.122	1.259	1.122	1.259
Image no.	21	22	23	24	25	26	27	28	29	30	31	32
p196	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	s r
p197	l l	s s	s s	s s	r s	s r	r s	s s	l l	l s	s s	r r
p198	l l	l l	l l	s s	r r	r r	r s	s s	l l	l l	r s	r r
p199	l l	l l	s s	l s	r s	s s	r s	s s	l l	l l	r s	r r
p200	s l	l l	s s	s s	r r	r r	r s	s s	s s	s l	s s	r r
p201	l l	l s	s s	l s	s s	s r	r r	s s	s l	s s	r r	s r
p202	l s	l s	s s	s s	r r	s s	s s	s s	s s	s s	s s	r r
p203	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p204	s s	s s	s s	s s	r s	s s	s s	s s	s s	s s	s s	s s
p205	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	r r
p206	s s	s s	s s	s s	r r	s s	s r	s s	s s	s l	s s	s s
p207	s s	s s	s s	l s	s s	s s	s s	r s	l s	s s	r s	s s
p208	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p209	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p210	l s	l l	l s	s l	r r	r r	s s	s r	s s	l s	s r	r s
p211	s s	l l	l l	l l	s r	r r	r r	r r	l l	l l	r r	r r
p212	l l	s s	s s	s s	s s	r s	r s	s s	l s	s s	s s	s s
p213	l l	l l	l l	l l	r r	r r	r r	r r	l l	l l	r r	r r
p214	l s	l s	l l	s s	r r	r s	s s	r r	s l	l l	r r	s s
p215	l l	l l	l l	s s	r r	r r	s r	s s	s s	l l	s r	r r
p216	l s	l s	s s	l s	r r	r r	r r	s s	l s	s s	s r	s s
p217	l l	l l	l s	s s	r r	r r	r r	s s	s l	l l	s r	r r
p218	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p219	s s	s s	s s	s s	s r	s s	s s	s s	s s	s s	s s	s s
p220	l l	s l	s s	s s	s r	r r	s s	s s	s s	s l	s s	r r
p221	s s	s s	l s	l l	s s	s s	r s	r r	s s	s s	s s	r r
p222	l l	l l	l l	s l	r r	r r	r r	r s	l l	l l	r r	r l
p223	s s	l s	l l	l s	r s	s s	s s	s s	l s	l s	s s	s s
p224	l l	l l	s s	s l	r r	s r	s s	s s	s l	l l	r r	s r
p225	s l	s s	s l	l s	r s	r s	r s	r s	l s	s s	s r	r s
p226	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p227	s s	l s	s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
p228	l l	l s	s l	s s	r r	r r	s s	r s	l l	l l	r s	r r
p229	l l	s l	l l	s l	r s	s r	s s	s s	l l	s l	s r	s r
p230	l l	l l	s l	l l	r r	r r	r r	r r	l l	l l	r r	r r
p231	l l	l l	s l	l s	r r	r r	r r	s r	l l	l l	r r	r r
p232	l l	l l	l s	s s	r s	s s	s s	s s	l l	l l	s r	s r
p233	s s	s s	s l	s s	r s	s s	r s	r s	s s	s s	r s	s r
p234	s s	s s	s s	s s	s s	s s	r s	s s	l s	s s	s s	r s

Table B.02 (6/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

	Set C - straight on varies, side exit same as entrance corridor																Set D - both straight on and side exit vary							
	E=2, L=2, S=2*b								E=2, R=2, S=2*b								E=2, L=2*a, S=2*b				E=2, R=2*a, S=2*b			
	Straight narrower						null		Straight narrower						null		Straight narrower, LHS wider				Straight narrower, RHS wider			
	ELS		ELS		ELS		ELS		ERS		ERS		ERS		ERS		ELS		ELS		ERS		ERS	
Ratio of	0.708		0.794		0.891		1		0.708		0.794		0.891		1		0.891		0.794		0.891		0.794	
corridor	1		1		1		1		1		1		1		1		1.122		1.259		1.122		1.259	
Image no.	21		22		23		24		25		26		27		28		29		30		31		32	
p235	l	l	l	l	l	s	s	s	s	s	s	r	s	s	r	s	l	l	l	l	r	r	r	r
p236	s	l	l	s	s	s	s	s	s	s	s	r	s	s	s	s	s	s	l	l	s	s	s	s
p237	l	l	l	l	l	l	l	l	r	r	r	r	r	r	r	r	l	l	l	l	r	r	r	r
p238	l	l	l	l	l	l	l	s	r	r	r	r	s	r	r	s	l	l	s	s	s	r	s	s
p239	l	s	l	l	s	s	l	s	r	r	r	r	r	r	r	r	l	s	l	l	r	r	r	s
p240	l	l	l	l	l	l	l	l	r	r	r	r	r	r	s	s	l	l	l	l	r	r	r	r
p241	l	l	l	l	s	l	l	s	r	r	s	r	s	r	r	r	s	l	s	l	r	r	s	r
p242	s	s	s	s	s	s	s	s	s	r	r	r	r	r	r	r	s	s	s	s	r	r	r	s
p243	l	l	l	l	l	s	s	s	r	r	r	r	r	r	r	r	s	l	s	l	r	r	r	r
p244	s	l	s	l	s	l	s	l	r	r	r	s	s	r	s	s	l	s	l	l	r	r	r	s
p245	l	l	l	l	l	l	s	s	r	r	r	r	r	s	s	s	s	l	l	l	r	r	r	r
p246	s	l	l	s	l	l	l	l	r	r	r	r	r	r	s	r	l	l	l	l	s	s	r	r
p247	l	l	l	l	l	l	s	s	r	r	r	s	r	r	s	s	l	l	l	l	r	r	r	r
p248	s	s	l	l	s	l	s	l	r	r	r	s	s	s	s	r	s	s	s	l	r	r	s	r
p249	s	s	l	s	l	s	l	s	s	s	r	s	s	s	r	s	l	l	l	s	s	s	r	r
p250	s	l	s	l	s	l	l	s	s	s	s	s	r	r	s	s	s	s	s	l	s	s	r	s
r=	0	0	0	0	0	0	0	0	171	177	143	155	120	122	99	78	0	0	0	0	121	139	156	172
l=	159	161	144	146	110	118	88	73	0	0	0	0	0	0	0	0	119	130	155	162	0	0	0	0
s=	91	89	106	104	140	132	162	177	79	73	107	95	130	128	151	172	131	120	95	88	129	111	94	78
sum	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
L%=	64	64	58	58	44	47	35	29	0	0	0	0	0	0	0	0	48	52	62	65	0	0	0	0
R%=	0	0	0	0	0	0	0	0	68	71	57	62	48	49	40	31	0	0	0	0	48	56	62	69
S%=	36	36	42	42	56	53	65	71	32	29	43	38	52	51	60	69	52	48	38	35	52	44	38	31

Table B.02 (7/7): Set C and Set D raw data from Corridor Width Experiment showing corridor width ratios in each image and the directions taken by each participant for each image.

Comment ID	Comments left by participants
1	Interesting study! Interface was pretty well designed - the email address with checkbox on the personal details screen was a nice touch, a lot of studies require the participant to get in contact with the researcher at some specified later time if they want to hear the results, when really courtesy would suggest the researcher should inform the participant, as you've offered to do. Would have been nice if we could use keyboard arrow keys instead of clicking directions. I wasn't sure I was consistent in my choices. In some cases there was very, very little difference between the options, it was almost random. I noticed I was quite loath to go all the way down that long-looking corridor - I think I usually picked to turn off sooner rather than go to the end.
2	A larger corridor denotes a main thoroughfare for me, so smaller corridors would make me feel I was going in the wrong direction!
3	Make an UP+DOWN to further your study. Stairs create another layer. Good investigation
4	My initial instinct would be to constantly go straight whenever possible. I suppose this way I can cover the most ground without having to worry about remembering the way I went.
5	The test became confusing due to all scenarios looking almost identical - which is not unlike in reality if you get lost in a university building!
6	I think it would have been better to alternate the two main views so it was less obvious what was changed. This way it seems more like a new decision every new picture. All the best.
7	possibly a few too many images to look through!!! they're all too similar to ask 64 questions about!!! i hope it goes well for you and i have helped!
8	I think if there were no signposts, I would follow always follow the straightest path as it would help me remember where I went in case I got lost, unless it led to a T-junction at the end, whereby I would probably take the bigger corridor until I found a signpost. Interesting experiment!
9	i don't think you can say which way you would go just by looking at a junction, as in reality when you got to the junction, you would look down both ways and then decide! also, the pictures were far too similar, it felt like i saw each one at least five times!
10	I didn't notice the difference in a lot of them: my decisions were often completely arbitrary.
11	I am not sure if it was intended but I assumed that people would be more likely to choose the wider passageway if there was variation and this assumption influenced my own choice.
12	too many questions once I noticed what was changing with each picture, and what answer might be expected, it became hard to imagine my genuine response
13	I would go straight on if that was one of the options and hope to find a sign at the end of the corridor, however I would choose to turn into a wide corridor (that is well lit) as this may be an indication that it is the intended route.

| 14 | If I understood the scenario correctly, then I had followed a sign for the lecture theatre until reaching this junction. Therefore, if the option to continue straight was available (and it was in most of the images), I would simply continue and hope that another sign appeared when reaching another junction. |

| 15 | It was very confusing and the differences were not found easily. I have no experience in architecture, but I am wondering whether you could use different images of different buildings to follow your aims. Good Luck! |

| 16 | The way the light fell seemed to affect which direction I chose to go in. |

| 17 | The pictures all looked very similar and I feel I lost sight of the aim part way through because there were so many pictures. |

| 18 | I don't know if you also consider about the light. I think it also has some influence. Thus, if not, you may need to reduce the different of the light. |

| 19 | I tended to go the way that I thought might be leading to somewhere where there would be people, so that I could ask. I also tended to go for the widest corridor. Some of the pictures were the same, weren't they? I didn't feel I was being very consistent in my decisions, in spite of trying to be. |

| 20 | too long and the images are too similar |

| 21 | difficult to make the same decision 64 times. Didn't like the darker corridors. |

| 22 | The junction where one wall protrudes seems to have the obvious effect of sending you in the direction of the shorter wall. |

| 23 | i would usually head down a long large corridor, looking down side corridors until I found one that seemed to be the right one. if the long corridor became very narrow it is more likely that I would travel down a side corridor if this were wider. |

| 24 | I am quite claustrophobic, and really dislike corridors such as you have illustrated. I tended always to go towards the maximum light, because it suggested either a door, a window, or a room which may have someone to ask or maybe a telephone. However, in the scenarios in which the choice was straight on or turn, I definitely would not have gone forwards, at least initially, because of the blank wall at the end. Having been in this sort of situation, I personally think that the designers of utterly featureless corridors such as these should be put up against the wall just after politicians when the revolution comes! I have noted with interest that some hospitals have begun to have art or other features to get rid of the blankness. I also think that the owners, designers, and maintenance staff of any building without adequate, well thought-out signage should be cruelly punished - there really is no excuse for it. It shows disrespect to visitors, and wastes time through disruptions caused by people endlessly asking where to go. What is wrong with simple coloured stripes leading to key areas? |

| 25 | I'm not sure if this experiment accurately reproduces the circumstances where I would have to choose a certain path. In real life I would be able to look around each corner before I made my decision. Or, I would walk straight ahead if I could and look to the side as I walked by the other path. Interesting survey though. Hope you get what you need from it! |

| 26 | If I am navigating in a building and following incomplete directions - I will always opt for straight forward and then retrace my steps. Then, methodically I will explore each left hand in turn, then right hand in turn - that way I can cover each turning in a logical manner. |

27	it is easier to appreciate the differences when you move faster through the images but I sort of got lost in the middle between my preferences for the similarity of the images. Good luck!
28	To be honest, I don't think my responses should be of interest to you. Because whatever design you made in the pictures has no whatsoever impact/influence on me. How the corridor/lighting/width of turn and etc. do not concern me. When it is a choice of going straight or turning in, I turn in because in case that is the wrong direction, i simply backtrack to the junction and walk straight ahead. Between a choice of turning left and right, i turn right. just for convenience sake.
29	I would always check the junction nearest to me, right first, and left if only it is nearest option
30	Very interesting! I was attracted to the light, and put off by the narrow passages.
31	I assume you are very wary of the fact that one has been instructed by a previous sign to go straight. This influences my decision greatly. If there was one sign previously, I expect that there will be another sign later once I arrive. Otherwise, I will obey the last sign unless something strongly suggests I shouldn't.
32	For me, I would always rule out the first options first; ie. I would not go right to the end first. And would be more likely to look to the right then to the left first.
33	I think I would always carry on straight forward in the direction I was already going in in the absence of a sign telling me otherwise. I don't think I'd change direction at the junction unless I had to (i.e. if the only way to proceed was to turn left or right as in some of the junctions shown).
34	I tried to follow the principle that given no further instructions than go straight, i would take the option that is furthest away.
35	I'm not sure how helpful my responses were. I decided that I would be most likely to go straight on if I was not directed and just randomly selected left and right if straight on was not an option. In a real situation I would look in all directions for further clues and probably would knock on someone's door and ask. I would not, usually, just keep wandering around without knowing what I was doing - I would assertively find out or go back to the beginning and find someone to ask! I am not convinced (and it was tricky to really imagine from computer images) that the design of the building would make any difference.
36	I have considered going straight first and then based on my feeling to choose left or right
37	To be honest, it is not very clear what I should do, and sometimes I just clicked on one an arrow! maybe u need to explain more why we do this so make us understand better before we choose a direction! Good Luck.
38	It's a little confusing and boring. If you could make it interesting like some search game, participants might take it more seriously n you might get more relevant results.

39	If there is no lighting in the right/left direction but straight on was lit, I would choose to go straight. I would turn to go in the nearest clockwise direction always if there was no lighting at all.
40	Much of the variations look the same...
41	I always chose the turn closest to me as it seemed a logical thing to do - check the corridor you're passing before going on with your search in case you have to look back. I see what you're getting at with the floor lighting.. interesting.
42	it was sometimes unclear to see the differences between the different images but I am not sure how you could fix that problem
43	Yes this is a good way to get an idea of people's attitude towards different environments and learn new concepts of design by people's movements, good idea, but new designs are always better as they improve good design of buildings and promote better ideas towards newer and more advanced facilities for the future. Good idea but new concepts are always better as they achieve more credentials for better projects.
44	felt lost and slightly uncomfortable
45	Tended to go to the nearest entrance on the left or right, unless the entrance was smaller with the larger entrance down the end of the hall leading me towards that. When it came to the left, right junction chose the larger with more light.

Table B.03 Comments left by participants on the Corridor Width experiment website after undertaking the experiment

C

Appendix C: Supporting information for the Applied Study - Experiment in St. George's complex

Appendix C includes supporting information for the experiment conducted in St. George's Complex. C.1 shows the instructions giving to the participant at the beginning of the test and C.2 shows comments given by participants.

C.1 Instructions to participants

Below are instructions given verbally to participants (notes in square brackets explain the point at which these were mentioned in the experiment).

[Enter building, facing main staircase]

Thank you for participating in this experiment.

I wish to find out how easy people find this building to navigate. You will be given seven wayfinding tasks and at the end of each one asked to say, on a scale of 1-4, how easy or difficult you found the task (1 =easy, 4=difficult). I would also be interested to know any comments you have about your impressions of the building and the task. You are free to give any comments either during or after the tasks. Finally, I would be grateful if you could complete a short questionnaire about the task. In total, the experiment should take about one hour to complete.

The trial will start with two practice routes. These two tasks are contained entirely within this area of the building [point to right].

First task: please walk to the St George's IT Centre. You are welcome to give any comments

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about anything you see as you are walking. If you can't find the St George's IT Centre you please explore until you find it. You are welcome to explore any floor, however I would be grateful if you didn't stray into that area of the building [point to left]. I will let you know if you do.

[After the first practice route]

Second task: please walk to room F166, Electronic Systems Group Digital Systems Lab. Again, it should not be necessary to go past the main staircase. You are welcome to give any comments about anything you see as you are walking.

[After the second practice route]

These first two tasks should have given you an idea of what is required of the rest of the experiment. It should also give you an idea of what a '1' difficulty task is and a '3' difficulty task (the IT Centre and room F166 respectively). Do you have any questions before we continue? Do you have any comments about the building and the tasks so far?

[Go back to the Main Entrance and undertake tasks three to seven, i.e., routes A~E in a different order for each participant]

[Go back to Common Room to complete Questionnaire]

C.2 Comments from participants

Comments from participants in the experiment in St. George's Complex are shown in Table C.01.

Table C.01 Comments by participants for each test route in the experiment in the St. George's Complex

Test Route	Comments from participants
Route A	the red signage has some confusing shape and height
	easier to understand the layout of the building now
	towards the end the signs stopped and I thought I'd gone too far
	the first few signage were useful but after that no sign for enquiries office
	some signage not noticeable
	signage are too far apart
	general signage - words too small
	no sign in stairewell, signage too small
Route B	even though the route is quite long, , the signage is quite useful and very easy to follow / find
	just based on logical judgment (numbers)
	most signage is OK, some colours of signage is not suitable
	felt difficult but signage was easy to follow
	it was easier because I'd noticed the sign
	some corridors are very narrow, feel strange to walk over them
	some signage too small, room number helps
	one signage confusing
	a little confusing in places, lack of signs at about half way
	not very clear at one turn
Route C	the signage to theatre 5 is not shown on the board even though the route is short
	terrible signage followed instinct!
	it seemed simple at first but I got confused when there was no sign for LT 4 or 5
	I found it by chance
	tried to look for it on the same floor
	very confusing signage
	signage very unclear, couldn't find any clue to lecture theatre 5
	no signage, I found it by chance. Didn't know where it is at all
	felt lucky to find it
	only found sign for LT 1-3 and 6-12, but where are LT 4 and 5?
	signs for theatre 4 & 5 are not clear
	floor plan differs from other floors I've been on
	felt confident until final stage where sign disappeared
	very difficult, find it by chance

	no direction for the point of where the sign says 1-3, 6-12
	no sign to LT 5

Route D	good signage
	very easy to see where to go
	signage is a bit small
Route E	the signage is quite difficult to see from the main entrance and make me confused either to go down or up
	the signage is misleading, even cheating
	the signage is very confusing! I think you'll have to ask someone for direction
	quite simple and helpful signage
	sign at the entrance was too high
	go downstairs is confusing
	signage very confusing, going up and going down look the same
	couldn't see the entrance to the mechanical dept.
	very bad signage at the beginning, the rest was OK
	first sign was not clear but the rest was OK
	entrance to the department is behind the lift!
	sign for enquiries is too high!
	the enquiries sign is too high so I couldn't immediately see it