Design of virtual worlds for accessing information : discovery of user preferences

A thesis submitted to the Robert Gordon University in partial fulfilment of the requirements for the degree of PhD

By

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Abstract

This thesis describes a study carried out with the aim of discovering user preferences as to the design of 3-dimensional virtual worlds for accessing information. No literature was found which dealt with this topic, and it was therefore thought that, rather than ask users to make a selection from arbitrarily-chosen designs, it would be informative to consult the users from the beginning of the design process.

To this end, a Grounded Theory methodology was adopted, and users were selected from postgraduate students and staff from Information Management courses at the Robert Gordon University, Aberdeen. Three "rounds" of interviews were conducted. The first round was concerned with finding out what ideas for a world design people would have, the second with testing four worlds derived from the first round, and the third with exploring further ideas that users had, based on their experience of the test worlds.

At each stage of the process, emergent theories were constructed, and modified according to subsequent findings. It was established that the factors which influenced this group of users in their preferences for the design of worlds were not structural, as might have been assumed, but instead were related to properties such as familiarity, organisation, assistance, and quality of information and presentation.

When the results were examined in the context of developments in the use of virtual environments, it was found that they provide a theoretical underpinning for practices such as the provision of "conventional" library structures in the popular online environment Second Life.

This is not a statistical exercise, but it would appear that there are no significant differences based on the criteria of age, gender, or whether a user was staff or student. More thorough studies would be required to determine this absolutely, but for the moment it appears more useful to draw a broad set of conclusions.

Issues were identified which indicate potentially rewarding areas for further research and design. Specifically, it would be of interest to discover whether the affective responses of these groups are also common to other groups, and to experiment further with worlds designed in the light of the current findings. Further investigation of the small number of cases in which users do not respond to the worlds would also be desirable, to determine whether this response is characteristic of a group of people who will not react positively to any world, or whether these users simply reacted negatively to the examples presented.

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Chapter 1 Introduction

As of February 2007, Boutell.com reported: “Web pages in the world, February 2007: multiplying our estimate of the number of web pages per web site by Netcraft's February 2007 count of web sites, we arrive at 29.7 billion pages on the World Wide Web as of February 2007” (Boutell 2007). Google claims to index “over 8 billion web pages” (Google 2007). The number of documents available across the networks is rising at an unprecedented rate, and this figure, though an educated guess which would include many pages of no value as documents in themselves, does not take account of networked information other than World Wide Web pages.

Access to this information in parts of the world with a good communications infrastructure is facilitated by increased bandwidth of network “backbones”, and by a rise in the adoption of xDSL “broadband” technologies for delivery to the home and workplace. At the same time, the processing and graphics capabilities of even “entry-level” computers has reached levels unprecedented even a decade ago, and these developments still seem to conform to “Moore’s Law” (Moore 1965), which states that the number of transistors on an integrated circuit chip doubles roughly every two years. These increases in content, bandwidth, and performance are making feasible models of user interface which have been explored only partially in the past, in particular the increasingly realistic rendering of apparently 3-dimensional “virtual worlds”.

However, there is a need for such interfaces to be useful to the potential user, rather than being developed just because they are technically possible. It can be argued that there has been a tendency in the past development of new technologies for user interface design to be a secondary consideration. For example, there is anecdotal evidence that adult users, in particular, find it difficult to set recording schedules on videocassette recorders (Thimbleby 1993). Although this may be commonly regarded as something of a joke, there is a serious point behind it – if user studies are not undertaken, and used to influence development, there is a risk that what is produced will be less suitable for purpose than might otherwise be the case.

These phenomena - the acceleration in network performance and content, the increase in workstation capability, and the lack of user-influenced design - can be seen as elements in a Conditional Matrix (Strauss and Corbin 1990 p. 158). See fig. 1, in which the outermost rings represent the ever-increasing “world” of information, and the growth in network services supplying and mediating such information. The increases in computer processing power and graphics capability lie between these layers and the innermost core, where the user attempts to interact effectively with the resources.

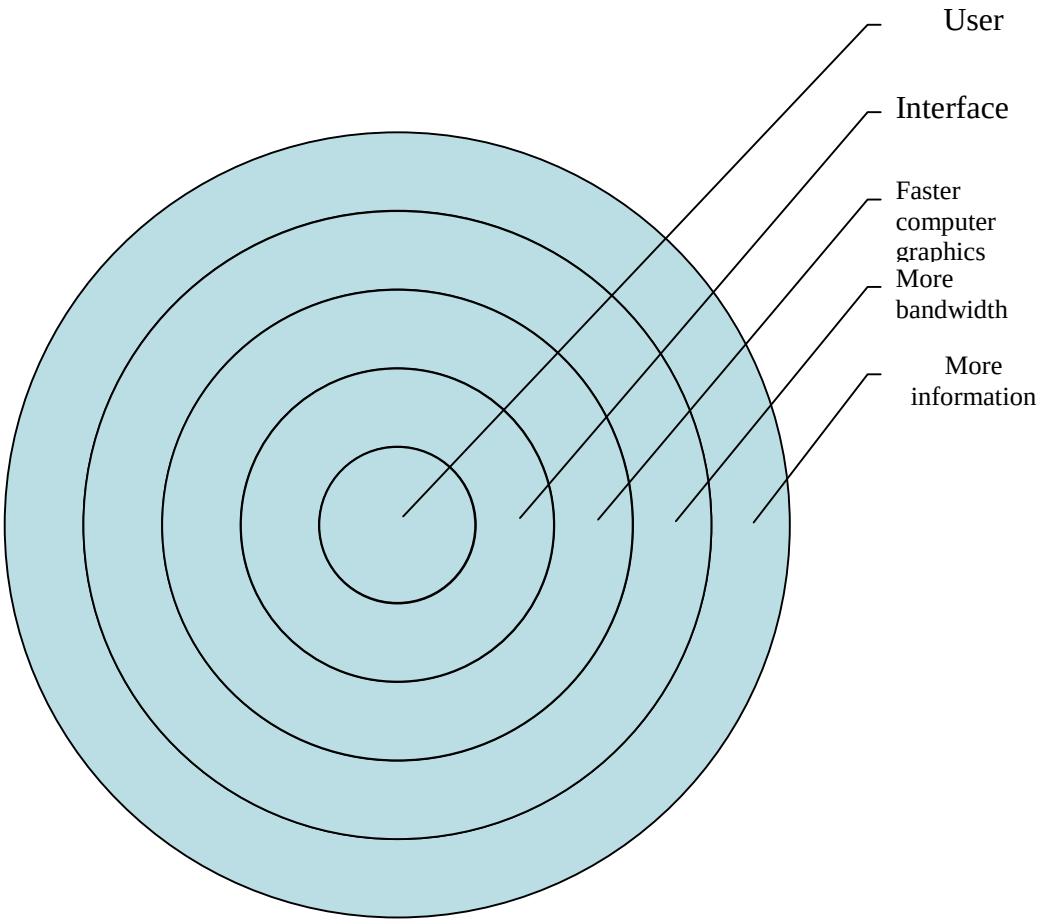

Fig 1: The conditional matrix

A “three-dimensional” style of interface has been the subject of sporadic development since the early 1990s, as the “front end” of applications for visualising primarily scientific information on stand-alone machines, and in the field of computer gaming. The development of the Virtual Reality Modelling Language (VRML) in 1994 allowed the information necessary for the construction of these worlds to be conveyed across networks as a text file which could be interpreted by appropriate software, and used to display a “virtual world”. Its successor, VRML2, and other languages such as Java3D and x3D, have waxed and waned in popularity since then, and also face competition from proprietary software used to create commercial “virtual worlds”.

The second half of 2006 saw a rise in the usage of virtual reality applications on the World Wide Web, with the widespread popularity of Second Life and Active Worlds, the most successful of the “online communities” which developed in the wake of the now-defunct Blaxxun. As of October 2006, Second Life had almost a million accounts – “963,212 accounts have been created as of this writing, 396,616 of them active within the last 60 days” (Terdiman 2006).

In parallel development, also dating from the rise of the World Wide Web, the term “virtual library” has now become quite commonplace, although its denotation is somewhat different from that of “virtual world”. A “virtual library” is not typically a representation of a “real world” library, in the same sense that a “virtual world” might resemble the real one, that is, in giving an illusion of three-dimensional space. Instead, virtual libraries, for example the World Wide Web Virtual Library (http://vlib.org/) are often more-or-less structured collections of hyperlinks, presented as HTML pages. The term “digital library” has a similar denotation, indicating a library in which documents are stored in digital formats, and hence may be made available either locally or across networks.

Given that so many people are spending time in virtual worlds, and also that the idea of the digital library or virtual library has become well established – a quick web search reveals hundreds of examples - it becomes interesting to establish what type of interfaces might be favoured for provision of access to information, in these and other “virtual” contexts. Information visualisation techniques developed to enhance retrieval might be considered well suited to the virtual environment, but examples of

their usage are comparatively rare. Where virtual reality {VR) or similar techniques have been used in an information retrieval context, there appears to be little evidence that their design has been influenced by user studies, or knowledge of user preferences, and it is this apparent gap in the research which the current piece of work was intended to address. The study itself examines the question of what user preferences would be for a virtual world designed to facilitate access to information.

The idea behind the current study came from an earlier exploratory study conducted by the author, involving the creation of a small number of 3D “worlds”, which users were invited to test, and their reactions established by means of an online questionnaire. This study had taken a traditional route to try to understand user responses to pre-defined examples of worlds. However, on consideration of the early results, it became apparent that the fact that the models for the worlds had been chosen arbitrarily represented a serious weakness in the methodology. The literature which had been consulted before arriving at this stage had shown no indication of designers questioning what 3D interfaces ought to be like – it seemed that in each case, they had had what seemed to them a good idea, and had developed it. It appeared that serious limitations might arise from this traditional approach. For example, designers other than those engaged in “blue sky” research could be assumed to have particular purposes, appearances, or end products in mind. Even if large numbers of designers were involved, there would be a danger of the result being something created from the designers’ point of view, whether because of ease of implementation, perceived elegance of an idea, or simply limited variety of input. This approach seemed to put users in the position of having to deal with what the designers came up with, and the idea that this need not necessarily be the case was the seed which developed into the current study.

When it became of interest to explore user preferences for a 3-dimensional interface for a world to be used for accessing information, an initial literature search appeared to indicate an absence of user-centred development in this field.

There are several areas of study which seem to be tangential to research into the design of 3D worlds. There is a body of work on information design, or the graphical display of information. Information visualisation is a field concerned with

representing information in 2D and 3D graphical forms, in such a manner that the user can see structures in the data, and in some systems can interact with the data display, so as to obtain different views, or emphasise particular dimensions. There are studies in the field of human cognition which are concerned with human wayfinding abilities, and these have used virtual worlds as experimental arenas, both to examine wayfinding abilities in general, and to explore design principles with a view to making virtual worlds more easily navigable. There is a growing body of work on the sociology of virtual worlds, both text-based and graphical. Of the many papers published about digital libraries, in which it might be thought at least the question of information access could be taken for granted, few appear to concern themselves with 3D representations of libraries, and in those, it appears that the decision to use a representation of a library has been taken somewhat arbitrarily.

In a chapter on 'Designing virtual environments', Sutcliffe writes, "when the system exists to help the user achieve a task goal, support for the user's task should be explicit. Taking a virtual library as an example, the user's goal is to retrieve specific information and to browse through the library. The application should help the user navigate and locate information, even if this means that the correspondence between the real-world library and its virtual counterpart is violated"(Sutcliffe 2003 p.167). This may say something about Sutcliffe's perception of real-world libraries, but it is also a good statement of the potential for a virtual design to outstrip, in some sense, its real-world counterpart. Although Sutcliffe's book contains a wealth of information on human cognition, interaction, and virtual environment design, the advice is always drawn from the associated fields of study, and not directly from users. If a library is to be built, it should "help", but there is little guidance as to what the user might find helpful.

Helpful features might be better signage, improved user guides, or even a complete re-working of the appearance and layout of a conventional library. The range of possibilities is such that it would appear that it could best be narrowed down by consulting potential users. Sutcliffe does note that "VR has been used in many other applications, including domains where there is little to model, for example, virtual representations of information categories for browsing and retrieval. However, most VR applications have a close correspondence with the real world." (Sutcliffe 2003 p.

161). Here, perhaps, is a clue to the scarcity of user studies. If most VR applications are modelled on their real world counterparts, then an information resource maps neatly onto a library, with the possible proviso that it be a helpful environment, which is not necessarily the case with the real thing.

The research presented here is concerned primarily with the use of 3-dimensional "worlds" in accessing information, and in particular with the questions arising when designing such worlds. If an architect wants to give a "virtual tour" of a proposed building, or a surgeon wishes to demonstrate a new operating technique, there are fairly obvious factors constraining the choice of an appropriate representation – one must resemble a building, the other some part of a human body. When dealing with a whole range of "information", however, there are no such obvious candidates, and indeed it may be that choosing a conventional representation negates the potential benefits of the "virtual" presentation.

The current study aims to make a contribution to filling the perceived "gap" in the knowledge regarding user preferences, in that it provides evidence from a user-centred study, which investigated requirements and examined preferences, using interviews and testing interview-derived models. Conclusions drawn from the analysis of this evidence are compared with both the more theoretical material mentioned above, and with actual examples of virtual worlds. This is seen as being a contribution not only to the usability of such interfaces, but also as a valuable set of findings for information providers and libraries who are facing the challenge of providing access to information in such environments.

Where Americanised spelling (e.g. "visualization") is used in quotation, the spelling from the original will be preserved, but otherwise conventional UK English spelling will be used (e.g. "visualisation").

1.1 Aim and objectives

The aim of the research was to discover user preferences for the design of a "virtual world" for accessing information, and the factors influencing those preferences.

The objectives of the research were:

- To conduct user interviews, using a “grounded theory” approach, to elicit user preferences for designs for 3-dimensional “virtual realities” for accessing information.
- To draw from these interviews conclusions as to common elements and recurrent designs.
- To construct “worlds”, used to demonstrate different designs as vehicles to develop further depth of understanding of user requirements and preferences.
- To analyse user preferences with particular attention towards affective responses, which might be indicative of the influence of non-structural features of the “worlds”.
- To draw conclusions as to possible factors influencing user preferences.

1.2 An introduction to terminology

Terminology such as “virtual reality” or “VR”, “3D world”, “virtual world”, is used in both primary and secondary material, with varying meanings and degrees of precision. In order to ensure that the study should be as clear as possible, it may be /6 helpful here to develop working definitions of this terminology as used in the thesis, in order to assist in understanding of the context in which the study is set.

1.2.1 Virtual reality

“Virtual Reality”, or “VR”, is a term which Jaron Lanier, a pioneer of the technology, claims to have coined in the late 1980s. “We are speaking about a technology that uses computerized clothing to synthesize shared reality … [t]he clothing consists of mostly a pair of glasses and a pair of gloves” (Lanier 1988). Lanier refers to what is now known as “immersive” VR. Immersive VR uses technologies such as Head-Mounted Displays (HMD) (the "glasses” referred to) and representations of the user’s hand, which in reality is wearing a motion-sensing glove, in order to induce in the user a “sense of presence” in a computer-rendered environment. A larger scale version of this is called CAVE (Cave Automatic Virtual Environment), in which images are projected onto the walls and floor of a cubicle, and the user controls her apparent movement through the projected virtual environment by operating a treadmill, or other motion-sensing device.

There are, of course, other factors to consider than just the appearance and information content of a world. There has historically been an awareness that some users have adverse reactions to virtual environments, ranging from nausea and physical disorientation to ataxia, a loss of muscle control and co-ordination.

Tarr (Tarr and Warren 2002), who works in VENLAB, a large (40’ x 40’) immersive virtual environment, writes “there are several elements that make today's virtual reality systems better than those of only a few years ago. First, the observer can move freely and have the system respond to his/her actions in close to real time. This is essential because a delay between a user's actions and consequent changes in the virtual world not only destroys one's sense of being embedded in a 'real' environment, but can actually lead to physical disorientation and nausea”.

A less expensive implementation has become known as “desktop virtual reality” (Tarr and Warren 2002). A “3D world” or a “virtual world” then, in this context, is a graphically rendered representation on a computer display of what appears to the user to be an environment, through which she can “navigate” her viewpoint by moving the computer mouse or other pointing device, or by using the cursor-control keys.

1.2.2 Virtual Reality Modelling Language

Virtual Reality Modelling Language (VRML) is a modelling language for the description of 3D “worlds”, which can be transformed by a suitable application (usually a “plug-in” for a web browser program such as Mozilla Firefox or Internet Explorer) into a navigable representation of the scene. Developed in 1994, it became more popular in 1997, with the release of VRML2 (also known as VRML97), which added features to enhance display, add animation, and increase extensibility. Programming issues will be discussed at the point in the thesis when the creation of the experimental worlds is dealt with (Chapter 5).

1.2.3 Accessing information

Hearst uses the term “information access process” in a chapter on User Interfaces and Visualisation (Hearst 1999 p. 262). It seems that this term might be sufficiently free of associations to be of use in describing the findings of this study. “A person engaged in

an information seeking process has one or more *goals* in mind and uses a search system as a tool to help achieve these goals …[i]nformation access *tasks* are used …[t]hese tasks span the spectrum from asking specific questions to exhaustively researching a topic … there is a common core around the information seeking component". The expression "accessing information", rather than "information retrieval", has therefore been used here, because of its relative freedom from preconceptions as to meaning. "Information retrieval" has at least two distinct interpretations, one in the context of information and library work, where issues of recall and relevance are important, and one in the context of computing, where a more mathematical approach prevails, typified by the retrieval experiments conducted on the TREC database. The approach here is less prescriptive than either of these, and is open to user interpretation as much as is the question of design.

1.3 Organisation of thesis

This thesis is organised as follows:
The current chapter introduces the topic, aim and objectives.
Chapter 2 presents the methodology used in the study.
Chapter 3 consists of a review of literature which is core material in the fields of virtual reality and information visualisation.
Chapters 4 to 6 present the findings of the interview stages of the study.
Chapter 7 presents a summary of findings from the interview stages.
Chapter 8 draws parallels between the findings of the current study and the literature which inspired it, and with some of the observations of the PARC team.
Chapter 9 discusses the contribution to knowledge made by the study, evaluates the research approach, and discusses implications for further study in this area.

Chapter 2 Methodology

The methodology chosen is reflective of the aim of the research, in that it was intended to discover user preferences as to the design of a 3D environment for accessing information.

It was decided that, in order to avoid the shortcomings of the research described in chapter 1, above, the users in the study should have complete freedom in expressing their design preferences. Without such free expression, there is no way of designers knowing reliably what is important to users. This does not mean that designers cannot add functionality to the worlds described by user preferences, because that would tend to stifle development, but that there could be a common understanding of a good basis from which to continue development, and a change in the overall process from design-driven to user-driven.

Preferences are elicited from three groups of users, and are the main focus of the study – they are, as set out in the objectives, used in the design of sample worlds, collected in the form of responses to those worlds, and collected again, with the intention of identifying common factors. It was therefore important to decide on the best methodology for establishing preferences.

2.1 Possible approaches

It was decided, for the reasons given below, that Naturalistic Inquiry, implemented through Grounded Theory, was the best model to adopt, but other models might have been candidates for use in this study, and it is appropriate to consider the possibilities.

2.1.1 Ethnography

Ethnography seeks to describe populations, using qualitative and quantitative methods, and puts emphasis on the researcher's sharing and participating in the lives and experiences of the population who are the subjects of the research (Genzuk 2003). This suggests that it could be applied to the research problem. However, "People's behavior is studied in everyday contexts, rather than under experimental conditions

created by the researcher" (Hammersley 1990). Whilst this study is descriptive, and seeks to discover the reasons behind people's preferences, it is not descriptive of an "everyday" context – since there was no suitable software to use, it could not be supposed that the people being studied were operating in an everyday context, as they had no experience of what they were undertaking. Neither were these individuals under study as a group *per se* – they had factors in common, such as being university students or staff, and they had the valuable common factor of having had some experience of electronic information access, but studied or taught or serviced a variety of courses, and had varied ages, life experience, social background, and personal interests. They were not, in this context, a homogenous "group or culture" of the type for which ethnography would be an appropriate method of study. The research issue is, in fact, an individual, not a group, issue.

2.1.2 Phenomenology

A phenomenological approach, on the other hand, was ruled out by the fact that most of the content of the interviews did not concern "the study of structures of consciousness as experienced from the first-person point of view. The central structure of an experience is its intentionality, its being directed toward something, as it is an experience of or about some object" (Smith 2005). As the research was concerned to elicit preferences, for virtual worlds which did not yet exist, and could not be directly experienced, whilst a phenomenological approach could have been adopted in describing use of the "model" worlds constructed, this would be of strictly limited utility, as these worlds were never intended to represent more than "proof of concept". If more detailed, and more complete, worlds are constructed in accordance with the findings of this, or related, research, then it will be appropriate to conduct phenomenological research, in order to understand better user experiences when interacting with these worlds.

2.1.3 Naturalistic Inquiry

Naturalistic Inquiry "involves studying real-world situations as they unfold naturally in a non-manipulative, unobtrusive, and non-controlling manner, with openness to whatever emerges and a lack of predetermined constraints on outcomes. The point is to understand naturally occurring phenomena in their naturally occurring states" (Linton, Joy and Shafer 1999 p.132). The distinction between this and the

ethnographic model described above, is that the study is of “real world” experiences, but not “everyday” ones. Lincoln and Guba write: “[t]he human instrument builds upon his or her *tacit* knowledge as much as if not more than upon propositional knowledge, and uses methods that are appropriate to humanly implemented inquiry: interviews, observations, unobtrusive clues, and the like. Once in the field, the inquiry takes the form of successive iterations of four elements: purposive sampling, inductive analysis of the data obtained from the sample, development of grounded theory based on the inductive analysis, and projection of the next steps in a constantly emergent design. The iterations are repeated as often as necessary until redundancy is achieved, the theory is stabilized, and the emergent design fulfilled to the extent possible in view of time and resource constraints.” [emphasis in original] (Lincoln and Guba 1985 p.187) There is also another important step: “Throughout the inquiry, but especially near the end, the data and interpretations are continuously checked with respondents who have acted as sources … differences of opinion are negotiated until the outcomes are agreed upon or minority opinions are well understood and reflected.” (Lincoln and Guba 1985 p. 188) This is the model found to be appropriate to the research discussed here, because the iterative structure provides the opportunity for refining and testing of theory based on findings which, being of a qualitative and essentially subjective and personal nature, require exploration and reformulation before they can be used to advance the theory. The checking with respondents not only confirms understanding of the original content, but also provides an opportunity for respondents to agree with, or dispute, the eventual findings. This “double-checking” aspect of the inquiry is seen as desirable, in that it affirms the integrity of the process as a whole.

2.2 Development of the methodology

2.2.1 Grounded theory

The problem centred on determining user preferences without unduly influencing their responses. It was also thought possible that user preferences would turn out to be a matter of personal taste, or dependent on some then-unknown factor or factors. For this reason, a simple statistical representation of user selection from a limited list of arbitrary models was felt to offer an inadequate picture of what a number of

individuals would actually want. There was a danger of the findings becoming biased towards a limited choice of models, and that the very selection of these models would be researcher-led. Also, the literature was inadequate to permit development of the range of themes which would allow construction of instruments such as questionnaires or semi-structured interviews.

For these reasons, a decision was made to use a methodology known as Grounded Theory (Glaser and Strauss 1967). The central concept of Grounded Theory is that theory should "emerge from" data. Glaser and Strauss worked in the field of sociology, and were critical of the approach to research prevalent at the time, where the research process consisted of the development of hypotheses and the subsequent testing of these hypotheses by gathering of data. "Verification of theory is the keynote of current sociology" (Glaser and Strauss 1967 p. 10) This approach led to the development of "great man", or "grand" theories, which were put forward by leaders in the field, and which later sociologists were encouraged to reformulate and test, but without generating theories of their own. Glaser and Strauss' point was that some of the "grand" theories were not grounded in data, and so "do not fit, or do not work, or are not sufficiently understandable to be used". (Glaser and Strauss 1967 p. 11) However, the generation of theory was not in itself difficult, and techniques could be developed which would permit generation of theories grounded in data, rather than verification of hypotheses – an inductive, rather than a deductive, methodology. The authors acknowledged the importance of the uses of both quantitative and qualitative data in both the generation and verification of theory, and denied that the two were incompatible, asserting rather that their importance depended on the requirements of the research and the researcher at the time. They also held that it was frequently the case that both kinds of data were needed, in order to test each other, and to complement each other in the generation of theory.

The methodology Glaser and Strauss set out for the generation of grounded theories uses comparative analysis, the units of comparison ranging in scale from individuals through organisations to countries. Evidence relating to the research area is gathered, and "conceptual categories" emerge from this evidence. These conceptual categories are somewhat akin to the facets in a faceted classification scheme – they are groupings, or categories, of properties or values related to a concept. The conceptual

categories then become entities which can be developed and explored by further examination of the evidence from which they have emerged: “the evidence from which the category emerged is used to illustrate the concept” (Glaser and Strauss 1967 p. 23).

The types of theory which can emerge from comparative analysis are described as “substantive” or “formal” – the former developed for an “empirical area of sociological enquiry”, the latter for a “conceptual area of sociological enquiry”. The former is concerned with actual events and processes – the authors give “patient care” as an example. Formal theories are at a greater level of abstraction from the empirical – “authority and power” is an example used. “With the focus on a substantive area …the generation of theory can be achieved by a comparative analysis between or among groups within the same substantive area.” (Glaser and Strauss 1967 p. 33) An emphasis is placed on the use of substantive theory in the generation of grounded formal theory, rather than on the search for an existing formal theory which might have application in a particular substantive area. This “bottom-up” approach was used in the current study – development of higher level theories would only be meaningful in the light of further, related, research.

“Incidents” in the data are coded into as many categories as possible. The term “incident” appears to be applicable to an event, or to a reference in an interview, or even to a datum taken from literature. As with much of the writing of Glaser and Strauss, their sociological orientation makes the sense of the text rather obscure, but Strauss and Corbin express this more clearly: “[o]nce we have identified particular phenomena in data, we can begin to group our concepts around them …The process of grouping concepts that seem to pertain to the same phenomena is called *categorizing.*” [emphasis in original] (Strauss and Corbin 1990 p. 65) Categories can be named by the researcher, or can be taken from technical literature. In the case of the current research, incidents and categories were drawn from, and related very closely to, user responses to interactions with the worlds.

The next step in the generation of grounded theory is the emergence of hypotheses relating the categories, which together with the categories form “an integrated central theoretical framework – *the core of the emerging theory*.” [emphasis in original]

(Glaser and Strauss 1967 p. 40) The theory is further developed by a process called "theoretical sampling" – a deliberate attempt to collect data which is relevant to the emerging theory, by targeting groups and using methods most likely to produce the required data. The current study adopted this approach in the selection of groups for each "round" of the process.

Strauss claims that under grounded theory, "[t]he research findings constitute a theoretical formulation of the reality under investigation, rather than consisting of a set of numbers, or a group of loosely related themes … The purpose of the grounded theory method is, of course, to build theory that is faithful to and illuminates the area under study" (Strauss and Corbin 1990 p. 24)

Strauss notes that the research question in a grounded theory study may be chosen because "there is the assumption that someone has never asked this particular research question in quite the same way, so it is as yet impossible to determine which variables pertain to this area and which do not" (Strauss and Corbin 1990 p. 37). In the current study, there did not appear to be sufficient data in the literature to indicate that the research question had been asked at all, and this assumption therefore appeared warranted. Indeed, as indicated above, the lack of literature was such that this particular way of conducting the research seemed the only one appropriate. There was no reliable way to choose variables to examine using more structured instruments.

Literature "enables the user to identify previous research in an area, as well as to discover where there are gaps in understanding" (Strauss and Corbin 1990 p. 49). "[T]here is no need to review all the literature beforehand … because if we are effective in our analysis, then new categories will emerge that that neither we, nor anyone else, had thought about previously … It is only after a category has emerged as pertinent that we might want to go back to the technical literature to determine if this category is there, and if so what other researchers have said about it" (Strauss and Corbin 1990 p. 50). The literature was used at stages throughout the research, in order to examine whether other researchers had written anything relevant in related areas, such as information visualisation, for example.

This is the reasoning behind the way that the literature is used here – a single-chapter presentation would make it difficult to recall the relevant sections of the review when reading a particular group of findings, and also the findings influenced the literature which was reviewed at any particular stage of the study, so that the review developed in parallel with, but antecedent to, the interview process.

2.2.2 The schism in Grounded Theory

It should be noted here that the discussion above uses points from both Glaser and Strauss' early work, 'The discovery of grounded theory : strategies for qualitative research' (Glaser and Strauss 1967), and Strauss and Corbin's version of Grounded Theory, published in 'Basics of qualitative research : grounded theory procedures and techniques' (Strauss and Corbin 1990) Glaser and Strauss eventually came to hold rather different positions on what the "true" version of grounded theory should be. There appear to have been two major areas of eventual disagreement between the two approaches, regarding coding procedures and literature.

2.2.2.1 The literature issue

The literature issue concerns how much influence previously published material should have on the study in hand. Conventional qualitative research includes a review of literature in the field, but Glaser and Strauss originally held that: "An effective strategy is, at first, literally to ignore the literature of theory and fact on the area under study, in order to assure that the emergence of categories will not be contaminated by concepts more suited to different areas." (Glaser and Strauss 1967 p. 37)

They advocate experimenting to find the correct balance between the researcher who avoids reading literature on the subject area until after fieldwork is completed, so as not to prejudice "personal insights", researchers who "read extensively beforehand", and those who "periodically return" to the literature. They warn that: "[n]ot to experiment toward this end, but carefully to cover 'all' the literature before commencing research, increases the probability of brutally destroying one's potentialities as a theorist." (Glaser and Strauss 1967 p. 253)

Strauss later moved to a position where he conceded that a researcher would have "some background in the technical literature", but held that there was " no need to

review all of the literature beforehand" (Strauss 1987 p. 50) The reasoning is partly that the research in hand should not be influenced by previous thinking, partly that the research in hand will break new ground: "new categories will emerge that neither we, nor anyone else, had thought about previously." (Strauss 1987 p. 50) Literature can be checked after a category has emerged, in order to find out what, if anything, others have written about it, but this is a much smaller role than in the traditional review, and necessarily so, since it cannot be known what categories will emerge as relevant before the research begins.

The technical literature does have a place in Grounded Theory, when it comes to providing a background – it can be used to stimulate theoretical sensitivity, to provide background on existing theories, as secondary data, to stimulate questions, to direct theoretical sampling, and as supplementary validation. As will become clear, technical literature was used in the current study when it became relevant at each round of the study, but this literature was not directly concerned with the exact topic, so was used very much in the sense of providing background and context.

Referring to documents outside the literature of social science – "letters, biographies, autobiographies, memoirs, novels and a multitude of non-fiction forms – tend to be regarded as irrelevant except for a few restricted purposes … Certain uses of these various documentary qualitative materials have been established. First, they may be used, especially in early days of the research, to help the researcher understand the substantive area he has decided to study. They may help him formulate his earliest hypotheses … Even more likely, he will introduce the information in an opening chapter as a prelude to his analysis of his own data, giving the reader a simplified backdrop for the work" (Glaser and Strauss 1967 pp. 161 – 162). "Third, special and highly empirical studies are made, as when the contents of novels or newspaper columns are studied for what they reflect of an era, a class, or the changing tastes of the country" (Glaser and Strauss 1967 p.162). These forms of literature have places in the current study which correspond very closely to Glaser's descriptions. The two works of fiction, 'Neuromancer' (Gibson 1986) and 'Snow crash' (Stephenson 1992) which have been particularly influential in the development of virtual worlds, have been mentioned in the introduction, and their relation to the findings of this study will be discussed in the chapter on contextualisation. Also discussed in this chapter will be

the relation to the findings of shared virtual worlds, such as Active Worlds and Second Life, as revealed in contemporary press and mailing-list content.

"How should he proceed in the library? The answer is that he should use *any* materials bearing on his area that he can discover. For instance, explicit categories are offered in the writings of other men (whether sociologists or not) on the area. … A very important early source of categories is an array of fiction (including "Pot Boilers") bearing on the relevant topic." (Glaser and Strauss 1967 p.169) As discussed above, the fiction has been used for contextualisation, although the categories emerged, not from the fiction, but directly from the users involved.

Glazer's position regarding literature later became more extreme – he advocated collecting data in the field, analysing it, and generating theory, and only when this "seems sufficiently grounded and developed, then we review the literature in the field and relate the theory to it through integration of ideas" (Glaser 1978 p. 31). This concern with preventing contamination of the theory, so it will "not be preconceived by pre-empting concepts" is treated with some scepticism by Selden, who does not believe that less knowledge of the literature can make for better research, and that a greater threat is posed by "unconsciously assimilating other more elusive preconceptions" (Selden 2005 p. 123) Selden's conclusions include: "One cannot claim without objections that comprehensive reading of previous research is detrimental to creativity. The proximity to the participant level carries the risk of reformulating known details – the risk of trivialities. Ambitions for greater pragmatism work in the same direction." (Selden 2005 p.126) These appear to be points well made against Glaser's stance, but grounded theory is used in the current research because there did not appear to be any literature on the topic. Because of the lack of literature concerned with user preferences, the charge of "reformulating known details" does not stand, and, in this context at least, user preferences are not trivial.

Selden ends his article with four bullet points to be paid "special attention" when using grounded theory "if at all":

- "finicky coding – the technical tail is wagging the theoretical dog;

- The break from context in the coding procedure – only notes, no melody;
- Lack of insight regarding the matter of pre-understanding putting a premium on lack of learning; and
- Production of everyday knowledge on participant level preventing attachment to high level theories – trivial pursuit."

(Selden 2005 p. 127)

It is believed that all these points have been given due attention – coding was used as an aid, but did not get in the way of immersion in the data, so that there was no break from context; the literature issue did not emerge for the reasons given earlier; and the theory which emerged does in fact seem to fit well with current practice, and go some way to explaining the reasons behind it.

2.2.2.2 The coding issue

The coding issue concerns Strauss and Corbin's use of "axial coding" and "coding paradigms". Glaser holds that all coding should emerge from the data, and that Strauss "forces" categories on the data by coding according to a "coding paradigm" "especially helpful to beginning analysts" (Strauss 1987 p. 27). This paradigm is, as with most of Strauss and Glaser's concepts and procedures, firmly rooted in sociology. The paradigm allows data to be "structured" according to "conditions", "interaction among the actors", "strategies and tactics" and "consequences". In this respect, the methodology adopted for analysis in this study tended more towards Glaser's early approach – coding was derived directly from the data, without any sociological framework being necessary, partly because this was not a sociological enquiry, in the sense that those of many users of grounded theory are. The coding process used here was more akin to the procedure adopted in the construction of a faceted classification – terms are identified, from which facets emerge, to be populated by foci, and the facets then arranged according to importance. This grouping and ordering is the equivalent of Strauss and Corbin's "axial coding", but dispenses with the sociological framework. Glaser, on the other hand, identifies "coding families" of concepts, drawn from a range of backgrounds:

"Thereby various theoretical concepts stemming from different (sociological, philosophical or everyday) contexts are lumped together, as for example

• terms, which relate to the degree of an attribute or property ("*degree family*"), like "limit", "range", "extent", "amount" etc.,
• terms, which refer to the relation between a whole and its elements ("*dimension family*"), like "element", "part", "facet", "slice", "sector", "aspect", "segment" etc.,
• terms, which refer to cultural phenomena ("*cultural family*") like "social norms", "social values", "social beliefs" etc.,
and 14 further coding families which contain terms from highly diverse theoretical backgrounds, debates and schools of philosophy or the social sciences (Kelle 2005 p. 4)

Kelle weighs up the two camps by finding that Straus and Corbin's approach is undeservedly criticised by Glaser, to some extent, because although there may result some degree of "forcing" from the axial coding, "the general theory of action underlying the coding paradigm carries a broad and general understanding of action which is compatible with a wide variety of sociological theories". Kelle concludes : "However, it must be noted here, that Strauss' and Corbin's coding paradigm is linked to a perspective on social phenomena prevalent in micro-sociological approaches emphasizing the role of human action in social life. Researchers with a strong background in macro-sociology and system theory may feel that this approach goes contrary to their requirements and would be well advised to construct an own coding paradigm rooted in their own theoretical tradition." (Kelle 2005 p. 7)
Since the difference here appears to relate principally to the field of application, this advice has been followed. Neither the literature issue nor the coding issue appear to impact sufficiently on the area of study: the literature directly relating to the study was not found, so could not be consulted, and the categories, though they could be identified with Glaser's "coding families", were found satisfactory for the theory generation which took place.

"The theory should provide clear enough categories and hypotheses so that crucial ones can be verified in present and future research; they must be clear enough to be readily operationalized in quantitative studies when these are appropriate." (Glaser and Strauss 1967 p. 3) Points in the findings where quantitative verification could usefully be undertaken in further studies will be identified as they arise, but, as Glaser

and Strauss recommend, the principal focus is on generation of theory, rather than verification of hypotheses.

2.2.3 Open coding

The use of other tools and techniques of Grounded Theory, such as Open and Axial coding, and the use of Memos, will become apparent through the course of the thesis. In brief, these consist of assigning codes to concepts emerging from observation of a phenomenon (in this case, through the medium of interviews), abstracting more general groupings from these concepts, analysing and recording modifications and developments in these concept groupings, and finally validating an emergent theory against the data. As the study progressed, through "rounds" of interviews, codings were applied and sometimes modified at each stage. This process was made considerably easier to perform by the use of the software tool Nvivo. The memos are notes made during the coding process, which identify areas of interest, newly emerging theory, and reflective thought which it is important to capture at the time.

2.2.3.1 Nvivo software

Nvivo is a powerful tool for coding and analysing text. Documents are imported into the system, and may be given attributes, for example the profession or gender of an interviewee, and assigned to sets, such as interviews from a particular location.

Using Nvivo, significant words or phrases in documents (in this case, interview transcripts) can be marked up, and assigned identifiers. The identifiers can be the words or phrases themselves – this is "in vivo" coding, from which the software takes its name – or can be decided in advance by the user. Nvivo also offers a "section coding" function, which could, for example, be used in processing more structured interviews by assigning the answers to a particular question to a distinct node.

Sections of text which are assigned a particular identifier, or code, are gathered by the software into "nodes". A section of text can be assigned more than one code, and coded sections can overlap. Nvivo has a feature which will display graphically, as "coding stripes", the codes assigned to a particular document.

The nodes can be "free nodes", which have no organising principle, or can be organised into a hierarchical structure or structures – "trees". Nvivo has effective

filter, search and browse capabilities, which are useful in the constant reviewing of transcripts that is necessary in order to get the most out of the material. The node structures can be navigated, and the pieces of text which have been assigned to a particular node can be displayed. These pieces of text are identified by document and paragraph.

The output from a search of documents or of existing nodes can also be saved as a new node, allowing great potential for generating different "slices" through the data.

Nvivo also makes it easy to generate lists of nodes, which can be a useful feature when "populating facets" – for example, if a node list revealed codings for affective responses, and these were predominantly positive, this might indicate that it would be worthwhile to re-examine the documents in order to identify any negative responses which had not been coded. The generation of the concept lists at each stage was a matter of selecting series A, B and C numbered documents from the nodes hierarchically beneath the Places node in the node tree.

Nvivo has further features, which were not used in the current study, but even at the relatively "basic" level at which it was used, it was found to be an extremely useful tool, reducing considerably the effort which would have been involved in hand-coding, and making searching and editing the work of a few moments, rather than the major operation which a paper-based approach might have necessitated.

2.2.4 Axial coding

Although it appeared initially that it was not appropriate to proceed further in the Grounded Theory methodology than the open coding stage, on further consideration at this point of the analysis, it seemed possible that the axial coding part of the methodology could also be used, if enough flexibility was allowed in the interpretation of the "paradigmatic terms" – conditions, context, strategies consequences. Initially, Strauss and Corbin's assertion that "[g]rounded theory is an action/interactional oriented method of theory building" (Strauss and Corbin 1990 p. 104) appeared to make the latter stages of their version of the process unsuited to the essentially thought-experiment nature of the current study. However, the authors go on to write: "Whether one is studying individuals, groups or collectives, there is action/interaction, which is directed at managing, handling, carrying out, responding

to a phenomenon as it exists in context or under a specific set of perceived conditions." (Strauss and Corbin 1990 p. 104) Action/interaction has features – it is processual, purposeful, and a failed example is as important to look for as a successful one. It began to seem possible that, if the terminology of axial coding was reinterpreted somewhat, to fit better the current study, then the latter parts of Strauss and Corbin's methodology would prove useful in generating a theory which had better integration than which had emerged from open coding alone.

Causal conditions, phenomenon, context, intervening conditions, action/interactional strategies and consequences – the features of the paradigm model - can all be seen as labels for elements arising from the interviews conducted in this study. The main difference would seem to be that much of the action takes place either at an imaginary level, or in the context of the experimental 3D worlds which were created as demonstrations of the technology.

- The phenomenon is what the study is actually about. It appears from Strauss that several candidate phenomena could be specified for a particular study, but here the specified phenomenon, what the subject of the study was intended to be, and what interviewees were told it was, is "user preferences for the design of 3D virtual worlds for accessing information".

- "Causal conditions" are harder to pin down. It might be that what causes preferences is personal taste, or being used to a system of organisation, or fear of the unknown. In a sense, the causal conditions are the target of the survey.

- "Context" could be the interview conditions, or might be the fact of having to deal with large amounts of information, personal or global, in a 3D environment.

- Action/interactional strategies would be the act of choice and specification of the design, formulating and expressing preferences.

- Consequences may not belong in this study, but would have to await an implementation of any 3D designs emerging from the study of user preferences. They might be interpreted as the influence that user preferences have on the design process, or as the impact that the use of the designs has on the users.

These features are not crucial to the understanding of the findings of the current study, and have not been further developed here – rather, they would be useful as dimensions along which the current study and future studies might be compared and contrasted.

2.2.5 Criticisms of Grounded Theory

Bryman (1988) notes three widely-acknowledged problems in qualitative research. First is that of interpretation – "how is it feasible to perceive as others perceive?" (Bryman 1988 p. 73) How can the researcher have the same perspective as the subject? Even an air of detachment and pure reporting does not reproduce the subjects' viewpoint. The researcher's interest may not be part of the subjects' concerns. The question is, "whether researchers really can provide accounts from the perspective of those whom they study, and how we can evaluate the validity of their interpretations of those perspectives" (Bryman 1988 p. 74). In the context of ethnography, one possible means of remedying this situation is to supply field notes and extensive transcripts, in order that readers can draw their own conclusions and reach their own interpretations of the data. There is also the approach of "constitutive ethnography" (Bryman 1988 p. 78) which additionally seeks to "preserve the social world that is being investigated as data for others to interpret" (Bryman 1988 p. 78). Respondent validation is another approach to solving this problem, but the respondents are not necessarily validating the data as presented in translation for an academic audience – "It is unlikely that respondent validation will greatly facilitate the ethnographer's second-order interpretation of subjects' first-order interpretations" (Bryman 1988 p. 79). In fact, respondent validation can be useful input to the second of the three stages of presenting the respondent's world view: the view itself, the researcher's interpretation of that view, and the researcher's construction of an interpretation for the academic audience. "These three basic ingredients are inherent in any attempt to provide an interpretation of other people's interpretations for a social scientific audience" (Bryman 1988 p.81). The implication is that checking is limited

in its usefulness to an affirmation that the researcher has transcribed accurately, and has not misrepresented the actual content of the data that was collected. However, whilst the three ingredients must be considered carefully, these are considerations of greater import for an ethnographic study, and it has been discussed in section 2.1 why this is not considered to be such a study. Respondent validation, or "member checking" is carried out both at the level of establishing accuracy of transcription (with all groups of respondents) and at the final level of checking the validity of the researcher's interpretation for an academic audience, with respondents who were themselves also part of that audience.

The second question relates to whether research can be conducted in a theory-neutral way, and with specific regard to Grounded Theory, whether it actually provides theories, or simply generates categories. There is a question on a practical level as to whether theory can actually be generated during data collection, especially given the effort entailed in recording, transcribing, coding, etc, or whether it is, in fact, generated afterwards. In the present research, it would be true to say that the theory, substantive rather than formal, was arrived at during the transcription, rather than the collection phase, although the direction of the collection phase had been influenced by the development of the theory. There is a relationship between data collection and theory generation which is akin to that between prior literature review and data collection, and is almost as difficult to disentangle. Grounded Theory methodology, with its developing of coding, categorising, and memos, documents the development of theory, and examples of this development have been given when appropriate. Also, Grounded Theory should be less liable to be constrained by early assumptions – the continual review of material and categories in the light of incoming data should militate against this.

Another aspect of the theory-generating issue which Bryman identifies is that researchers may be reluctant to depart from what they get from the research, and introduce theoretical elements. "In addition to the emphasis on naturalism … is the predilection for contextualist understanding … This tendency inhibits comparison with other contexts and thereby discourages theoretical development" (Bryman 1988 p. 86) . This point, again, appears more directed towards ethnographic studies, particularly of "deviant groups and their subcultures" (Bryman 1988 p. 85), rather

than the participants in the current study, who varied as to culture, ethnicity, age, life experience, and in many other attributes.

The third question is whether theory based on a study in a single setting, of a particular case, or of a particular group, can be generalised outside that setting. Bryman considers possible solutions: the study of more than one case, the involvement of teams of researchers, and the selection of either "typical" or "deviant" cases. All of these strategies, though, have their own problems relating to generalisability. Bryman suggests, however, that these perceived problems arise from a misunderstanding of the aims of case study research – that, as in the current case, a wide range of individuals is studied, and that the generalisation which takes place is from cases to theories, rather than to larger populations. "Case study data become important when the researcher seeks to integrate them with a theoretical context" (Bryman 1988 p.90). The grounded theory approach, he writes, "exemplifies this reasoning: a 'substantive theory' … is then translated into a formal hypothesis". In Glaser and Strauss' work, the substantive theory is about the social loss of dying patients, the formal hypothesis is about the social value of the individual related to access to services.

Rather than attempting to defend the questionable position that the (interpreted) experience of a specific group can be generalised to a larger population, as a quantitative survey might generalise quantifiable data about a rigorously sampled group of participants, grounded theory encourages the generation of formal hypotheses, which are open to testing against other contexts.

Sperber and Wilson (1995) present a theory of communication which could be seen as problematic for Grounded Theory. They claim that communication can be described as having an inferential model, that "an act of ostention carries a guarantee of relevance, and that this fact – which we call the *principle of relevance* [emphasis in original] – makes manifest the intention behind the ostention" (Sperber and Wilson 1995 p.50). Part of an act of communication lies in making it clear that the intention is to communicate, and the content of the communication is, as it were, vouched for as being relevant to the audience. A potential difficulty for the Grounded Theory practitioner is that the authors allow for the possibility of unintended ostensive communication, but add "It would be easy … to … make intentionality a defining

feature of communication." (Sperber and Wilson 1995 p. 64) If intentionality were a defining feature, then it becomes difficult to justify the interpretive act of deriving from interviews meanings which are not those expressed directly by the interviewees.

"Grounded theory has been criticised for its failure to acknowledge implicit theories which guide work at an early stage. It is also clearer about the generation of theories than about their test. Used unintelligently, it can also degenerate into a fairly empty building of categories (aided by the computer software programs already discussed) or into a mere smokescreen used to legitimise purely empiricist research" (Silverman 2006 p. 96). Silverman also claims that, amongst other "cookbook means" of resolving technical issues to which analytical questions are reduced, "simplistic versions of grounded theory … are no substitute for theoretically inspired reasoning" (Silverman 2006 pp. 386 – 7).

2.3 Selection of users

Glaser and Strauss write: "[t]he basic criterion governing the selection of comparison groups for discovering theory is their *theoretical relevance* for furthering the development of emerging categories. The researcher chooses any groups that will help generate, to the fullest extent, as many properties of the categories as possible and that will help relate categories to each other and to their properties." [emphasis in original] (Glaser and Strauss 1967 p.49)

The user groups selected for the first and second rounds of interviews were composed of postgraduate students on Information Management courses at the Aberdeen Business School, Robert Gordon University, Aberdeen. The principal reason for this is that it gave a "constituency" who were already familiar with the concept and practice of accessing information, and thereby rendered unnecessary the "scene setting" and preparatory orientation which, in the case of this sample, had already been accomplished through experience of practical retrieval problems. There could be some degree of confidence that interviewer and interviewees were communicating in a common "universe of discourse".

The user group for the third round of interviews was composed of academic and technical staff, also from the Aberdeen Business School. This decision was taken partly for the same reasons as applied to the selection of the first two groups, but also as a "theoretical sampling" decision, in keeping with grounded theory principles. In addition to having the familiarity with accessing information which made the students suitable subjects, it was felt that the staff typically would have greater experience, and would be more practised communicators. This was borne out by the subsequent findings of the study.

2.3.1 Formative nature of sample

The sampling was therefore formative – there was a basic requirement that the interviewees were to some extent familiar with the idea of accessing information, but beyond this, the reason behind the sampling was that the tacit knowledge in each of the groups could be made to play its part in the progress of the research. The students came from a wide range of previous academic backgrounds, and brought a correspondingly wide range of experience and viewpoint. At the first stage, the intention was to elicit a range of tacit knowledge regarding information access from people who had not necessarily considered the possibilities of using a 3D world for this purpose.

The second round of interviews, with a similar group of students, was again intended to elicit tacit knowledge, this time in reaction to sample worlds created in response to the first round of interviews. The reactions of the interviewees were then fed into the next stage of model development.

The staff comprising the third group, many of whom are research-active, again brought a wide range of personal and academic backgrounds, added to greater experience of information access, applied to particular subject areas. This greater practical and theoretical knowledge, combined with greater experience in expressing themselves, was considered to constitute the best group for the final stage of the research, in which the individuals with this body of knowledge, shown the examples derived from the first two groups of interviews, could extrapolate to an "ideal world" for each.

2.3.2 The interviewees

All 101 interviewees in the study were volunteers, and were assured anonymity. The size of the sample was determined largely by who volunteered, and the sample was therefore to some degree self-selecting, as such samples, without the use of some form of incentive or coercion, will tend to be. This is perceived as a positive feature – those who volunteer are those who are interested in contributing, and the drive behind the research is to go some way to filling the gap in the literature where it appears that user consultation has been lacking. There are still some interviewees who, whilst willing to help, did not respond to the notion of 3D virtual worlds, and this is to be expected. The first round of interviews demonstrates that a "one size fits all" solution is unlikely, and the discovery that there are no "sizes" to "fit" some interviewees is not surprising. Some people simply do not "get on" with this type of interface, some find their working practices unsuited for reasons of perceived speed and efficiency, some may perceive the interface as somehow frivolous, or better suited to gaming than to work.

Only one interviewee identified himself as colour blind, but, clearly, there would be a need for worlds to be optimised to maximise their usability for people with this condition. There were no other visually-impaired users, but, again, it would be necessary in a "production" system to design for the widest usability. It might be that extensions would be necessary to schemes offering advice on usability of Web pages. It is also probable that other users with differing abilities would have to be considered, and it would be unlikely that the 3D interface could replace a text-based interface for all users, particularly those who rely on text-to-speech systems.

In general, the more abstract, less realistic, or less conventional worlds were proposed by younger staff and students, whilst the older staff and students tended to produce fewer of these ideas, but there was no clear distinction – some young interviewees were very unimaginative, and some of the more unusual ideas came from the oldest interviewees. In a similar way, male interviewees appeared to be more "concrete" in their approach than females, across the whole range, but males produced some of the least conventional, and females some of the most conventional, ideas. Of the six interviewees who said that they could not envisage using a system of the type

described, three were male, three female, three younger, and three older. In regard to age, they could be described as one older female, and two older males, one younger male, and two younger females. Three were staff, and three were students.

2.4 Selection of interviews as an instrument

The decision to use interviews as a research instrument was taken because of the nature of the information sought. Since it had been decided that a choice amongst arbitrarily-selected models was not a satisfactory way of establishing what the users really wanted, in a situation where almost any imaginable model could be implemented if desired, and since there was a wish not to influence the choice by presenting a selection of models by which interviewees might be influenced in their choice, it seemed inappropriate to administer a questionnaire. In any case, the fact that the idea of accessing information through a 3D environment had been a novel one to the group in the earlier study, and was relatively uncommon outside the literature on information visualisation, led to the conclusion that a more flexible, personal, contact would be valuable in explaining what might be an unfamiliar idea, and providing reassurance, where necessary. Development of details of interviewing technique also took place in a reflective manner throughout the interviewing stages, and these will be described at the appropriate stages in the findings sections.

Interviews were very loosely structured. Glaser, one of the originators of grounded theory, says “If the data is garnered through an interview guide that forces and feeds interviewee responses then it is constructed to a degree by interviewer imposed interactive bias. But … with the passive, non structured interviewing or listening of the GT interview-observation method, constructivism is held to a minimum.” (Glaser 2002 paragraph 11) He further defends against an accusation of constructivism (the idea that findings are unduly influenced by the interviewer) “Let us be clear, researchers are human beings and therefore must to some degree reify data in trying to symbolize it in collecting, reporting and coding the data. In doing so they may impart their personal bias and/or interpretations—ergo this is called constructivist data. But this data is rendered objective to a high degree by most research methods and GT in particular by looking at many cases of the same phenomenon, when jointly collecting

and coding data, to correct for bias and to make the data objective" (Glaser 2002 paragraph 28). Interviewees were encouraged to talk freely, even when this led to lengthy digressions. Interviewer contributions were limited, as far as possible, to prompting interviewees when "stuck", or bringing them back to the main topic.

Interviews were tape-recorded with the permission of the interviewees, and transcribed, interviews being assigned a number at the transcription stage. It was felt that tape recording was a relatively non-intrusive way of recording interviews, and all interviewees agreed to it without reservation. Interview transcripts were subsequently checked for accuracy with the interviewees, revealing one minor misunderstanding in one interview, which was corrected accordingly. This "member-checking" is in accordance with the procedures recommended by Lincoln and Guba (Lincoln and Guba 1985 p. 188), as described in section 2.1.3, above.

2.5 Iteration

Although the continuing availability of the same students over the course of the research would have been problematic if an extended quantitative study had been the methodology of choice, the grounded approach meant that there was no particular requirement to interview the same individuals several times - just to interview individuals, although sessions were therefore slightly longer, to allow for "scene-setting". As long as the necessary information was acquired, there was no necessity to repeat interviews. The development of the theory, and of the research instrument itself, takes place independently of any development in knowledge or skill on the part of the interviewee.

For this reason, the methodology, like the literature review, was treated in a sectional, or sequential, manner. Grounded Theory allows, and indeed expects, that the theoretical structure will be developed through "rounds" of, in this case, interviews, and that each round will be both founded on previous rounds, and an attempt to reflectively develop a research instrument of greater precision than in the previous round. It is therefore considered more meaningful to show this development as the rounds progress, and the theory's development changes accordingly. As shown in fig.

2, the overall structure has a cyclical pattern, as older material is revisited and reviewed in the light of more recent material.

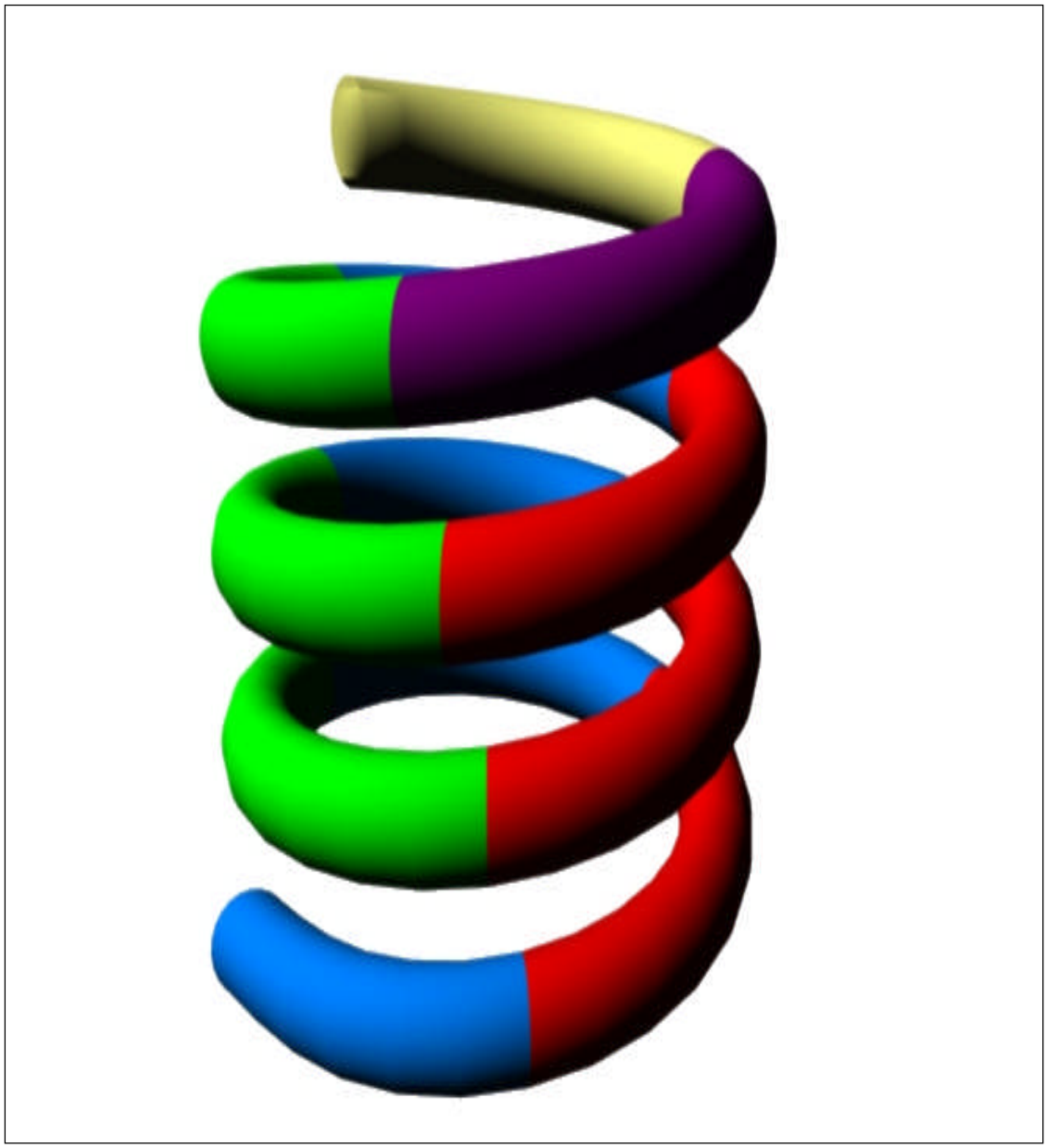

Fig 2: Structure of thesis © Marx Murdoch 2007 Used with permission

Key: Interviews/Analysis Literature Discussion/Theory

Contextualization Conclusions

The fact that the study "evolved" into a series of "rounds", with a theory emerging and undergoing modification during the process, is in keeping with Grounded Theory practice, in that the theory "emerges" iteratively from the interviews, and is tested at each successive stage.

2.6 Organisation and presentation of findings

Literature was sought out as it became relevant, and relevant topics changed during the course of the research. This also affects the presentation of the literature in this thesis. The study is structured as a series of sets of interviews. Each set of interviews constitutes a "round" in the structure of the research, and the results of each round are used to develop a theory, which is then explored further in subsequent "rounds". This is in keeping with the principles of grounded theory, as discussed above. In order for the theory to emerge, and in accordance with Strauss' advice, relevant literature was consulted after each round, and findings from that literature compared and contrasted with the findings from the round. This dialectic then fed into the development of the theory, and so influenced the direction taken during the following round.

Some items of literature are revisited, as different parts or different aspects of them become relevant to different rounds of the study. These re-appearances are prompted by actual re-consultation of the sources, each time with different questions in mind. In particular, the work of the Xerox PARC researchers will be considered in different contexts, which is indicative of their considerable influence in the field of information visualisation.

There will be an initial scene-setting literature review in Chapter 3, which will help to explain why there was a need perceived for a study of this type. It sets the study in the context of both the fictional literature by which much of the work in this field has been inspired, and the current implementations of virtual worlds which are relevant to this field of study. As indicated in section 1.3, above, this will be followed by chapters 4 – 7, which present the results of interviews.

Chapter 4 and the first round of interviews are concerned with gathering what might be called “naïve” ideas for the design of virtual worlds for accessing information, from people who usually have little or no previous experience of the topic. The literature component of Chapter 4 is thus concerned with the basics of the use of spatial representations of information, and some observations regarding navigation in such spaces.

Chapter 5 and the second round of interviews are concerned with users experiencing for the first time virtual worlds designed on principles derived from the previous round of interviews. The literature component here is concerned with actual models of virtual worlds which have previously been developed for information access, and the discussion surrounding them. Chapter 5 is also concerned with discussion of observations regarding the performance of interviewees using the model worlds developed for the study. The literature component here is concerned with navigation and usability issues discussed in other studies, and how their findings relate to the observations in the current study. This section does not deal with a set of interviews, but rather constitutes a “development round”, and, as such, is more akin to the development process in other studies which do not concern themselves with user input at the design stage, but later conduct usability testing of models designed on different principles.

Chapter 6 and the third round of interviews are concerned with the views of a “non-naïve” set of interviewees, who have experienced the virtual worlds designed in response to the first round of interviews and discussion, and modified in response to the second round and discussion of usability issues. The literature component of this chapter again discusses the findings of the set of interviews against the models found in the literature.

Placing the understanding drawn from the current study in the context of others’ work makes a contribution to knowledge by providing a theoretical basis for what appears to be evolving without such a basis in the development of social virtual worlds. Rather than being technology-driven, it would appear that the expansion of ILS services into these domains can be theoretically supported by this study, which gives professionals an insight into what users actually want.

Chapter 3 – Background literature

There is disagreement amongst grounded theorists as to the extent to which literature should be allowed to influence a study, but there appears to be a consensus that extensive prior study of literature in an emergent study is not to be encouraged, in case the interpretations of the findings are constrained into previously mapped-out categories. Glaser recommends broad background reading, but avoidance of literature directly related to the field of study.
As indicated in the preceding chapter, the literature review will be presented in sections, rather than in one whole, and these sections will be matched up with the relevant cycle of interviews which directed the review. As the grounded methodology uses each "round" of interviews to inform the next, and to build or to improve on the current theory, it is also necessary for the literature review to investigate different areas at different stages of the interviewing and theory-building process. This is an evolutionary process, in which each set of findings, considered together with the relevant literature, is used to evolve the theory towards its next stage of development.

Literature is thus introduced to aid interpretation of findings and to assist in theory building, as the categories of interest emerge.

However, a principal purpose of this particular section of the literature review is to examine research which is concerned with 3D environments as means of accessing information, and to show that there appears to be a gap in the literature concerning user involvement in the design of these worlds. This perceived gap was the feature which encouraged formulation of the basic research question, what would user preferences be, and what would be the factors influencing those preferences?

3.1 Integration with earlier literature

3.1.1 Neuromancer

"Cyberspace" is a term coined in his 1984 novel 'Neuromancer' by William Gibson. Gibson's vision was apparently based on his observation of video game players, but he developed this into a story of data theft in the Matrix, an abstract space, a "consensual hallucination" (Gibson 1986 p. 12) into which participants are directly

connected by neural linkages. Gibson's imagery is of grids extending through space, of coloured structures representing data storage for large corporations, and of battles between the "console cowboys" and counter-intrusion programs, or "ice" (Intrusion Countermeasure Electronics) (Gibson 1986 p.39).

3.1.1.1 Accessing information in Neuromancer

Case, the central character in 'Neuromancer', is a data thief, who uses "dermatrodes" placed on his head to access the Matrix, and controls his movements there with a "cyberspace deck", which is not described further. The world he enters is like a "transparent 3D chessboard extending to infinity. Inner eye opening to the stepped scarlet pyramid of the Eastern Seaboard Fission Authority burning beyond the green cubes of the Mitsubishi Bank of America, and high and very far away he saw the spiral arms of military systems, forever beyond his reach." (Gibson 1986 p. 68) Case uses his skills to penetrate the software defences of one organisation, whilst his partner, Molly, is physically burgling their headquarters. He is thus able to deactivate the alarm systems protecting the item that Molly intends to steal. Case also accesses information via his computer, which has access to an "array of libraries, journals and news services" (Gibson 1986 p.74).

3.1.1.2 Another virtual world

Later in the book, Case finds himself in another virtual world, this time a very realistic simulation of a beach. It transpires that this world is the creation of an artificial intelligence (AI) which is one of the other "characters" in the story. Both this type of simulation and the more abstract cyberspace appear in all Gibson's "Sprawl" novels, and heavily influenced the so- called "cyberpunk" school of science fiction, but neither is precisely the kind of world investigated in this study. Cyberspace is the domain of the large corporations and military systems, a "graphic representation of data abstracted from banks of every computer in the human system" (Gibson 1986 p.67), but it is not organized to facilitate retrieval, which is why the like of Case can find illegal employment.

3.1.2 Snow Crash

In the fictional arena, these ideas were developed by the so-called "cyberpunk" school of writers, including Neal Stephenson, whose 'Snow Crash' (Stephenson 1992) has

also been influential in that genre. Stephenson's "Metaverse" – which corresponds to Gibson's "Matrix" – is a more social space, populated by "avatars" – the computer-generated forms which represent human users, and by "daemons" – representing system processes. The Metaverse is a globe, 65,536 (2^{16}) kilometres in circumference, making it larger than the Earth. Around the equator of the Metaverse runs the "Street", a 100 metre wide boulevard with a free elevated monorail system running down the middle. "Downtown", the busiest part of the Street, is heavily populated – "a dozen Manhattans, embroidered with neon and stacked on top of each other" (Stephenson 1992 p. 24). In the busiest part of Downtown is the Black Sun, a huge bar where the social elite of the Metaverse congregate.

As indicated by his name, Hiro Protagonist is the central character in 'Snow Crash'. Hiro is a "hacker", one of the programmers who wrote the software for the Metaverse, and as such has considerable status there, although in real life he delivers pizzas. In the Metaverse, he is represented by an "avatar" – a digital representation of a person, which allows users to interact with each other. About 120 million avatars can access the Metaverse at any given time, and users are able to build streets running off the Street, and build houses and businesses on them. There are property developers and planning agencies in the Metaverse, and many large businesses: "When Hiro goes into the Metaverse and looks down the Street and sees buildings and electric signs stretching off into the darkness, disappearing over the curve of the globe, he is actually staring at the graphic representations – the user interfaces – of a myriad different pieces of software that have been engineered by major corporations" (Stephenson 1992 p. 23).

3.1.2.1 Accessing information in the Metaverse

The Metaverse is therefore a social, recreational, and business environment. It is also a place for accessing information. In addition to the naturalistic conversations between avatars, information can be exchanged in the form of hypercards – "The hypercard is an avatar of sorts. It is used in the Metaverse to represent a chunk of data. It might be text, audio, a still image, or any other information that can be represented digitally." (Stephenson 1992 p.40) This function can also be performed by scrolls, one of which induces the "snow crash" of the title. Hiro also accesses information through two other pieces of software. One is "Earth", which is "a globe about the size of a

grapefruit, a perfectly detailed rendition of Planet Earth" and can be used to "keep track of … all the maps, weather data, architectural plans, and satellite surveillance stuff" (Stephenson 1992 p. 99) owned by CIC, the intelligence organisation for which Hiro does some freelance work. The CIC is the Central Intelligence Corporation, an amalgamation of the Library of Congress and the Central Intelligence Agency (CIA). The CIC also owns the other piece of software Hiro uses for information access: the "Librarian", through whose mediation Hiro is able to access the "nearly infinite stacks of information" in the Library (Stephenson 1992 p. 100).

In the novel, Hiro uses the Earth software to track the progress of a huge raft of refugees. Earth could be regarded as a precursor of Google Earth and similar technologies, and its functions could, in principle, be duplicated with current technologies. The Librarian, though, is of a higher order of software. In appearance, he is quite stereotypical:

> The Librarian daemon looks like a pleasant, fiftyish, silver haired, bearded man with bright blue eyes, wearing a V-neck sweater over a work shirt, with coarsely woven, tweedy looking wool tie. The tie is loosened, the sleeves pushed up.
>
> (Stephenson 1992 p. 99)

The term "daemon" refers to one of a Unix-type operating system's native processes – a program that runs "in the background" of whatever user applications the system is running. Although we are told that "the only thing he can't do is think" (Stephenson 1992 p. 100), the Librarian does have a very sophisticated natural language processing capability.

3.1.3 Gibson's later work

Tony Myers claims "The concept of cyberspace is valuable as a narrative strategy because it is able to represent 'unthinkable complexity,' to gain a cognitive purchase upon the welter of data." (Myers 2001 p. 887) Gibson has admitted "it immediately becomes apparent that I have no grasp of how computers really work- it's been a contact high for me" (McCaffrey 1986) and found inspiration for cyberspace in a video games arcade : "I could see in the physical intensity of their postures how rapt the kids inside were. … Everyone I know who works with computers seems to

develop a belief that there's some kind of actual space behind the screen, someplace you can't see but you know is there" (McCaffrey 1986). It would seem that Gibson has decided to advance with the technology - after all, the "three megabytes of hot RAM" (Gibson 1986 p. 31) which Case was trying to sell in 'Neuromancer' would be seen as a trivial amount today. He also stated, after the Sprawl novels were published, that "When you're not forced to invent a new world from scratch each time, you find yourself getting lazy, falling back on the same stuff you used in an earlier novel" (McCaffrey 1986).

In Gibson (1993, 1996, 1999, 2003), there is a move away from the abstract data spaces of the Matrix, and toward a set of representations more akin to Stephenson's. The characters now wear "eye-phones" – small, goggle-like devices, and use "thimbles" or "tip-sets" as input devices. Access to the virtual spaces is achieved through data ports in buildings, and by means of small, often portable, computers, like the much-admired "Sandbenders" model owned by Chia in 'Idoru' (Gibson 1996). There is still a plot requirement for Laney, the other character in the novel to whose point-of-view the reader is privy, to access relatively unformatted data : "He clicked back, through points of recession, trying for a wider view, a sense of form, but there were only walls, bulking masses of meticulously arranged information" (Gibson 1996 p. 117). His ability to find "nodal points" in data has been artificially enhanced by drug trials in his youth, but the other users of virtual space seem to require neither drugs nor invasive physical connections to allow them access. Frequently, the spaces are designed by their owners – Chia's personal space is modelled on Venice, her friend Zona Rosa has a Mexican-influenced world, and Masahiko and his associates have designed the Walled City, modelled on an ancient Chinese city, but with a host location which is both "on-net" and "off-net" – the processing is distributed, so that "Walled City is not anywhere."(Gibson 1996 p. 155) Avatars are personally designed, and it appears that a great deal of thought and symbolism goes into deciding what messages are conveyed by an avatar's appearance, clothing and behaviour: "Mitsuko was wearing the kimono and the wide-belt thing, the whole traditional outfit, except there was some low-key animation going on in the weave of the fabric. Chia herself had downloaded this black Silke-Marie-Kolb blouson-and-tights set, even though she hated paying for virtual designer stuff that they wouldn't even let you keep or copy" (Gibson 1996 p. 98).

Meanwhile the networks and network applications foreshadowed by Gibson and Stephenson, and the processing and storage capacities to make these applications practicable, have also arrived – it is even possible now to have simple computing applications controlled by the user's brain waves (Sato et al. 1993). More practicable currently, though, is the development of, and remote access to, 2-dimensional representations of 3-dimensional "worlds", which can be used for purposes as varied as computer gaming, estate agency and surgical training.

The technologies which could be seen as the real-world equivalents of Gibson's and Stephenson's expressions of information networking have been developed and explored in several disciplines, such as information visualisation, cognitive science, games programming, cognitive ethnology, virtual reality and information retrieval.

3.2 Information visualisation

The largest body of work concerns information visualisation. There are many definitions of this term, but there is a broad consensus that it is concerned with 2D or 3D, interactive, graphical representations of abstract data, intended to facilitate discovery. Goguen and Harrell (2003) point out that "Information visualization design is generally ad hoc, using trial and error, and perhaps prior visualization experiments", and this view would seem to be supported by the literature. Goguen and Harrell consider information visualisation as a "semiotic morphism", a question of the representation of signs, and there are elements of this approach which it will be useful to consider in chapter 9, when the issue of further steps in world design is considered.

3.2.1 The PARC team

Much of the early work in information visualisation which is relevant in this context emanates from the Xerox PARC (Palo Alto Research Center), specifically from the grouping of Card, Mackinlay and Robertson, all of whom have remained influential in the field, Robertson having worked for Microsoft since 1994, still in the field of 3D Information visualisation (Robertson 2004), and Card and Mackinlay still being employed at PARC, concerned with various Human-Computer Interface projects. Their notable contribution to the early stages of information visualisation came in

1991, with the publication of ‘The information visualizer’ (Card, Mackinlay and Robertson 1991). Here, the authors propose a new paradigm – the information workplace. The authors are concerned “not just with the retrieval of information from a distant source, but also with the accessing of that information once it is retrieved and in use” (Card, Mackinlay and Robertson 1991 p. 186). The workspace metaphor is drawn from other situations where there is a requirement for easy access to materials in use. In the authors’ terminology, access to material in a workspace is “low-cost”. The 3D/Rooms model they propose expands the familiar ergonomic arrangement of the desktop, with frequently-accessed items closest to hand, into a 3D environment through which the user can “move”. The rationale behind this design is based on the idea of “information cost”, whereby there is a cost associated with retrieving each piece of information. The cost of accessing information in the “immediate storage environment”, such as a desktop, is low, whereas the cost of accessing information in a filing system is higher, and highest is the cost of accessing information held in “tertiary” storage, such as a library. Both this office structure and a computerised information retrieval system have this cost structure, but with the computerised example, the different cost areas are RAM, disk, and optical storage, in decreasing order of access speed. Information may be represented in this environment in several ways, many of which had been devised by the same authors and described in a series of publications in the same year.

This extremely productive period has indeed the appearance of a period of paradigm change, perhaps partly brought about by the recent advances in computer graphics and the increasing sophistication of Graphical User Interfaces (GUIs). Cone trees, the Perspective Wall (Mackinlay, Robertson and Card 1991) the Information Grid (Rao et al. 1992), a Data Sculpture (“the user can walk around or zoom into this visualization containing over 65000 sampling points as if it were a sculpture in a museum” (Card, Mackinlay and Robertson 1991 p. 187)) and a 3D representation of a building are all potential ways of presenting information within the 3D/Rooms environment.

By the next year, 1992, the same team had devised the Information Visualizer (Mackinlay, Robertson and Card 1992), an experimental system based on the model described in the earlier paper (see fig. 3). The model does not appear to be developed significantly beyond the description in the earlier paper, and it may be that this

similarity is the result of near-simultaneous publication of a large number of closely-related articles and conference papers by the same small group, with rotation of the first-named author. In none of these papers is there evidence of formal user studies, though Mackinlay, Robertson and Card (1992) state that "Our initial prototypes suggest that such highly interactive user interfaces are likely to support the applification [sic] of information-based work processes" (Mackinlay, Robertson and Card 1992 p. 178).

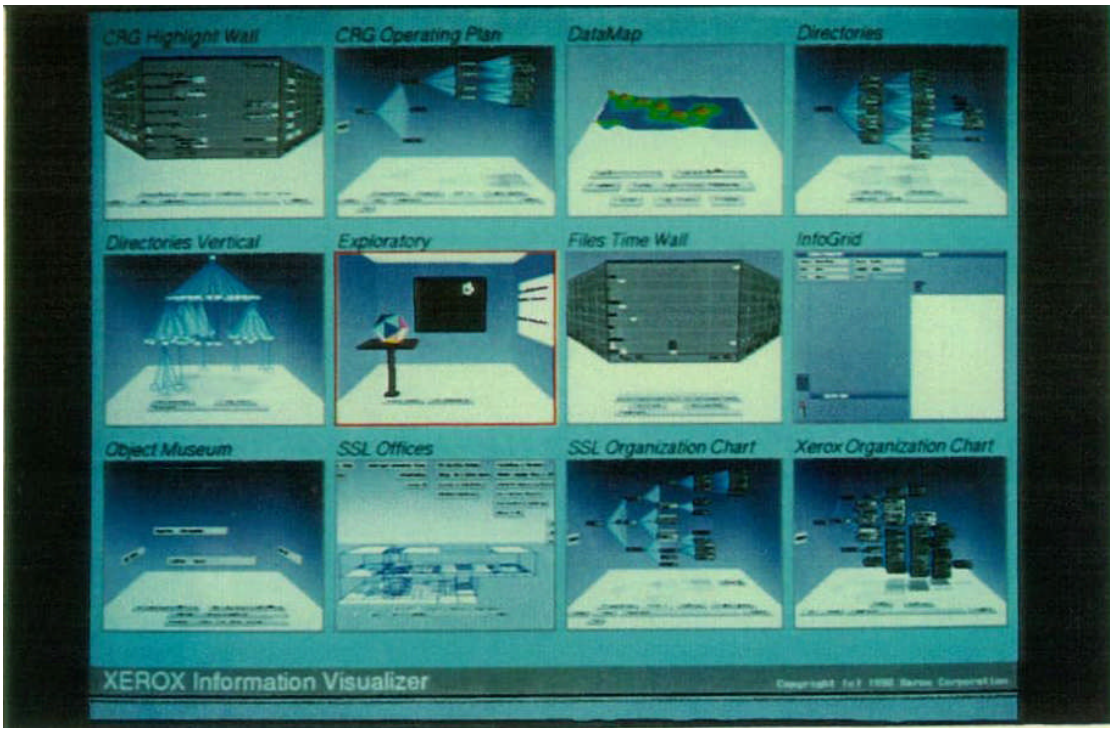

Fig 3: Information Visualizer © Card, Mackinlay and Robertson. 1991 Used with permission

The visualisations will be described in greater depth here, partly because they have been extremely influential in later work on information visualisation, and partly because the focus of later works has tended to concentrate on them, with the result that there has been a tendency to ignore the framework within which they appeared. It should also be noted that whilst these visualisations are themselves 3D, it does not appear from the publications that there was the opportunity for the user to have a presence "in" the space in which the visualisations were displayed. The "sense of presence" element which contributes to the "virtual reality" experience was apparently lacking. The user experience here would be more akin to looking at a bar graph drawn with perspective and shaded, but from a fixed viewpoint. Interaction is

restricted by the inability to move the user's viewpoint within the scene, though elements within the scene may be moved relative to the viewpoint.

3.2.2 Perspective Wall

The different displays are appropriate for different kinds of data. The Perspective Wall (see fig. 4) is a linear display in which the area of focus, represented by the centre section of the wall, can be moved along the length of the wall (or the wall scrolled past the area of focus) with the sections of wall to the left and right of the focus apparently

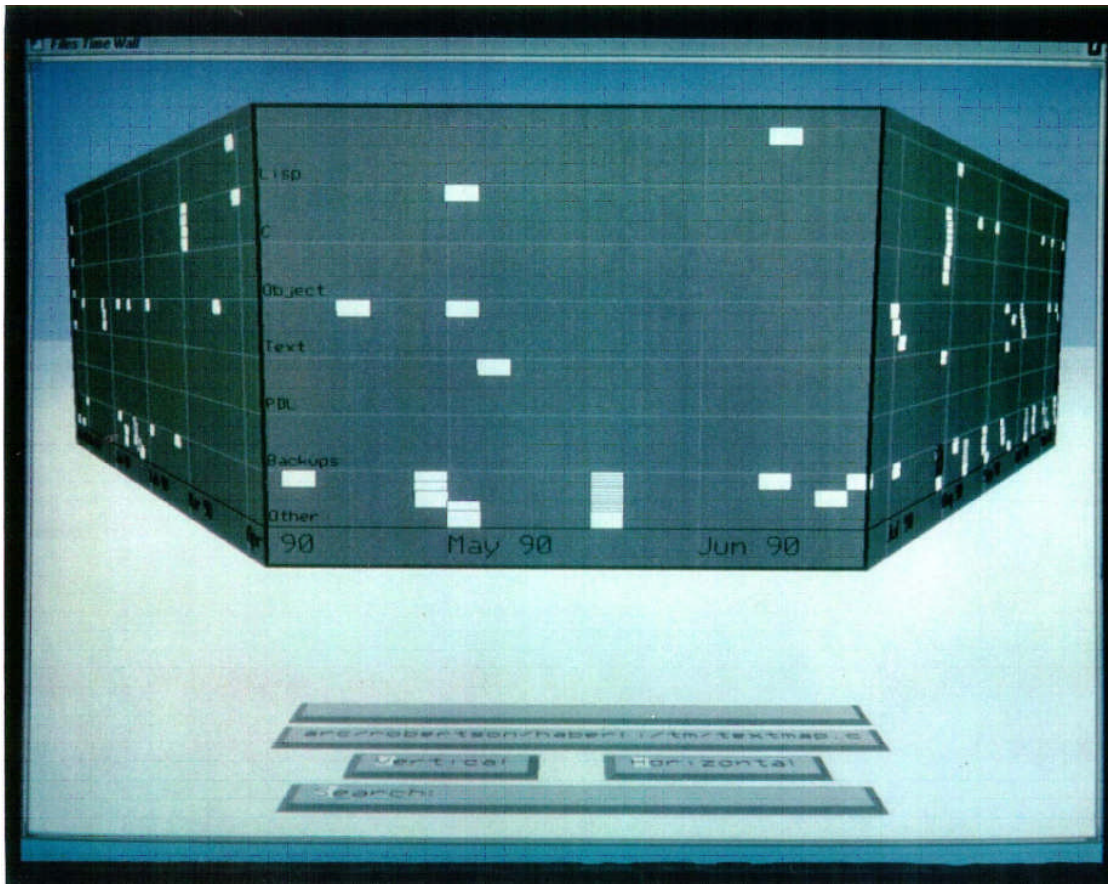

Fig 4: Perspective Wall © Mackinlay, Robertson and Card 1991 Used with permission

receding into the distance. It is intended for the display of information arranged in a linear fashion, perhaps a set of publications sorted by date of publication. The combination of a detailed view with a contextual setting allows for considerable flexibility in the display of information with what Mackinlay calls, a "wide aspect ratio". He gives as example a display of computer files of different types (arranged vertically) and dates of creation (arranged horizontally). The area of focus or detailed view can be moved along the wall, and can also be "stretched" for a view with greater

detail. Files “are classified by their modification date and file type. Vacations and other work patterns are clearly visible. The technique has also been used for corporate memoranda and reports, which also have a useful linear structure. The effect is particularly effective when combined with a retrieval technique that allows the user to select an item and find similar related items” (Mackinlay, Robertson and Card 1991 p. 5).

3.2.3 Cone Trees

The second display type, Cone trees, are “hierarchies laid out uniformly in three dimensions … [t]he top of the hierarchy is placed near the ceiling of the room, and is the apex of a cone with its children placed evenly spaced along its base. The next layer of nodes is drawn below the first, with their children in cones” (Robertson, Card and Mackinlay 1993 p. 65). The whole tree is scaled to fit into a room in the Information Visualizer model, and when a node in the tree is selected by using a mouse, the whole tree rotates, so that the cone selected is brought to the front.

3.2.4 Cam Tree

There is an alternative design, the Cam Tree, which displays each node as a text string, and is oriented horizontally, rather than vertically. These designs, and the animation feature which brings a particular node to the front of the display, are intended both to maximise use of display space and to aid the viewer’s perception and understanding of the hierarchical relationships displayed. The authors explain that the use of animation, colour, shading and perspective, work to “reduce the cognitive load by exploiting the human perceptual system.” (Robertson, Mackinlay and Card 1991 p. 191)

Particular parts of a tree can be collapsed and telescoped, or “pruned” and “grown” in the authors’ terminology, to allow the user to “further explore and manipulate the structure of the information being visualized” (Robertson, Mackinlay and Card 1991 p. 191).

These models can all be placed within the 3D/Rooms environment, which “contains an overview allowing the user to view all the 3D workspaces simultaneously … the

user can actually reach into the Rooms from the overview, move about in them, and manipulate their objects" (Card, Mackinlay and Robertson 1991 p. 187).

In a 1993 paper, the same team introduce the idea of an Information Workspace, a large area of low-cost storage (cost in terms of retrieval cost), partly operated by semi-autonomous agents, in which visual abstractions of information may be interacted with in real time, to "speed assimilation and pattern detection" (Robertson, Card and Mackinlay 1993 p. 59). This paper re-examines the 3D/Rooms interface, but also provides some useful analysis of requirements for user "movement" in a 3D workspace.

3.2.5 Relevance to the current study

The relevance of this discussion of information visualisation techniques to the current study is that these techniques represent the early attempts to represent information graphically in 2D or 3D formats, by means of a computer display. The influence of PARC is acknowledged throughout later literature, and although technically, they were limited in their use of 3D to a representation which kept the user "outside" the environment, the interactive elements of these visualisations can be seen as precursors of some other facilities which would be offered by later virtual reality systems. However, their development processes appear to concentrate on technical excellence, rather than considering what users might want.

3.2.6 Further PARC projects

It is informative to examine the reasons for combining the visualisations into a larger tool, and to consider whether a user-centred design could, perhaps, be responsive to the same criteria for information access. Card, Mackinlay and Robertson (1991) make six observations based on previous research.

First, hierarchical organisation makes information cheaper to process. This is drawn from biological, socioeconomic and engineering systems. The example given is that of an office, arranged so that frequently used information is close to the user on the desktop, in what Card, Mackinlay and Robertson refer to as "immediate storage", less frequently used material is filed in "secondary storage", and infrequently used

material housed elsewhere in “tertiary storage” (Card, Mackinlay and Robertson 1991 p. 183).

Second, the cost of accessing information varies because so do the costs associated with finding it and assimilating it. Is it easy to get at, or not? This example comes from computer access times, where there are differences of orders of magnitude between access times for RAM and hard disk, and removable media. Here Card, Mackinlay and Robertson use the example of a scholar, for whom it takes a long time to gather material, but once it is acquired, it can be accessed quickly.

Third, over a small time interval, references are concentrated in a small working set, not distributed uniformly throughout the corpus. This comes from studies of computer memory use, and human window referencing. It is called “locality of reference” (Card, Mackinlay and Robertson 1991 p. 184).

Fourth, locality of reference moves between clusters of information, processing in one at a time. Some information may belong to more than one cluster. There is no gradual change of the working set, but an “abrupt transition” (Card, Mackinlay and Robertson 1991 p. 184).

Fifth, information systems tend to adjust themselves to try to get the most information processed at the least cost. But they say, “or sometimes minimise” and “relative to some processing cost constraint” (Card, Mackinlay and Robertson 1991 p. 184), so this may mean that if it is too expensive, it will not be extensively used. Examples are eyes processing curves, because they carry most information, and conversationalists anticipating each other.

Sixth, lower levels of the system “simplify and organise” (Card, Mackinlay and Robertson 1991 p. 184), so that higher levels see aggregated forms. At each successively higher level, there is less detail, more abstraction. In biology, this allows mixing of information obtained through different sensory modalities.

In discussing the desktop metaphor, in particular BigScreen, an experiment involving “another attempt at a large desktop” (Card, Mackinlay and Robertson 1991 p. 185),

Card, Mackinlay and Robertson note that "The problem … is that the cost of search for relevant parts of the workspace rapidly increases with the number of elements in the workspace (unless the space itself has meaning as in a city map or a grocery store)" (Card, Mackinlay and Robertson 1991 p. 185). Here are two of the models mentioned by the interviewees, and a precursor of Chen's semantic spaces.

The Information Visualizer "has three major components" (Card, Mackinlay and Robertson 1991 p. 185) – one to increase the immediately available storage space, so it is more effective, see observations 1 – 4. This is done by having different Rooms – the room on a desktop is limited, so the metaphor is changed to allow the user to move between the higher capacity rooms. This is effectively a multiple desktop system, which would be more naturally described nowadays as consisting of multiple windows, all of which may be present simultaneously on the screen, using the Overview facility, and which have the focus easily switched amongst them. The Rooms contain instances of the PARC team's visualisation tools, for example the Cone tree. The "buttons" in the original Rooms application, which triggered actions within rooms (such as sending a mail message, for example), have been replaced by these "autonomous interactive objects" (Card, Mackinlay and Robertson 1991 p. 186). The authors claim that these features make the immediate storage area "not only larger but denser" (Card, Mackinlay and Robertson 1991 p. 186). There are more displays available, and each is manipulable, and can be zoomed in on, for example. The different visualisation tools are appropriate for the display of different organisations of information, so the cone tree is suitable for hierarchically organised information, the perspective wall for linear organisation, the data sculpture for some scientific data, the spatial structure for geographical data. The so-called "Cognitive Co-Processor" is an "animation-oriented user interface architecture" (Card, Mackinlay and Robertson 1991 p. 185) which balances speed of animation of the autonomous objects against processor speeds and display quality in such a fashion that the user always gets the impression that something is happening in response to her actions.

Because of the third observation, locality of reference, a set of small workspaces, with quick switching amongst them, provides a good way to work. The contents of the workspaces may be "overlapping", in that the same data may be used in more than

one workspace. “These visualizations use interactive computer graphics to explore dynamically changing views of information structures … The visualizers attempt to present abstractions of large amount [sic] of data tuned to the pattern detection properties of the human perceptual system” (Card, Mackinlay and Robertson 1991 p. 188).

Card, Robertson and York’s Web Book and Web Forager (see fig. 5) explore the same principles, but in a more familiar-looking environment, consisting of web pages assembled into book-like structures. These can be interacted with in ways similar to interactions with a physical book. Their stated reason for using this model is not because of its familiarity, but because it maps on well to the material they want to display, “and the efficient display characterisation” (Card, Robertson and York 1996 p. 114). The authors claim that the familiarity of the book is a “bargain” (Card, Robertson and York 1996 p. 114), enabling them to provide tempting interaction possibilities (“irresistible affordances” (Card, Robertson and York 1996 p. 114) with a low training cost. The Web Book is composed of a set of web pages, possibly grouped by their inter-relationship on a web server (identified by the use of relative, rather than absolute, addressing in the URLs by which they link to each other). Other sources from which Web Books may be generated are: from web pages of links; from a user’s “hotlist” or favourite links list; from a set of search results, or from a physical book which has been encoded into HTML web pages. The pages can be turned in several ways, at different speeds, can be “riffled through” (Card, Robertson and York 1996 p. 113) , and can be “exploded” into a flat layout which can then be viewed with a Document Lens, the fisheye view tool developed by PARC for use with their earlier visualisation, the Perspective Wall. The Web Books also have sophisticated annotation and bookmark facilities.

The fact that these “virtual artefacts” can be generated automatically from such a diverse range of sources is of great interest when considered in the context of the current research. One of the features of an early version of the “library” world used in series B and C was that the books on the shelves could be manipulated so as to move them off the shelves, rotate them towards the user, and open them to reveal a title page which was a link to the resource they represented. However, the manipulations

necessary to achieve this were not easily mastered, and could hardly be described as "affordances" – the Web Books evidently had much more "natural" means of use.

Fig 5: Web Forager © Card, Robertson and York 1996 Used with permission

The Web Forager allows for the information workspace to be "tuned" (Card, Robertson and York 1996 p. 112) to optimise access times to relevant information. The "foraging" element comes from Information Foraging Theory (Pirolli and Card 1995), which views information acquisition as analogous to the foraging behaviours found in certain animals. The efficiency of foraging can be enhanced by encountering "enriched patches" of information sources, examples of which are search engines (e.g. Lycos), directory services (e.g. Yahoo), and web pages of relevant links. Whilst web users try to evolve their strategies in order to encounter these enriched patches, the creators of the patches try to evolve them to attract more users. The foraging analogy is an interesting perspective on the growth of the Web in historical terms, but is not strictly relevant to the problem dealt with here, which is closer to Card, Mackinlay and Robertson's concerns with information cost.

The Web Forager aggregates Web Books into a three-stage environment similar to the "ideal" office space described by Card, Mackinlay and Robertson and discussed above. It is at a higher level of aggregation than the Web Book, and thus meets Card, Mackinlay and Robertson's sixth criterion, above. The Focus Place shows a full-size book, open or closed. The Immediate Storage is a desktop and air around it permitting

documents to be placed at varying distances from the viewpoint (Z-distances), becoming smaller as they are placed "further away", so that, at greater distances, more documents can be accommodated. The desktop is special, because it and the objects on it move through the space with the user's viewpoint. Tertiary storage is a representation of a bookcase, from which books can be moved instantly to the focus area, or to which the viewpoint and desktop can be moved to permit inspection of all titles.

It is important to note that the rate of accessing web pages was more important to the researchers of 1996, because the bandwidths they were dealing with were considerably lower than commonly available today. Card refers to page access times of "often 15 ~ 30 sec[onds]" (Card, Robertson and York 1996 p. 116), whereas pages stored locally have access time of 1 ~ 0.1 seconds. This has considerable implications for the "cost" of the information – if it is downloaded and contained in a Web Book, it can be accessed much more quickly. The difference with today's bandwidth would still be significant, but much less striking.

Robertson's Data Mountain (Robertson et al. 1998) was an interface designed to allow users to place icons in any position on a representation of a 3D inclined plane, via a 2D interface (see fig. 6). Tests were carried out to establish whether users would exhibit the same abilities in terms of spatial memory as they do when working with a real 3D surface, and it was found that this was, in fact, the case. The users were tested with Internet Explorer 4 (IE4), and to different versions of the Data Mountain, the second having been modified in response to user feedback, although users were not involved in the original design.

Fig 6: Data Mountain © Robertson et al. 1998 Used with permission

In the tests, each group of users was made to arrange 100 icons representing web pages on the Data Mountain, or in the case of the IE4 group to organise links to the pages using the Favourites feature. When asked later to retrieve the pages, the Data Mountain groups performed better then the IE4 group, and the group using the second version of Data Mountain outperformed the group using the first. Robertson's review of earlier systems, including those discussed above, states that "The 3D interfaces make it possible to display more information without incurring additional cognitive load, because of pre-attentive processing of perspective views (i.e., smaller size indicates spatial relationships at a distance)." (Robertson et al. 1998 p. 154)

Data Mountain was further enhanced by the inclusion of textured landmarks on the inclined plane, to take advantage of the design features discovered by Darken and Sibert (1996) to be aids to performing navigational tasks in virtual environments. From Darken and Sibert's recommendations, Robertson also adopted "stationary or slowly moving cues", and mixed modalities – events in the Data Mountain were accompanied by sounds. The intention was to "leverage natural human capabilities,

particularly cognitive and perceptual skills" (Robertson et al. 1998 p. 155). Since we can use clues such as perspective, and we can infer relative position by noticing which items partially hide more distant ones, and since we do this without any extra conscious effort, more items can be placed on screen by allowing them to be arranged on the Z-axis (going "into" the computer screen) at different apparent distances.

These factors, and the fact that people can employ "spatial memory" in recalling where they have placed something, mean that much of the cognitive burden of the retrieval task is handled "for free". The second Data Mountain group performed better on reaction times, number of incorrect retrievals, and number of failed attempts than either the first group or the IE4 group. The second Version of Data Mountain had been enhanced with improved animations, the removal of occlusion (one page could not completely hide another) improving the page titling, and improving the quality of the audio feedback. These changes also led to a better response from the users who said they would prefer to use the second Data Mountain over IE4. Robertson concludes that his prototype was "an effective alternative for current Web favourites mechanisms" (Robertson et al. 1998 p.161) and that "the user study also suggests that spatial memory does in fact play a role in 3D virtual environments" (Robertson et al. 1998 p. 161).

Cockburn and McKenzie (2001) measure the performance of users on a system "heavily based on Robertson *et al's* Data Mountain" (Cockburn and McKenzie 2001 p.434), as against a 2D version. Although differences in user performance for storage and retrieval tasks were not reliably different, a significant number of users gave a higher rating to the effectiveness of the 3D interface. Also "[t]he effectiveness of spatial memory (one of the fundamental hypotheses motivating the original implementation of the Data Mountain) was strongly reinforced by the subjects' performance in retrieving pages and in their responses to Q4 'I remembered the location of the pages needed'" (Cockburn and McKenzie 2001 p. 439).

Modjeska and Waterworth conducted a series of user tests in three VR environments which differed in presentation but were isomorphic in spatiality and labelling. The worlds ranged from a "naturalistic" presentation called "Day World", based on Waterworth's previous work on Information Islands, and employing the spatial cues

recommended by Lynch, through a “Dusk World” which featured a twilight effect, but with brighter labelling, to a “Night World”, which dispensed with the VR objects, and relied solely on labelling. The objects and text in the worlds represented a subset of hierarchically organised data from a web index (Modjeska and Waterworth 2000). Dodge and Kitchin describe some of the applications mentioned above in their book ‘Mapping cyberspace’ as well as considering both works of fiction discussed here, and other “imaginative mappings” (Dodge and Kitchin 2001 p. 181).

3.3 Contextualisation with current developments

For the same reasons as it is informative to set the work of this study in the context of earlier literature, as has been done in the previous section, it is also informative to set it in the context of more contemporary developments in both literature and systems. These fall into two main groups; first, the work in information visualisation systems typified by the PARC group and by Chamoei Chen, and secondly, the 3D communities which have proven to be popular beyond even the developers’ expectations. Although there appear to be no instances of single-user worlds of the type examined in this study, it can be shown that the current study provides a rationale underpinning this popularity.

3.3.1 PARC

The PARC technologies have since been “spun out” to Inxight.com, as StarTree (hierarchical), TimeWall (linear, temporal) and TableLens (a record-oriented, spreadsheet-like tool with filtering and focusing capabilities). Interestingly, several of the potential uses for the technology are in the field of counter-terrorism – this is by no means an outdated group of applications, and its name has now changed to VizServer.

3.3.2 Chen

Chen has co-edited a monograph (Geroimenko and Chen 2003) on information visualisation techniques applied to the relatively new idea of the “semantic web” – a “new generation” of the Web, in which computers will be able to derive meaningful relationships between entities, independently of human input. Despite the increased richness and complexity of the underlying data, it would still seem that the problem

from the designer's viewpoint still lies in how to make this increased potential usable by the end-users, and it is felt that the results of the current study can make some contribution towards this.

Chen (2006) has also moved on to examine the development of disciplines, and is concerned with the visual representation of the semantic space of scientific discourse. Although this area might seem to be at a considerable remove from the concerns of the present study, in fact it uses 3D models to envision, and provide access to, a particular type of information. Interestingly, the graphical representations of some of Chen's work, depicting webs of co-citation, could be said to resemble the complex river system model of interviewee 29.

3.3.3 Other visualisations

In-Spire "uses statistical word patters to characterise documents based on their text content". It comprises two visualisations, Galaxy, which represents documents as dots, clustered according to document characterisation (the term "meaning" would be incorrect here, as only keyword occurrences are considered), and ThemeView, which builds on the Galaxy visualisation a "landscape" the contours of which reflect the frequency of term occurrence, or "density of text content" (Hetzler and Turner 2004 p. 22).

ThemeRiver represents occurrences of themes over time in a collection of documents, as coloured currents in a "river" drawn along an X-Y time axis. The wider the current, the more frequent are the occurrences of the themes. This tool is intended for purposes such as understanding cause and effect, or identifying trends.
The Pacific Northwest National Laboratory is responsible for the development of these and many related tools in the field of Information Visualisation, on behalf of the US Department of Energy.

Grokker (see fig. 7) is claimed to be "a web-based enterprise search management platform that leverages the power of federated content access and visualization to maximize the value of information assets for enterprises, content publishers, libraries and other research-intensive organizations."

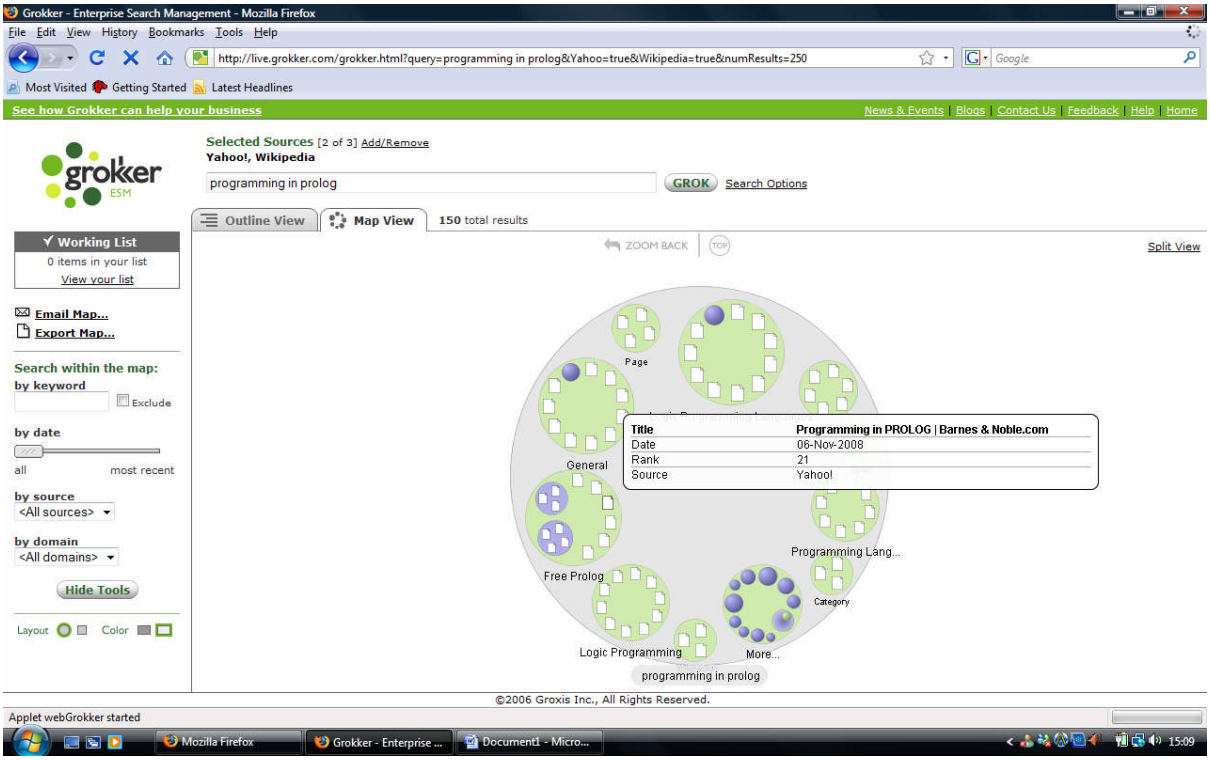

Fig 7: Grokker © Groxis, Inc 2008 Used with permission

One of the Technology and Strategy Advisory Board listed on the Groxis, Inc. website is Ben Shneiderman, co-author with Card and Mackinlay of 'Information Visualization : using vision to think' (Card, Mackinlay and Shneiderman 1999). Grokker uses a 2D map to display search results harvested from Yahoo, Wikipedia, and Amazon Books. The display resembles a map view of Gopher VR, discussed in section 4.8.2.1, below, with search results grouped by topic. Groupings of documents are represented as circles, which can be zoomed in on, until individual documents are identified for examination. The search depicted in fig. 7 was for 'Programming in Prolog', and it can be seen that, in addition to a link from Yahoo to site referencing the specific document (the Association for Computing Machinery's Portal web site) there are also links to information about logic programming, artificial intelligence, and other applications of the Prolog programming language.

Tianamo (see fig. 8) is the beta version of an application which displays search results from the World Wide Web as an information landscape (Tianamo.com 2008). It bears some resemblance to ThemeView, mountains in the 3D landscape in this case representing major subtopics of the search results. The map is interactive – it can be rotated and zoomed in on, and the display of search results changes to focus on

documents corresponding to the positioning of the cursor on the map. Other than the application itself, the only information provided by Tianamo appears to be a video on YouTube (Tianamo.com 2008b).

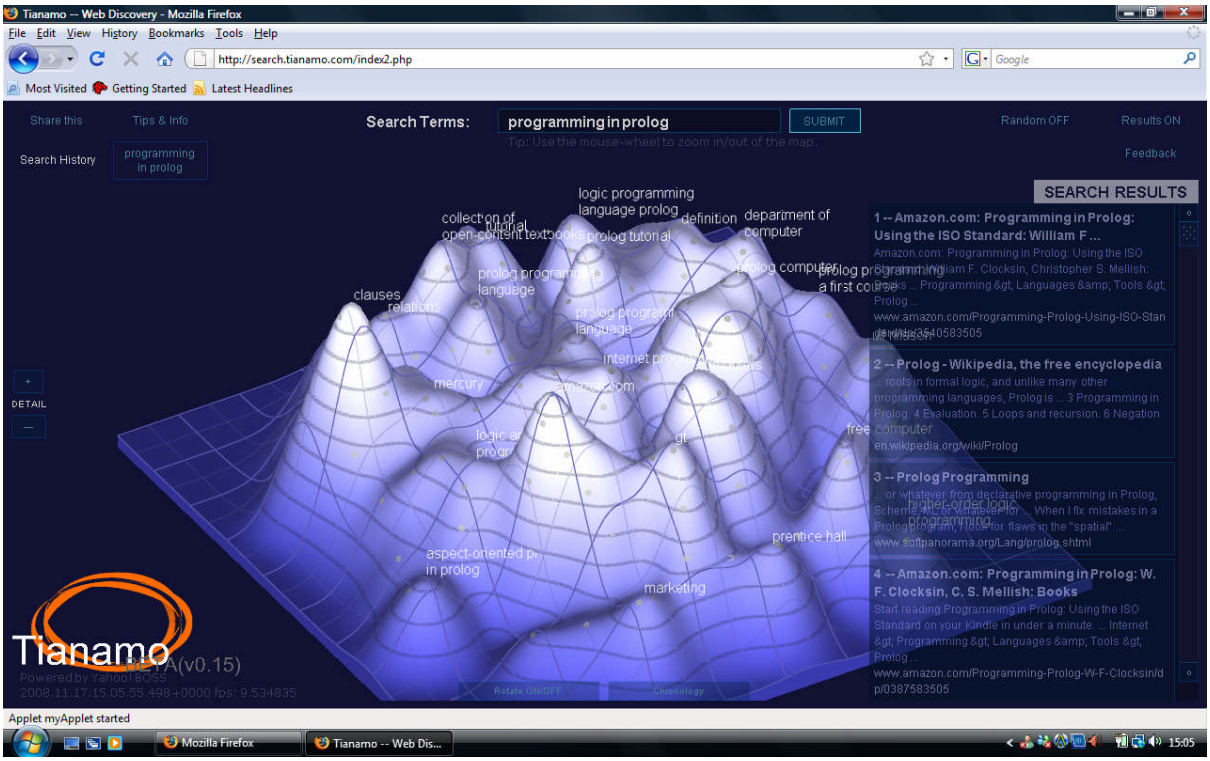

Fig 8: Tianamo © Tianamo.com 2008 Used with permission

3.3.4 3D communities

The current study has concentrated on single-user worlds, “occupied” by one user at a time, and lacking any interaction between users. The rationale for this was that
Of the six 3D platforms listed by Gu and Maher (2001), only two, Blaxxun and ActiveWorlds, are accessible at the time of writing. Blaxxun is used in Cybertown, which appears to be one of the most successful communities of its type. It is noteworthy that worlds in both platforms tend towards the architectural. Gu and Maher write: “Designing the World Wide Web using the metaphor of architecture provides a consistent context for people to explore digital information, interact with the virtual environment and communicate with each other” (Gu and Maher 2001). Cybertown and its predecessors were deliberately constructed as social spaces, as may indeed be inferred from the “town” element of the name. ActiveWorlds tend towards a greater variety of format, but are still social – they are spaces which people “visit”,

and in which they can communicate, engage in trade, and so on. Gu and Maher argue against “place-centric” virtual cities, in which “the resultant virtual architecture is structured as static solidity in the virtual domain. Similar to physical architecture, this type of virtual architecture exists no matter whether people use it or not. The design and existence of place-centric virtual architecture is separated from users.” (Gu and Maher 2001) “Some virtual environments, such as eRoom (http://www.eroom.com), use the metaphor of rooms but do not make reference to the room as a place. Other virtual environments, such as The Palace (http://www.thepalace.com), make a visual reference to place but do not include any of the functional uses of a place” (Gu and Maher 2001) This is a succinct summary of both sites, as eRoom is essentially a groupware product – a “Web-based collaborative workspace that enables distributed teams to work together” (Gu and Maher 2001), and the Palace is a collection of chatrooms, where avatars appear as icons superimposed on still images of rooms.

The Palace can be dismissed as an enhanced chat-room, because it is not really a 3D environment, or, rather, it is simulating a 3D environment in a way different to the technique under discussion here. Blaxxun and Cybertown are important, as probably the first widely popular developments, but are really very conventional.

There is also a set of applications called Rooms3D (not to be confused with the PARC 3D/Rooms environment discussed in Chapter 3) which essentially give a user the capability to redesign their Windows desktop to have a 3D appearance, building worlds, with 3D icons to access files and run applications, all without programming. The website has little information about the origins of the software, and there appear to be few recent contributions to the users’ forum. There are 26 contributed worlds (as of 21/03/06) but the most recent are dated 2003.

Win3D is a more cartoon-like, less customisable interface, which has the advantages of very slick graphics and a short learning time. It is produced by an Israeli company, Clockwise Technologies Ltd, the most recent press release on the site dates from 2001, and the copyright statement is “Copyright 1999 – 2003”, so it may be that this site is more stagnant than Rooms3D.

3.3.4.1 Cybertown

Cybertown has “set-piece” locations, such as The Plaza, where avatars can meet and interact, but the design possibilities are limited to acquiring a home, selected from a limited range of models, and furnishing it from a limited range of furniture. Other avatars can be invited into one’s home, and interactions can take place there. There is a limited map facility, which allows homes to be placed in one of the “zones” of Cybertown, but travel outside the set-pieces and homes is only by teleporting. In other words, there is a map, but no territory.

Gu and Maher (2001) go on to propose “user-centric” worlds in which the users are agent processes – “reflexive”, “reactive” and “reflective” – which are themselves capable of creating and modifying their environment. Maher and Gero (2002) give as an example “wall agents”, which can determine when a virtual meeting room has reached capacity, and can respond by moving the walls to suit. Gu and Maher develop the idea using the example of a user-centric virtual museum, in which the user agents interact with the museum’s own agents to produce an environment particular to the group of users present at a given time.

This approach certainly has elements of user design, but the actual details of the agents’ interactions are not fully explained, and there does not appear to be evidence of the system having been fully implemented, although an example of a “virtual museum” can be downloaded. In this environment, the exhibits respond to actions of the user either clicking on them or moving the avatar to within a certain distance of them. In one of the exhibits, walls appear in response to the avatar’s proximity, and the avatar is taken on a short “ride” into what is apparently a vertically-oriented tunnel, as if being sucked up by a tornado.

ActiveWorlds is rejected as a “world server” on the grounds of its being overly “place-centric”, and the effort involved in the development of an alternative is acknowledged : “However, the development of the virtual world server will require extra time and effort to develop or adapt the 3D real time rendering and modelling capabilities within a multiuser networked environment”(Gu and Maher 2001). Gu and Maher’s point here is that the architectural elements in Active Worlds are static,

stored on servers, and do not interact with the users. Whilst this criticism may be important in the field of virtual architecture, it is of less relevance here, where the emphasis is on finding out what users want. There were certainly some worlds in which the architecture reacted to the user – the mansion with classified rooms seems particularly relevant here, and the rides in the fairground might also fit the description, as would the library which oriented itself so as to present the user with the desired item – but overall, the challenges in interacting with static, "place-centric", architecture appeared to be quite sufficient for most interviewees.

3.3.4.2 Active Worlds

It is now appropriate to look at Active Worlds, Second Life, etc, because it is informative to compare what the interviewees said with what people actually do, when they have the opportunity and the ability to create their own virtual environments. The Active Worlds interface is also used by Metaverse and Dotsoul, which offer sets of worlds in which content creation is freely available to all. Both have very elaborately developed worlds, some based quite closely on Stephenson's model, of which Active Worlds was intended to be an implementation. Active Worlds buildings look very modern, while Cybertown appears deliberately futuristic, and has its own Black Sun club.

In Active Worlds, there is a bibliographic instruction world related to Eastern University (Harwick 2006).

With Second Life the idea is very well developed, as explained by Levine, in the Shifted Librarian blog (Levine 2006). While Second Life and Active Worlds share some features of another extremely popular phenomenon, the Massively Multiplayer Online Role-Playing Game (MMORPG), and while role-playing, in the sense of adopting an identity other than one's own, is certainly a feature of both, they differ from MMORPGs by the fact that they are not set in the context of a game. MMORPGs typically feature a quest or conquest or magical theme, players acquire treasure and/or experience to develop their characters, and usually have some sort of aim to achieve or quest to accomplish.

The online worlds have no such plot, and are primarily social spaces. It is possible to buy land, build virtual property, and even have jobs to earn the currency used in the world. Second Life has a thriving economy, and individuals who are skilled in writing code to produce the virtual artefacts used in the world can sell them to other "residents" for Linden dollars. Chia from 'Idoru' (Gibson 1996) would be able to buy designer clothing for her avatar here, in one of the many shopping malls, and would also be able to keep, and perhaps edit, it. There can be no doubt that the Second Life environment is made much richer by the fact that virtual goods, including skin and hair for avatars, as well as clothing, transportation and furniture, can be created by those with the necessary skills and time, and purchased by those who do not necessarily have either. This economic possibility occurs in neither 'Snow crash' nor the later Gibson novels, and only appears to have become fully developed in Second Life itself – Active Worlds allowed the transactions to take place, World of Warcraft artefacts and currency can be bought on eBay, but these are closed economies, whereas the "Linden dollars" of the Second Life economy are exchangeable for real world US dollars.

3.3.4.3 Navigation

Navigationally, Active Worlds is not much more advanced than Cybertown. As discussed above in section 8.2.4.1, above, Cybertown has the possibility of only quite basic navigation , and is dependent on the teleport metaphor. Active Worlds relies on teleporting between worlds, and permits it within worlds, but there is also the option of walking, running, swimming or flying. Although the co-ordinates of an avatar in the world are displayed, no maps are available. There are pictures on the Active Worlds server of a mapping exercise of Alpha World which was carried out in 1996, 1998, 1999 and 2001, showing the pattern of building. "You can see the "starfish" shape of building as people crowd their buildings along the North-South axis and the "equator" of AlphaWorld, and as they build along the coordinates with matching numbers. (i.e. 200n 200w, 450s 450e, etc) Some do this so that their coordinates are easy to remember, and others are simply building onto what others have already built."(Activeworlds 2008) Bodum notes that "Considering that one has to navigate through an area of more than 400 000 km^2 on a small screen does not really make sense. Teleporting is the only way to solve the travelling matter in that case … When

smaller areas are used other virtual aspects of way finding are of interest."(Bodum and Kjems 2002 p. 91)

Although it must be acknowledged that the potential for customisation of the environment in Active Worlds allows these to be far more sophisticated than the test worlds used in this study, there is a growing sense of familiarity when using the Active Worlds browser. The worlds are very differently themed, ranging from the spiritual to those based on the Gor novels of John Norman, but there is a tendency for similar structures to appear over and over again, as one teleports from world to world. This is probably attributable in part to the technique for building items, which involves copying a pre-existing item, then modifying its orientation and appearance. Since the first "seed" item in an empty world is a section of street, this will probably influence a lot of the world-builders to base their world around a street layout. It is also appropriate for the Metaverse-influenced Active Worlds that a street should feature heavily in the design.

3.3.4.4 Performance

Active Worlds hosts worlds on its own servers, but also makes the server software available (for a fee) so that users can host their own worlds, or even a galaxy or a universe (containing multiple worlds). Since access to these worlds is through the Active Worlds universe, and since some world hosts will not be using high-bandwidth internet connections, performance at busy periods is very variable.

3.3.4.5 Second Life

There is now a feeling in the VRML authoring community, as evidenced by Miriam English, a developer, that VRML is too cumbersome a development tool, compared to Second Life and its like, and that they are therefore the way forward (English, 2006). What people want, she says, is networking, shared worlds, and easy ways of assigning behaviours to objects, i.e. animating them. VRML is capable of providing these features, but not easily, whereas in Active Worlds and Second Life, they are easily achieved even by non-programmers. The www-vrml and (later) x3D mailing lists have always been the domain of programmers, rather than designers – their focus is almost exclusively technical, and concerned with how to do things, rather than why. Their usability concerns appear to be with the usability of programming languages

and the interoperability of systems and standards. Although this is a fascinating resource for the developer, end-user issues are rarely acknowledged, and it is mentioned here primarily to note the growing disenchantment of a previously loyal developer community, in the face of “slicker” solutions. The Second Life programming language was treated with some disdain in this forum, being a proprietary language of Linden Labs, the owners of Second Life. However, when the Second Life code was released as open source in January 2007, there was some shift in this position, and there appears to be a grudging acknowledgement developing that working with Second Life code as a basis might provide a useful collaborative editing environment.

The specific language used for implementation is not a major issue, here – VRML was used because it was free, it was a reasonably simple language in which to implement reasonably simple worlds, and because it has the capacity to include “anchors” in scenes which link elements in those scenes to external resources. At the time the research was started, VRML was the only candidate that did not involve financial expenditure, and was not a proprietary format.

There is a Google newsgroup, alliancesecondlife, sponsored by Alliance Library System, which also helps to fund the development of library services in Second Life (SL). This group has seen some discussion of the issues related to reproducing the appearance of Real Life (RL) libraries, and several points are raised which are relevant to the current discussion. Names in quotation marks are SL identities.

> “Art Fossett” asks:
> why do we need tables when objects can just float?
> why do we need a roof when it never rains?
> why do we need doors and glass windows when there's no one to keep out?
> why do we need stairs when we can teleport everywhere?
> why do we need an inworld web browser that looks like a RL computer!?
>
> “Fleet Goldenberg” answers:

why do we need tables when objects can just float?
Human eyes are used to objects not defying gravity. When they do it can look odd.

why do we need a roof when it never rains?
Many people fly, and looking down on open offices would look unattractive.

why do we need doors and glass windows when there's no one to keep out?
Humans think that if these elements are not present then there's something broken or incomplete about a building.

why do we need stairs when we can teleport everywhere?
Teleports break down very often in Second Life.

why do we need an inworld web browser that looks like a RL computer!?
Because again, it's what humans associate with opening a web browser.

So as you said, humans feel comfortable in environments that mirror what they are familiar with in their real lives. :)
Fleet

And Camilla Herod:
I too am glad to see this line of discourse. It is too easy to get caught up in building virtual models of our bricks and mortar libraries. We are so fascinated by the technology and what we can build, but we have not yet made the intellectual jump that will allow us to apply it in totally new ways. We are limited by our RL experiences. We don't need the same kind of structures that we have in RL. We need to be open to how users are experiencing SL, and remember that those

> experiences are constantly changing and evolving right before our eyes. Simply putting library buildings in place, and expecting people to find them and use them, is not the best use of our skills. Think instead about the kind of experiences we can create for people. Reference work is not the best use of our efforts; Google and Wikipedia meet those needs for most people. But we can create 3D experiences for people that also serve to educate them. Books can literally come alive for people in this environment! Let's think outside the box, and see what we can come up with in terms of interactive experiences. It's an exciting thing to contemplate - there are no limits to what we can do!
>
> Princess Ivory (Camilla)

(Cybrary observations 2007)

This discourse provides a good summary of the expectations, assumptions, and conclusions adopted or reached during the course of the current research. There was an initial expectation that there would be some wholly unorthodox models, as turned out to be the case, but it was somewhat unexpected that they would reduce to just a few basic models, and that the library would be so predominant. However, closer inspection of the transcripts appeared to reveal the need, or desire, for familiarity to which “Fleet” refers, above. Some users are attracted to the “Princess Ivory” approach, but it appears that even a relatively mildly “unusual” world is difficult for the majority to come to terms with. This does not mean that the more idiosyncratic choices are in any way inferior, but whereas a small number of “generic” worlds appear to meet the design preferences of most users, some will always be happier with an individualised solution. Partly because the less structured models would have been more difficult to program, there was no opportunity to let the people who had the ideas try them out in practice, and this is to be regretted. However, in the space of a single academic year, it is unlikely that a large enough number of functional models of these less common worlds could have been built, and their unusual natures meant that developing unusual models “on spec” would probably not have been successful

either. The problem with the attitude suggested above by “Princess Ivory” – “Let's think outside the box, and see what we can come up with in terms of interactive experiences”, is that “thinking outside the box” may result in spending a lot of time in developing something which does not reward the investment, whereas the tried and tested models have the virtue of being known to work. At least, this research has shown that approaching users in the first instance can be a source of rich and stimulating input to the design process.

3.4 User studies

The PARC authors conclude that their techniques (structure of information, 3D and animation technologies and the human perceptual system) “can be effectively exploited to improve management of and access to large information spaces” but state that “formal user studies are needed to verify and expand on these conclusions” (Robertson, Card and Mackinlay 1993 p. 8).

Card, Mackinlay and Robertson explain the apparent absence of user studies by describing a “systems research paradigm” which “reverses the more familiar natural science course of theory to application” (Card, Mackinlay and Robertson 1991 p. 8). They describe this systems research paradigm as being an “exploratory” process, in which interesting ideas for well-performing designs can be described in an abstract “design space”, sub-regions of which may be tested empirically for performance, and the knowledge gained thereby “codified” for the benefit of designers of actual systems. “Regardless of the order, the general need is for new user interface paradigms that utilize emerging technological possibilities and the analytical and empirical foundations that help us to understand the merits of these designs and the possibilities for new ones” (Card, Mackinlay and Robertson 1991 p. 9).

A 1995 publication by Moll-Carillo et al. describes a study in which there is user input to the design process, but there are indications that this input was somewhat constrained by pre-existing parameters. The design consultancy involved were approached by a division of Xerox Corporation to "assist in development of PC

Catalog, a Windows application based on a book metaphor" which had constraints as to window size and number of colours used. "Our task" they write, "was to create a design that implemented this metaphor in an elegant, usable and economical way within the constraints of the delivery platform." (Moll-Carrillo et al. 1995 p. 556)

It is claimed that they used "a user-centered, iterative method", consisting of three phases, Observation/Visualisation, Product definition, and User Test, each of which could be iterated, and the whole process iterated also. The observation phase was based around user practices in existing work conditions, in both physical and computing environments. It appears, however, that user input here was limited to helping in the development of a pre-determined design, so whilst it may be both user-centred and iterative, it is not based originally on user preferences.

Chen, Czerwinski and Macredie (2000) examine “identifying and accommodating user differences”. This paper, an introduction to a special issue of JASIS, discusses “a generic framework for accommodating individual differences through design and training”. The strategies identified are, “challenging” – forcing the user to become more flexible, given that they have sufficient cognitive abilities; “capitalization” – making the most of the user’s capabilities by tailoring the task to suit them; and “compensatory” – making up for the user’s deficiencies through help or training (Chen, Czerwinski and Macredie 2000). This approach seems to be a clear indication of a design agenda centred on the system, rather than on the user. It may be the case that the systems to which Chen, Czerwinski and Macredie refer are relatively complex, and that there are considerable difficulties inherent in their use by users of less than optimal cognitive and spatial abilities. However, the corollary of this is that if the users cannot operate the interfaces, it may be a shortcoming in the design of the interfaces.

Borgman, writing about ‘Designing digital libraries for usability’ makes some relevant points about the usability of software in general.: “[w]hile the value of making systems easier to use may be self-evident to users, it is not always self-evident to software vendors, programmers, or even the managers who acquire software on behalf of end users. The literature on human-computer interaction abounds with

studies indicating that companies release software without basic human factors testing … usability testing is often seen as too expensive or as ineffective" (Borgman 2003 p. 91)

This gets closer to describing the gap in the literature. Borgman refers to testing existing systems for usability, and it appears that there is little evidence of this in the sphere of 3D systems for information access. However, grounded theory can provide input into HCI research into the construction of optimally-usable systems. Its contribution can be both complementary to, and the basis for, empirical and quantitative research, because it can give a characteristically "human", affective, perspective on what might otherwise be "impersonal" design decisions. It is in this fashion that it is felt that the current study can contribute to the field of HCI.

Sutcliffe (2003) has many useful guidelines as to design principles, and provides an Appendix of Generalized Design Properties (Sutcliffe 2003 pp. 275 – 294), which would be invaluable in creation of a working application.

Goguen and Harrell (2003) write of the "two advantages that information visualizations have over arbitrary design problems. These are that the source space is concrete and given in advance, and that the target space consists of visual signs. The designer must be sensitive to features of the data to create a useful visualization, but certain structural features may not be obvious, and it may be even less obvious which of them are the most important. The process of considering a visualization as a semiotic morphism can focus the designer on such basic structural issues, and thus help in creating a good graphical representation." These structural features have emerged from the interviews, and have been considered in isolation, as colour, sound, movement, etc. Making the most of this semiological approach for a given model would involve further consultation with the user or users involved, and Goguen and Harrell note that, "In general there are many different semiotic morphisms between two given semiotic spaces." Goguen and Harrell cite two different designs for a film finder interface, where he writes, "We can also infer what the designer of this version thought would be most important, by examining the controls on the right of the display" and contrasts these features with the requirements which a typical user might have. For example, the typical user, Goguen and Harrell say, would presumably be

more interested in “looking for a good video to rent, than they are to be analyzing trends in the movie industry” (Goguen and Harrell 2003).

Goguen and Harrell also have a principle that, if it is not possible, for reasons of space, to preserve both structure and content, it is more important to preserve structure. This would appear to fit well with the conclusion that one of the good things about the 3D interface is that it gives the facility of having an overview of the information, a way of setting particular topics in context. It might be that this has to be achieved through the use of an additional display option, such as the map which some interviewees mentioned as desirable. Darken and Sibert (1996) discuss an experiment in which users were asked to perform navigational tasks in virtual worlds, and concluded that these were performed better when aided by a grid or a map, and by such features as landmarks, edges, and districts, the features identified by Lynch (1960). Interestingly, two of the ten test subjects suffered from motion sickness during the tests, which used an immersive type of display (a high-resolution screen held to the head). The subjects were able to simulate “flying” over the model at a simulated height of up to 400m, and at simulated speeds of up to Mach 3. These factors may make the motion sickness less surprising. However, it might be that users’ avatars would have to adopt a different mode of movement, such as overflying a model, with consequent loss of granularity, until an appropriate area was identified. One advantage of the library is that, for a given classification scheme, its structure is to some extent constrained by the order of the scheme.

These navigational considerations would principally be of value in larger scale worlds, but the interview responses seemed to indicate that some interviewees were already reaching the limits of their ability to orientate themselves even in the small scale models used.

Chen, Czerwinski and Macredie (2000) deal with adapting interfaces to cope better with individuals’ cognitive abilities and cognitive styles, and there is an obvious opportunity to look at the findings of the current research as related to these factors.

It would need some kind of automatic classification, but a tool could be envisaged which does not search, but takes search terms, decides which “neighbourhood(s)” the

user ought to be looking in, and moves the user's avatar there to browse around. If the user prefers a town, that is possible; if she prefers a tank of tropical fish, or a planetarium, that is possible, too.

It would be just as interesting, though more difficult to program, to have the following of links in the pop-up windows have the effect of moving the avatar in the 3D world.

The Open Source Metaverse Project (OSMP) at http://metaverse.sourceforge.net/index.html seems worth investigating, as does Interreality and the Virtual Object System. These projects appear to be active, but quite slow in developing, due perhaps to the fact that they are the work of volunteers. It is, however, possible that these, or similar projects, might provide testbeds for further experimentation.

During the design of the GopherVR system (McCahill and Erickson 1995) which will be considered in section 4.8.2.1, below, the authors decided that from the "problems and prospects" they identified in the menu-based Gopher and a 3D version, respectively, "mapped into" four design criteria. Two of these, "metainformation" about Gopher servers and documents, and "backwards compatibility" with the existing Gopher infrastructure, are not particularly relevant here, just because they are predicated on a structure which no longer exists. The other two, however, bear further examination.

They write that there "is a need for richer representations for servers, directories, and documents." The World Wide Web paradigm has replaced Gopher so completely that servers and directories are now of concern to users primarily because of their appearance in URLs, but the authors go on to write: "The lost-in-space problem suggests the need for a high level overview of gopherspace. The grouping problem indicates the need for a representation of collections of documents that can reflect their similarities and differences along a variety of dimensions. Similarly, richer representations for individual documents would alleviate the browsing problem." If "gopherspace" is replaced by "information space" or "document space", or some such expression, the design criterion appears well founded.

The other criterion which can be useful here is “dynamic representations”. This refers to ideas such as the representations reflecting usage: “Representations need to be able to change over time. Sense of place requires representations that can be customized by administrators and end users, and interaction traces require representations able to reflect the interaction history of individual documents and collections of documents.”

3.5 Summary

This chapter has discussed the literature dealing with the major pre-existing 3D models for accessing information, these coming from an information visualisation background, a document representation background, and as a means of returning results from a search tool (Gopher). In addition to the literary “antecedents” of the virtual worlds, both spatial and semantic models have been discussed, and an examination of the literature shows no evidence of these designs being influenced at the early stages by studies of user preferences. This gap in the knowledge is what the current study was designed to fill.

Chapter 4 Series A interviews

The first series of interviews was undertaken with a group of postgraduate students at Robert Gordon University, Aberdeen. The students were enrolled on MSc courses in the subject area of Information Management, comprising Electronic Information Management, Information Analysis, Information and Library Studies, and Knowledge Management.

4.1 Interview conditions

Before being asked to volunteer, the students were given a short presentation describing the area of research, illustrated with screenshots taken from information visualisation texts (the PARC wall, the Cone Tree, and Information Landscape). It was emphasised that these were in no way prescriptive, but were intended to give a feel for the sheer variety of representations possible. It was also emphasised that what was wanted from an interviewee was a personal description of what their own "world for accessing information" would look like. The world could be "anything you like" – issues of practicality, which would obviously be of concern for implementation, were not raised here, and even ideas which it seemed would have caused quite evident problems in implementation were not challenged. The focus was very much intended to be on what people want, not on how to deliver it, which was regarded as being a separate issue.

The interviews were relatively unstructured, consisting of a reiteration of the aims of the interview, and then a discussion of the "world", or in some cases, "worlds", imagined by the interviewee. It was occasionally necessary to explore further such questions as organisation of information in a world, or to seek clarification of points which seemed unclear, and there were also occasions where prompting on such a point led to development of that, or another, idea. Schedules of the interviews at each stage can be found in Appendix A.

The first round comprised 53 interviewees, who were interviewed over a three-week period. Interviews were conducted in social spaces around the university, chosen to be convenient to the interviewees, whilst being as quiet as possible, to optimise clarity of the tape recordings which were made.

4.2 Conventions of style

Interviewees will be referred to by number (e.g. “25”, or “Interviewee 25”). To avoid the stylistic awkwardness of switching between this and the spelled-out form (“twenty-five”) and excessive use of the term “interviewee”, some sentences will begin with the ordinal number (e.g. “25 observed that …“). The personal pronoun “she” will be used generically throughout, but should be understood to mean “she or he”, or “he or she”. No gender bias is implied.

4.3 Findings

The transcripts of the interviews were first assigned a label relating to the type of “world” which was described. This resulted in the following table (Table 1), in which interviews presenting more than one image are indicated by the presence of a slash (/) between image labels. One interview was carried out with two interviewees (numbers 2 and 3), a practice which was not repeated, as it was felt that they influenced each other too much, and arrived at a consensus, rather than expressing fully their individual thoughts.

Table 1 : Series A interviewees and concepts

1	Brain	28	Town
2&3	Connected blocks	29	Rivers/map/lotus
4	Desktops	30	Space/underwater/tree
5	Molecules, mental maps	31	Card catalogue
6	Library	32	Multi-dimensional wheel
7	Floating documents	33	Car park
8	Shops	34	Library
9	My house/office	35	Lollipops
10	Car park/forest	36	Touch screen/Google/OPAC
11	library	37	Nothing
12	Blocks of text/city of words	38	Nothing
13	Timeline	39	PARC wall
14	Like the office	40	Car/road/Monopoly
15	Office/building	41	Brain
16	Forest	42	Trees
17	Coloured transparencies	43	Jungle/deep sea
18	Clouds	44	Zoo/safari park
19	Aquarium/music	45	Universe/library
20	Library	46	Theme park/fairground
21	Hierarchy/tree	47	Game
22	Solar system/wormholes	48	House/garden
23	Hierarchical mansion	49	Buiding
24	Library	50	Town
25	Card catalogue	51	Street market
26	Town	52	Memory palace
27	bubbles	53	planets

There is evident repetition in the labels assigned, as will be discussed shortly, but a first grouping of the labels produced the following table (Table 2).

Table 2: Frequency of concepts			
Concept	No.	Concept	No.
Library/catalogue	7	Lotus	1
Forest/tree	5	Map	1
Town (inc, street market)	4	Memory palace	1
Planets/space	3	Molecules	1
House/mansion	3	Music	1
Office	3	OPAC	1
Brain	2	Packets	1
Building	1	PARC wall	1
Car park	1	Room	1
Aquarium	1	Rivers	1
Bubbles	1	Safari park	1
Clouds	1	Theme park	1
Deep sea	1	Timeline	1
Desktops	1	Touch screen	1
Game	1	transparencies	1
garden	1	Wheel	1
Lollipops	1	zoo	1

Two interviewees had no ideas for a world. Interviewee 37 said: “I really don’t see it” The idea was introduced again, but this time 37 said, “Actually, I’m not used to this, maybe I will need to use it a lot, so far, but I think I will need to do this, to use it.” What the interviewee seemed to mean was that he did not have an image, and, though he might be able to use such an interface, would need to experience it first. 38 drew a comparison between the idea and the three-dimensional models used by architects, and another with driving simulators. Whilst he said that “I can see it’s a real practical probability, yes, there’s absolutely no question about that.”, he also stated, “Not my particular thing, no, but I can see that it would be incredibly useful.”

4.3.1 Coding

The first stage in coding was to attempt to assign codes to all concepts in the interviews, without being influenced by preconceptions as to what would be interesting or important in the transcripts. Glaser is particularly insistent that everything in research using grounded theory, even the research question, should emerge from the data. The use of Nvivo software greatly facilitated the coding process, because it was easy to define and apply *in vivo* codes, from which the software takes its name. In vivo coding means that the text becomes its own label, and

in this study single-word or short phrase labels were used. This method has advantages of speed and ease of understanding over more formally organised codes, but requires some detachment in the coder, in order to recognise the same concepts appearing under different labels. The codes thus produced are called “free nodes” in Nvivo, and the next step in the process is to group these free nodes into categories. This process is akin to the construction of a faceted classification, where the pool of terms taken from the literature is divided into facets, and each term is a candidate to be a focus in a particular facet.

Concept categories identified at this stage were mainly descriptive of the worlds themselves – their structural features - and their more obvious characteristics, such as colour, size, sound and motion, which will be discussed in sections 4.4 and 4.5 below. A first attempt at grouping, discussed in 4.6.1, below, also led to interviews being coded for organisation. Many other categories emerged also, but were not considered to be the most important to investigate at this stage in the development of theory, where the principal interest was in establishing the range and variety of world designs. For example, top-level categories included Places, Objects and Topologies, but also Authors and Motion, the significance of which were not explored further at this stage.

4.4 Common features - structural

There was a great variety of ideas forthcoming, several interviewees mentioning two, and one interviewee three, distinct ideas. The level of detail into which the descriptions went varied considerably, and it was apparent during the interviews that some people were more comfortable with the general concept than others, finding it easier to come up with alternative worlds, or to expand the metaphor expressed in their world in greater detail. Since interviewees were being asked at this stage for initial ideas about worlds, rather than giving reactions to using them, it seemed appropriate first to group the worlds according to structure, and then to examine them according to other similarities or differences.

4.4.1 "Brain"

The first interviewee made an immediate association of the 3D concept with the "Sprawl" novels of William Gibson, some of which he had read (Gibson 1984, 1986, 1988). However, whilst remembering the novels as portraying a place "sort of like an ordinary landscape with buildings of a certain size and colour", the image which eventually emerged was more complex : "synapses in the brain . . . almost like a 3D universe, galaxies clustered together being here, in the same way they got document clustering, …keyword jump to a representation of a cluster . . . from this location you can see, perhaps not in 3 dimensions, similar clusters, denoted by size or colour, or brilliance for their relevance". These clusters were to be connected by "strands … like nerve endings … the thickness of the strand indicating increased relevance". This is an elaborate and well-developed image, although quite dissimilar to the "cyberspace" depicted by Gibson. It is, however, difficult to understand how "relevance" might be calculated for the purposes of designing such a world.

In contrast, the other person who chose a brain image, interviewee 41, had a less developed image: "a 3D picture of the brain? You know, just like the different neurons, kind of how they spread out and touch each other, and that kind of seemed to me like an analogy for a … say like web sites, each site with the different cells. Like

different branches leading to different parts of the site, as well as links to other sites, as well". This might be interpreted as a site map representation, and does not appear to offer a practicable model, as the semantic linkage inside and between websites is uncontrolled. However, this interviewee also presented a richer image, which has been categorised as a library, and will be dealt with in that section.

4.4.2 Urban

The next group of worlds are, to varying extents, realistic models based on towns, buildings or other urban imagery.

4.4.2.1 "Office"

Three interviewees chose an office model, but interpreted it in slightly different ways.

Interviewee 9 wanted "a replica of my office, where I do have my files in a certain order, I would have my virtual world in the same order as that. I wouldn't have two or three systems, I would just have the same system for both worlds." This interviewee repeated, "I have to be organised, or I don't function", and, having worked out a particular system, wanted to "keep it that way". This would be for keeping information related to work.

Interviewee 14 claimed his was "[d]efinitely shaped by Gibson" and describes "a sense simulation … like artificial reality, if you have a visor or whatever … in the workplace, the person that does your work is a graphical representation of you, and you move through your daily work life without actually visiting the building". This artificiality is extended to virtual meetings, moving between virtual offices, and "going to virtual information banks". Government departments and companies would be represented by "information blocks", which the user's avatar could then access. Although the interviewee mentions Gibson twice, the world described seems to have more in common with 'Snow Crash', or perhaps Second Life.

The second "office" world belonged to interviewee 15, who took a more bounded approach. "If … you work for a huge multi-national company", drives on a computer

are represented as office buildings, with topics depicted as rooms within the building, sub-topics as desks within the offices, then drawers in the desks, and so on. “What’s held in that cabinet could be terabytes of information that you could just rotate through certain headings until you got to what you were looking for.” Outside the company, however, the model becomes less clear. If someone needed information from a particular place, for example the University of Istanbul, “it would be no physical hardship for you to relocate your virtual self to Istanbul, in a generated English written speaking environment”. This would be as easy as logging on to a web site is currently.

The three “offices”, then, have something in common – all are places to keep information organised. 9’s office is “a replica” of her real-life office, 14’s also seems to be a “virtualisation” of a real office, but 15’s is a more abstract representation of data structures. When 14 wants to access information about other organisations, they can also be accessed in an abstract form, as “information blocks”, though individuals can be contacted through virtual meetings. “Companies would become represented by the information they hold, and you could have a virtual, a business-scape”. This is balanced, however, by the fact that the user is working “with” their colleagues, albeit in the form of an avatar. 15’s world offers the possibility of virtual travel, whilst 14 appears to envisage the avatar staying in the same virtual office, apart from trips to the data bank.

4.4.2.2 “House”

Interviewee 9 appears again in the “house” group, having suggested that a representation of “my house” would be a good way of accessing personal information. She says, “you know your way around things that would be your own personalized world.” This idea of familiarity will be encountered later in the final series of interviews. There is still the emphasis on realism, and still maintenance of the same system of organisation.

Interviewee 23 has a “mansion”, containing many doors, each of which is numbered and labelled with the subjects it contains. When a door is opened it may lead to a room with other doors, it may lead to a room containing the required information, or it may lead nowhere, in which case “you have to come out again.” This model requires

knowledge of the classification scheme, and it was agreed that a map, or a schedule, or key to the classification, would be required. This model also seems to demand a lot of the user, who, it seems, is always liable to choose a route that "terminates", whereupon it is necessary to "come back, then find another route."

The next interviewee to favour a house was 48, although this house has some unusual characteristics. There are stairs and doors in the house, and "kind of almost like a maze, but not be like a maze - each door has like a subject pattern, and as you go in, you can now specify where exactly you want to end up." There can be more than one route to a place, and if a dead end is encountered, that does not necessitate retracing the path to the start. It appears that, as well as a maze, this house has some property of expressing compound and complex subjects – "you may end up in the same place and you have a different route of going there, you can go there through Humanities, you can go there through Social Sciences." The interviewee described it as being like "those books each book has different endings", and agreed with a suggestion that she meant the Steve Jackson Fighting Fantasy series (e.g. Jackson and Livingstone 1982). These books were marketed as role-playing adventure stories, in which the character "played" by the reader is asked to make decisions, which then affect the narrative flow of the story. The result is akin to a "programmed text". The "subject pattern" on the doors is to aid users who do not understand classification schemes, and is therefore potentially more user-friendly than the "mansion" of interviewee 23.

4.4.2.3 "Building"

Interviewee 49 emphasised very strongly that the environment would be "structured". The example used was a "building of management", within which would be floors for different branches of management (e.g. project management, operations management, knowledge management), identified by pictures on the stairs. On each floor, there would be rooms identified by icons for topics within the branch (e.g. Tools and Technology).

4.4.2.4 "Memory palace"

The most abstract model that could be classed as a building was that of interviewee 52, who described a world "like the Renaissance memory palaces, it would be somewhere, in my ideal it would be somewhere very beautiful that you'd enjoy

wandering around things that you could make connections to." Whilst the memory palaces were usually very personal tools, however, (Yates 1966) this interviewee envisaged galleries containing icons that would have resonance for everyone, even across cultures. Examples given were the Mona Lisa to represent Art, the DNA helix to represent Genetics, and the Venus de Milo to represent sculpture. The model also included sound – "like the talking pictures in the Harry Potter movies, that might speak to you and tell you what sort of information they contained." Although the "memory palace" label might be debatable, this is quite a well-developed idea, which has a practicable air to it. However, as it stands, it provides only "high level" access to subjects, supplemented by the spoken description, and it would need to be developed further to provide more specific material.

4.4.2.5 "Town"

On a larger scale than "building", four interviewees favoured a model based on a town. Interviewee 26 had a model which was not very developed – "it could be like a street, or something like that - just like a computer game, to make it sort of user-friendly? …Like a sort of virtual town - you've got all the different things there." Interviewee 8 also favoured a shopping metaphor, because "I was sort of thinking, if I'm going shopping in town I know what sort of shop something would be in." Interviewee 28 had a more elaborate image, in which supplying a keyword would result in the highlighting of buildings containing relevant information, and the size of the buildings being proportionate to the amount of information stored. Moving through the streets or flying above the town could be chosen, depending on whether a specific search was being carried out, or a more "browsing" mode of interaction was required. This interviewee also proposed "an underground system, like the London Underground, to shift you from building to building." He observed that "that's maybe taking it a bit far, but there's no reason why you shouldn't have a bit of fun, in information retrieval." This suggestion is interesting on two counts. First, it will be seen at the practical testing stage that several interviewees comment on the time taken to move around, and the practical difficulties of navigation. Secondly, there is the fact that Second Life and Active Worlds both provide "teleportation" as an alternative to analogues of "walking" or other more conventional means of movement. It appears that, when the scale of the environment grows to be significantly larger than a single building, the user may become impatient with a "realistic" speed of movement, and,

depending on one's viewpoint, either sacrifice the realism of the representation, or take advantage of the possibilities it offers.

The town proposed by interviewee 50 was a more literal interpretation. "I was thinking of a high street, a typical high street because you can get a lot of information, a lot of stores, you can get … you have the bank, you have post office, you have the consul, you have mayor's, doctor's …shops on both sides, in the middle houses and flowers. You have street lamps, they could represent any sort of information you want" This model also integrates email, represented as writing and posting of letters, and chat, represented as an internet café. The model is both more literal and richer than the other town examples.

4.4.2.6 "Market"

Slightly different from the town, but part of the same class of images, is the street market proposed by interviewee 51. This world is small, but quite sophisticated, and incorporates an "agent", with which the user can interact. The image is of a market trader, standing behind a stall, on which different kinds of produce are arranged, radiating out from the trader like segments of a circle. Apples oranges, or bananas might represent different business topics, such as management or economics, and the trader would be able to select from his stall the correct item to match a user query. If the query related to a different subject area, the trader would instead direct the user to the appropriate stall. "From his stall he'd say, yeah, management, great, yeah - haven't quite got the person about knowledge management here, but I'll just get him." "So, if you ask for oranges, he'd say, 'Oranges, yeah!' You'd say, 'A kumquat?' and he'd go, 'No, over there.'" A variation on this model was also discussed, in which the first stall holder would have very general "goods" on his stall, and would direct the user to stalls containing more specific topics in a particular subject area. This variation is better suited to a hierarchical representation of knowledge. Either could be interpreted as an embodiment of the expression "to set out one's stall" – to show what one has to offer, in this case information.

4.4.2.7 "Car Park"

Interviewee 33 proposed a car park world, where the size of the vehicle was related to the "size" of the information: "with lorries to represent the kind of big bits of

information, and various different … bigger cars to represent the next bit, and then smaller cars could represent smaller bits." These vehicles are then arranged by size, not by topic: "I think that what I would do is put all the bigger, like all the lorries together, and all the next size vehicles would be together." The user would come into the car park and enter the vehicle, to retrieve the information, but there is no indication of how the user would be able to identify the correct vehicle¨" I couldn't really figure out how to organise the information."

4.4.3 "Space"

Grouped under the heading "Space" are models referring to planets, solar systems, and wormholes. Interviewee 22 mentioned solar systems and wormholes: "I thought maybe of a solar system of planets, something along those lines, or, like wormholes, say you go down a wormhole, and then you come to a piece of cyberspace that's like, in a different dimension, or something like that … and then that would be like, a document or something that you arrived at." This model can be adapted to a hierarchical one: "it would be like having solar systems a group of documents … your subject area would be like the sun, and your planets would be the … and you'd have like different galaxies." Here is a picture of galaxies for major classes, solar systems for subject areas, and planets for documents. Wormholes provide a means of travel which offers a shortcut to a document, in much the same fashion as the city model's underground system.

Interviewee 45 had a less developed idea, but one which sounds very similar: "a kind of 3D universe, you'd have like planets and solar systems representing different categories of information, that kind of thing," and interviewee 53 had hardly formed the idea at all: "it could be like planets it could have three dimensions." On further prompting, this interviewee agreed that there could be a hierarchical structure of the type mentioned above, but gave a distinct impression of not having thought through the model to any great degree. Interviewee 43 mentioned planets as a second idea: "you could have like, em, planets, sort of outer space themes …"

Interviewee 30 had the most complex picture, though it undergoes revision as he speaks: "I came up with the idea of outer space, sort of you've got sort of different planet sizes and different star sizes to indicate relative importance, but you've also got

then links, you've got … if you sort of bumped into a specific, so you could have the first view of it would be the whole view, you've got sort of galaxies and stuff and sort of the bigger galaxies have more information, obviously, and you can kind of click into them, and you've got the systems and you can have sort of links then, the more relevant information would be the larger planets, but then you've also got the orbiting moons and stuff that will be sort of topics that are closely linked to the topic you're looking at, but might not be of the same relevance as maybe another document. So, you've got that interaction, and then if you wanted to take it a step further, you could click onto the actual planet, and then sort of your information [indistinct] divided up again into continents and stuff if you wanted or sort of different masses, not just sort of representing the data, but you've got that interactive kind of movement that you can go between documents that are related as sort of links and study just as you hyperlink stuff there would be specific things in the system."

Size is an important factor here – the size of galaxies is related to the amount of information they contain, the size of planets is related to relevance, and physical proximity to related topics. When a planet is selected, the documents and data are linked to landmasses on the planet, and there can be hyperlinks between documents. While there is no "teleport" mechanism here, the hyperlinks could provide an alternative to extensive navigation on a planet's surface.

4.4.4 "Forest"

Under "Forest" are grouped the ideas of forests, woods, jungles and trees. The forest of interviewee 16 has height as a distinguishing feature: "a forest with plants of varying heights, and you could move around in the forest … taller trees, different kinds of trees, different kinds of plants, for obviously representing different things." Plants can be added, and they can grow: "You could either be in the forest, just browsing, walking around, coming across some flower, you could actually plant things in the forest as well as a way of adding new things and those things could grow rapidly, or they could take their time to grow." Growing, therefore, seems to be dependent on the size, or importance, of the resources. Resources can also be dynamic in a negative sense: "or they could die, as information can die back, or can be chopped down as information maybe like changes that could be cut back, or it can be removed

altogether." On a simpler level, as interviewee 30 acknowledges, is a single tree: "just a tree - you've got the different branches, and if it was a deciduous tree, you've got different levels of leaves within the branches and stuff which show relevance, but again that was a simpler one". The jungle proposed by interviewee 43 is also very simple: "you could click on a tree for something, or it could all be done sort of in a sort of hierarchy, you know to do with animals, you know, maybe your smallest bit of data would go with, like, an insect, and your biggest or best piece of data would go with like an elephant." There is a concept of "size" here, but not of subject, a feature shared with the car park envisaged by interviewee 33.

Interviewee 42 has a more complex model of trees: "I thought about trees. Because I thought, like trees you could show like different heights, different, how much information they had, and you could have different types of trees for the type of information and the qualities of information, and the root, because really you're drawing information, search sort of different databases that they searched, and .. I don't know, sort of branches leading off to different sections, and I thought you'd have trees sort of behind other sorts of trees, to represent the relationships between … things?" Here, height is related again to size of resource, "types" and "qualities" of information are unclear, but could be taken literally as format and perceived value, because subject is clearly related to relative placement. There is a development of the metaphor here, expressed in the idea that the trees have roots which draw information from underlying databases. This is the first time that data sources are explicitly mentioned, and the fact that quality is also a determinant of tree appearance implies a more complete mapping of the "world" to a real-life information access scenario, the quality of a data source being one of the critical factors in its evaluation.

4.4.5 "Garden"

Although the forest as envisaged by interviewee 16 has elements of cultivation, in that trees can be planted and removed, the garden imagined by interviewee 48 is less developed than the forest of 16: "I thought of fluid, as opposed to being very structured we are going to have the plants, the garden? As we walk through the garden, we pick up a plant and the little information we need, a cascade, right? Go in and going further, if you pick up the plant, and it's not exactly what you are looking

for, would you have to drop it again, and pick up something else?" This appears to be a very unstructured and indeed "fluid" approach, which was left undeveloped as the interviewee proceeded to talk about one of the "house" models.

4.4.6 "Library"

Interviewee 6 said, "It's going to seem really boring" but opted for a library, because "you could walk around in the way librarians do but it would be, like, a virtual library. Everything would be easy to find, because it's all labelled." It would have to be "structured" to make it easy to use, and would "look like a computer game - you know the ones that you can walk around and pick things up?". It was agreed that this could be a game of the Doom or Quake type, and that the world need not look like an actual library, the important thing being the ordering of the stock – "structured, and you know it's quite clear you've got reference material over there". This appears to be a clear appeal for semantic spatiality – items are organised according to the type of information they carry, and the user can walk around, identify the correct type of item, and pick it up to use it.

The library pictured by interviewee 11 was again very structured – "regimented" was the word used, and with the unusual feature that the library moves, rather than the user. "You sort of stay stationary and that bit which you want to find would then sort of move round and come to you, rather than you walking upstairs and going various places." This is a semantic space which reorients itself dynamically, and all information sources are represented by "the same graphic" – another aspect of being regimented – rather than being the usual mixture of colours and sizes found in a real library.

Interviewee 20, conversely, emphasised the browsing experience: "a library, not necessarily a library, many shelves and stuff on so many shelves, so you're going round the shelves, and you say I'll pick this, this and this, but there's much information around the walls, so you are don't understand which is the information you're looking for, you just wander around." The other feature mentioned was "special offers", so it appears that this library may have some of the features of a

shop. If the user has a well-defined information need, she can go to the right place, but failing that can browse until something attracts her attention.

The world of interviewee 24 was quite simple: “Something where you have lots of computer access to sort of be up to date, but also relatively good printed access as well, published materials.” This library has items which can be clicked on to give access to printed resources, and also has computers to give access to online materials. This computer-within-a-computer idea seems a very literal interpretation of the “virtual library” – resources are organised by Dewey classification, and online resources are “online”. However, when Second Life is discussed in Chapter 8, this is exactly the kind of service that will be described.

Interviewee 34 had an even simpler image – “a stack of books like library shelving, and have it colour coded by subject, with different sizes of books for less important things.” 34 is making semantic use of the colour and size that 11 felt would not belong in the “regimented” library.

The image presented by 41, who also had a “brain” image, is more than simply a library: “there’s this great library [I] immediately tuned in, because of the course, one of the things this library does is, if you want to go and research, the librarian comes to visit you, takes away your topics, and gives a magic stone, or something. You’re put in this blank room, put the stone in there, it’s like the Matrix, it immediately expands into this illusionary three-dimensional space, with all the books and files pertaining to what you were wanting to look at. That would be fun, but I sat there thinking, ‘Well, how on earth would they know exactly which books you would need?’”. This image has an interactive element – the librarian who comes and takes away your topics, and returns the magic stone. It has a “tailored” element, in that the books and files are “pertaining to what you were wanting to look at”. The question about “which books you need” is more a matter of presentation – if the keyword search – “takes away your topics” can be handled efficiently, then the “magic stone” is simply a graphical representation of a result set, which then expands into a fuller display. Although this image offers rich graphic potential, and has distinct echoes of the librarian character in ‘Snow Crash’, it achieves this effect by interposing two stages between the making

of the request and viewing the “library” display, at which point the user has still to select an item or items.

In summary, it seems that the library might not have to look too much like an actual library, and might not even have to be moved around in like an actual library – the important features are the ordering of stock, and the ability to identify resources, often through cues of colour or size. In the one example where the items all look the same, the library positions itself so that the required items are presented to the user by the library itself. There is only one librarian character, who operates in a rather mysterious way, and browsing seems to be the most popular way of finding material, facilitated by ordering, labelling, or selection by the librarian.

4.4.7 Library catalogue

Related to the library, but specifically targeted at retrieval, are the card catalogues chosen by interviewees 25 and 31. Interviewee 25 chose the model because “you don’t want a lot of metaphorical stuff, where actually large parts of the metaphor are unused and not actually working to qualify the thing that you want to convey.” This approach gives the essence of the library, as it were, without the, strictly speaking, unnecessary overhead of reproducing the items and stacks. However, this interviewee also expressed an interest in “a conspectus of the catalogue, or whatever it is that you’d be able to get an overview of it, and I’m quite happy with the idea that that would be effectively conveyed by size and clustering”. This sounds more like a 3D view of a scatterplot arrangement by subject, one of the more common information visualisation models.

There was also a pie chart model: “like a pie chart which broke up, if you asked it to, into its component parts and then each of them came forward and became bigger, and zoomed in on it somehow but I mean, if it was a big circle, or if it was a ball I mean I wouldn’t want it then to … if it was a circle, I wouldn’t want it to be presented as a flower or a cake or something, I just think that distracts. Simple will do nicely.” This is another minimalist model from someone who has worked in libraries, and would like, were it possible, a reproduction of a card catalogue “because you can see how big the thing is, it takes up a physical amount of space, and you can see how finely it’s

been subdivided but the thing that you're not going to get I can't imagine reproducing the sort of feel of the physical cards, if you're familiar with that, it has this sort of the familiarity that a marked deck has to a cardsharp. You find your way, you notice if there's a new one there."

Interviewee 31 had also worked in a library, which had dispensed with its card catalogue in favour of a computerised one, but was impressed that people remembered the card catalogue with affection, and enquired as to its whereabouts. The virtual version envisaged by the interviewee was, however, considerably more interactive than a traditional wooden-drawered model: "like a regular card catalogue kind of thing, and then you just - you can do anything, right, it's just your imagination, OK, so then you'd like wear goggles, and have gloves or something, and then it would be this whole world maybe that surrounds you and stuff? And then all you'd have to do, you'd walk into like I guess this room or whatever, and it'd just be like, maybe a small drawer or something, you just say, "this is what I'm looking for" and just like pull an imaginary drawer and another one will pop up and stuff, and then if you want to look at something else, then say, "this is also what I'm looking for" and pull out another drawer, level or something like that, and then if you want to start over or something, you just like push back all the drawers and then say, "start over" and then add another one, or something." This is quite similar to the model with the librarian, discussed earlier – there is speech input of search terms (these, and the market, are the only models with this feature) and the results are delivered as requested. It is also apparent from the description that this interviewee is imagining a fully immersive display – goggles, gloves, and a "world … that surrounds you". Resemblance to an actual card catalogue is limited to the presence of drawers. The system will also alert the user to related material: "the computer will light up a drawer to say that, 'Oh, there's another link over here, too, if you want to …'"

Interviewee 36, another person who had worked in a library, imagined something like an OPAC [Online Public Access Catalogue], but with "a bigger screen … except digital, you don't really need to use the keyboard or anything". This is an OPAC with a touch screen, which "a child can use", which also has "a Google type of engine" and presents information in a similar way. This is a virtual implementation of a real OPAC, and might be thought to be on the limits of what constitutes a virtual world – a

criticism which might also be levelled at the other two catalogues. On the other hand, if the virtual world was to serve for purposes beyond that of accessing information, these catalogues might present an access point familiar to the user.

4.4.8 Path

Both 29, with three worlds, and 46, with one, addressed a common theme which differs essentially from the other models presented at this stage. The world described by 46 was a fairground, but an important feature was the path through it, leading to the various attractions which were icons representing the top level of a subject hierarchy. The worlds described by 29 were: a river system, with confluences and a delta, representing the merging of existing disciplines and the emergence of new ones; a map with routes representing the development of a discipline; and a lotus plant, emerging from ignorance towards clarity. There is a path-like structure to all these worlds, but these are paths which are not necessarily directional – the user could move anywhere in the top level of classification, to any point in converging and diverging disciplines, backwards in history as well as forwards, or to any point in the refinement of knowledge in a particular field.

4.5 Common features – non-structural

Section 4.2 covered the interviews where a similarly-labelled model was mentioned by more than one interviewee. However, these cases cover only 31 of the 69 interviewee/concept combinations developed in the 53 interviews at this stage. Because interviewees were not limited to one model, and because they sometimes chose models which could be grouped with others, as above, there is still a good deal of material which has not been covered, and it is important to consider what part this plays in helping to explore preferences.

Since the remaining worlds are unique, it would be of little interest to examine their structural features individually, but it does appear that some show other similarities which may be of interest.

4.5.1 Colour

Colour was mentioned several times, but was of special significance in relatively few of the worlds. Interviewee 1 imagined clusters of documents, represented as neurons, and "denoted by size or colour, or brilliance for their relevance, though perhaps colour's not such a good idea - I'm colour blind." This last is a good point to bear in mind for any future implementation, and it is interesting that the interviewee should consider colour as a distinguishing feature, given his colour-blindness. However, there are combinations of colours which are considered "safe" to use for colour blind viewers, and these would be good candidates for worlds where colour was significant. This interviewee also remembered that colour was significant in Gibson's matrix, so it is possible that his imagery was to some extent imported from 'Neuromancer'.

Interviewee 7 pictured himself as "in a space suit kind of floating round and picking up envelopes that look interesting, that have colours on them, extra long addresses or something like that." However, this interviewee's image was more his personal image of the processes involved in accessing information over networks, than a practical scheme – as he put it, "it's my own like baby language for me to say the computer's able to access anything it wants, via any route that it likes, and, you know, it saves me having to worry about things not working - it just does it, you know." This is more a metaphor for web-surfing than a model which could be constructed, and the interviewee admitted that "I couldn't imagine myself physically being able to sort through all that addresses."

Colour was already noted as significant in one "brain" and one "library" example, above, but the most extensive us of it appears in interview 17, where it is used in the form of semi-transparent sheets of colour, denoting subject areas. The user can move through these sheets of colour, finding composite subjects where sheets overlapped to give a mixed colour. More complex subjects would be darker coloured, as more sheets overlapped, whereas areas of pure colour would have less information, but more clearly on a specific topic. "[Y]ou could look from different angles - from one side you could look and see broad areas, and you'd be able to see the cross-overs, where lots of search areas, say, crossed over, which would be easy to pick out instant, because you'd find the darkest spots, and then you could also run from that other

angle down the side and be able to see just where pure segments of information were." This world is distinctive in that it has no real structure other than coloured sheets.
27 had coloured bubbles, with "menus one colour, blocks of information as another colour", but in a world in which a query would locate the user within the world of bubbles, which could be entered, and exited by different doors, revealing different aspects of the subject. Size and proximity of bubbles to the user are also significant. Interviewee 35 had lollipops of different colours, shapes and sizes, "And depending on what you're looking at, it would affect the different colour or different shape." It appears to depict the results of a search, rather than a means of representing all subjects – "the main match would be in the centre, and then it would go off from, yeah, especially if you were doing sort of a search that incorporated two ideas." 46 had a fairground which was colourful, but did not use colour to denote anything.

It is noticeable that these interview transcriptions are less easy to envisage than those referring to houses or libraries. This does not appear to be due to greater precision or detail in the latter, but rather to the lack of a shared understanding of what the subject of discussion is. When discussing a library, for example, the library-user brings to the discussion a certain understanding of what a library is, what it might look like, and what its function is. The speakers also communicated enough by other means, such as emphasis and gesture, that the descriptions appeared more complete at the time. It would be interesting at a further stage of research to explore the possibility of the interviewees drawing or otherwise creating images of these spaces, but that fell outwith the plan and timescales of the present research.

4.5.2 Size

Size was mentioned several times, but in distinct senses. 27 referred rather vaguely to "colours or size" as helping distinguish amongst bubbles. The lollipops of 35 appear to be sized so as to enable more distant ones to be seen from a central position, in a tier-like arrangement. This idea of size as an aid to arrangement or recognition appears to be in contrast with the library example in interview 34, above, where size is used to differentiate between more and less "important" things. Then there is the idea of the size of an item being related to the "size" of the resource which it represents. This mapping also appears in 42's forest and 30's solar system. The most simple

example of this type is in the car park of interviewee 33, with larger vehicles representing “bigger bits” of information.

4.5.3 Sound

In this series of interviews, sound was mentioned only in the form of music. Interviewee 19 had a world represented as an aquarium, with “different noises, maybe different types of music for each amount that’s held in each area.” Here again, as with size, above, there is the notion of an “amount” of information. The other occurrence was in interview 52, where the interviewee, whose image was of a “memory palace”, reflected that different kinds of interface might suit different types of people, and that musically-oriented people might respond well to different tunes. As interviewee 19 had done a first degree as a music student, this would seem to be a perceptive statement. Interviewee 52 suggested that different types of people were best suited by different types of interface, and that people who were musically oriented might associate tunes with different categories of information.

4.5.4 Motion

Motion occurs in different contexts. In many cases, the user moves through the world, to search for or access information. For example, this is the arrangement in the town and forest examples. In only one case, the library in interview 11, does the world move to meet the user, so that the appropriate information can be accessed. The other type consists of worlds moving independently of the user, as in some of the space examples.

Interviewee 18 had a world with motion, but only in a rather limited way, which might be considered to be a variation on the previous one. This world consisted of a central cloud, labelled “Computer”, circled by smaller clouds labelled “info”, and arrows indicating that the smaller clouds rotate clockwise around the larger one. Movement was permitted in one plane only, and in one direction : “because I’m quite systematic, and plan, so I wouldn’t want the information to be everywhere, and to move around - I wouldn’t want that. Does that sound right? Only like, you know, if it’s going to move, it has to just move round there [clockwise].” The central idea was agreed to be something like a carousel display, as used in sushi bars, “Rather than jumping around, so that’s everything’s got to come round here, you know, and then,

it'll come round and you wouldn't go from here anti-clockwise." This world, ten, does not respond in quite so helpful a manner as that of 11, above, but patience will eventually be rewarded by the appropriate information coming into view.

Interviewee 21's hierarchical tree of blocks is discussed below in 4.5.5.1. and has a "fly-through" property : "like say, in a game, you'd be able to sort of fly through, over it, use an overview and then zoom in and be able to see it in more detail."

Motion had been mentioned explicitly in the introduction, because the intention was to elicit images of "a world you could move around in, or in which you could move things around". It may be that this was picked up as a cue by interviewees, and was therefore mentioned more frequently than colour or sound, but it seems likely that motion is simply more part of the "3D experience", and is more directly connected with notions of "locating" and "accessing" than colour, texture, size or sound.

Interviewee 40 has a vehicle to move through a landscape, stopping at icons which represent subject areas, and give access to subjects below them in the hierarchy, also represented as landscapes.

4.5.5 Organisation

The matter of organisation of resources in the worlds was sometimes implicit in the model (though, of course, a library need not necessarily be organised conventionally), was sometimes made explicit (as in the case of the "building of management" with floors for subject areas, and doors for topics), and was sometimes hardly relevant (as in the case of the overlapping sheets of colour). It is clear from the wording of many responses that the question of organisation had not been considered, or that it was somehow implicit in the world design, the most extreme example being the library which moves the desired documents to the user.

4.5.5.1 Hierarchical

Since no library models were mentioned which did not follow a classification scheme, it is assumed that the libraries are hierarchically organised, as are the mansion with subject rooms, and the various planet/solar system/galaxy models. Whether towns, shops and buildings are arranged in some hierarchical order is less clear, and the point

is not usually made clear. Interviewee 21 described an arrangement of blocks for representing a file system on a computer, the top level of the arrangement being frequency of use, and the size of the blocks reflecting the size of the file, “you’d have a directory of the block, you’d click on it, and it would open up, and then it would have mini-blocks inside, which would be more directories, and then the bigger the thing and you could come and see your priority.” So, directories contain sub-directories, which contain files. This interviewee also revealed experience of taking an information visualisation course in a previous degree, and models of this type are to be found in information visualisation literature, so, although the interviewee said, “it went totally out of my head, I mean I said that the other day, thinking, I’ve seen that before, I’ve seen that before”, it seems probable that this influenced the choice of model in this case. The model was referred to as a tree, which has obvious hierarchical connotations, but might also be a link to the forest world – it was never properly explored whether the trees in the forest might themselves be hierarchical structures. Interviewee 46 has a combination model – a path through a landscape, leading to icons which give access to further hierarchically-arranged landscapes.

4.5.5.2 Non-hierarchical

The most clearly non-hierarchical model is the car park, in which resources are organised by the “size” of the resource, and hence the size of the vehicle representing it. However, lollipops, bubbles, and the various models in which cells or blocks or packets float in space, whether connected by neurons or wires, or simply floating past, do not have any obvious hierarchical relation between elements, though it may be that the connections are related in some way to “relevance”. Interviewee 43 claims to have hierarchical models, but they appear to based on “size” or “quality” of data: “it could all be done sort of in a sort of hierarchy, you know to do with animals, you know, maybe your smallest bit of data would go with, like, an insect, and your biggest or best piece of data would go with like an elephant. Something like that, and the same with like a deep sea world, sort of seahorses and blue whales, and stuff like that?”

Interviewee 29 had schemes which might best be described as linear – the first was a road through Europe, on which the user could travel to examine the development of European philosophy, using, for each period in its development, a mode of transport appropriate to the period. Thus, for example, the Edinburgh of David Hume would be

visited on horseback, while World War I military transport would be more suitable for Wittgenstein's work on the Tractatus Logico-Philosophicus in an Italian prisoner-of-war camp.
The second used a river system to explore "flows of information", and the development of disciplines from their theoretical roots. These models could be combined with a map to add a geographical dimension. The first is reminiscent of a well-known example of information visualisation, the depiction by Minard of Napoleon's Russian campaign, a line, the thickness of which varies as the strength of the army, plotted against location, direction, and temperature.

This interviewee also had a Buddhism-influenced model – "a lotus flower model, of ignorance being at the bottom of a lily pond, where the waters are muddy, rising through, as lily flowers grow up through the water to the surface, through clearer and clearer water, to finally, the aim of the Buddhist monk to break free of the surface of the water, where the expulsion of ignorance is one analogy for Nirvana." As the interviewee said, this example was "stranger … but would look nice in computer graphics", though whether it would also "add some spirituality to the world of cyberspace" is debatable. These models demonstrate an imagination quite different from others proposed at this stage – they are concisely stated, but well-developed, and they also different in that they are adapted to a particular query, or representation of a particular field.

The nearest match would be interviewee 13, who wanted a timeline to represent stages in the development of his artworks, a very personalised information set, for which there was no world model forthcoming. In this case, though, the models could be used for these particular types of queries where a theory or a field is represented as emerging from, or as being a result of merging, previously distinct topics or disciplines. It is a historical perspective, but could be used to model many subjects. It is also one of the worlds which could be created "on the fly" in response to a query – that is, the model could be generated programmatically as a VRML file, depending on the results returned from a query, each time giving a different configuration of the river or road system, or the lotus blossom, depending on the exact terms of the query.

4.5.5.3 Hybrid

Finally, there are two worlds, belonging to interviewees 46 and 40, which are like hybrids of the two approaches. 46 imagined a funfair, through which the user could walk and try out different rides for different subject areas. The subject access is not developed further than this, though the interviewee suggested using the hammer and bell type of 'Test Your Strength' machine to indicate the collection strength in each category. 40 described an "information landscape", through which the user, represented as a "little person" could drive in "a little car", past icons representing subject areas. When these icons were clicked on, a menu would appear, choosing from which would open up another landscape, further down in the subject hierarchy, "until gradually you would narrow it down, as far as it would let you go, to exactly what you were interested in."

These worlds have hierarchical components, (and 40's is the first to have an avatar, though 29 also had vehicles), but they also have in common with the non-hierarchical models discussed in 4.2.5.2, above, the element of a path or process.

4.6 Series A interviews – general analysis

Series A provided the equivalent of 32 different concepts, from 53 interviews (see Table 2). They appeared to be distinct concepts, at the first attempt to organise them, but when examined more carefully, it becomes apparent that they should not be grouped without further consideration of possible loss of "richness".

For example, though all libraries are described as such, there might be a distinction between "a house" described by 47, which has a very fluid structure, and "my house" described by 9, which has a definite arrangement, preferred by a person who emphasises her personal need to operate in a very organised environment. Checking keywords is not enough. Similarly, there are distinctions between "my office" (9, again), "like the office" (14, who proposed having a representation of a real office, and using it an avatar, which would be a 3D version of the "telecommuting" idea), and "office block" (a very rigidly structured environment, which nevertheless bears similarities to 48's very fluid house). The "hierarchical mansion" bears probably more

similarity to a library or to the “office block” than to “my house”, which is a representation of an actual house.

It seems, therefore, that the simple structural descriptions picked out here are already failing to do justice to the richness of the images described. It is also worth noting that these first interviews were short in duration, and did not examine most individuals’ images in any great depth.

However, based simply on the short descriptions above, the most popular image is “library”, followed by “forest/tree” and “town”. There are, in fact, two mentions of “forest”, two of “tree”, and one of “trees”, and on re-examination of the transcripts it would appear that 10’s forest is a means of finding information about trees, whereas 15’s is a more typical “IR” forest, with different sections of the forest, “taller trees, different kinds of trees, different kinds of plants, for obviously representing different things”. There is also the possibility of adding to the forest, by planting things, so this is a much more interactive tool. When the jungle image from 43 is examined, it is apparent that 43 has come up with several ideas which are superficially attractive to the interviewee, but have not been developed to any great degree.

Another way of looking at this is that there are different degrees of abstraction in similarly-labelled worlds. Interviewee 50’s town is much more “realistic” than that of interviewee 28, in that it has made use of the “identities” of buildings in the town to denote the subject of the information located there. For example, to access information about the church, the user would click on the church; to access retail information, the user would click on retail shops. Interviewee 26, whose town idea was not fully developed, had initially suggested “for medical information, you could have an icon with a hospital”, but this had been before the town world was mentioned, and it may be that the two are not parts of the same world.

This is just an example of the dissimilar denotations of similar terms, and served as a warning in further analysis. There was much more to the images than a simple label, but it appeared that the “person-centred” approach gives a route to pinning down these differences, to a much greater degree than questionnaires, for example.

In Table 3, an attempt has been made to group similar worlds together, without incurring the “loss of richness” described above. The cruder form of grouping was useful in choosing the models to develop for the next stage of interviews, but risked losing valuable detail. It was also considered desirable to preserve the models chosen by only one interviewee, because, although the models themselves were not developed further, some were found, on analysis, to have interesting themes in common.

Table 3: concept groupings - total = 52

Concept	Interviewees	No of interviewees	Concept	Interviewees	No of interviewees
aquarium	19	1	mental map	5	1
blocks, connected	2, 3	2	molecules	5	1
brain	1, 41	2	music	19, 52	2
bubbles	27	1	nothing	10, 37, 38	2
building	49	1	office building	15	1
car on road/Monopoly	40	1	office, my	9	1
car park	33	2	office, like the	14	1
card catalogue	25, 31	2	OPAC	36	1
city of words	12	1	PARC wall	39	1
clouds	18	1	planets	45, 53	2
desktops	4	1	river system	29	1
documents, floating	7	1	safari park	44	1
forest	16	2	sea, deep	43	1
game	47	1	shops	8	1
garden	48	1	solar system	22	1
google	36	1	text, blocks of	12	1
hierarchy	21	1	theme park	46	1
hierarchical mansion	23	1	timeline	13	1
house	48	1	touch screen	36	1
house, my	9	1	town	26, 28, 50	3
jungle	43	1	transparencies, coloured	17	1
library	6, 11, 20, 24, 34, 41	6	tree	21, 30	2
lollipops	35	1	trees	42	1
lotus plant	29	1	underwater	30	1
map	29	1	wheel, multi-dimensional	32	1
market, street	51	1	wormholes, space	22	1
memory palace	52	1			

4.6.1 Groupings

A few “characteristics of division” arose from a first analysis:

- Real vs. imaginary: some interviews refer to a pre-existing, perhaps “real” structure. That mapping is characteristic of the “memory palace” (Yates, 1966), but in simpler terms could be “my house”, or “the office”, “shops” or “street map”. In a memory palace, images of the things to be remembered, or representing passages of text to be memorised, were placed around a recalled image of a building, often, at least initially, based on a real building. Perhaps if a real office or home were used, it would be easier to locate the imaged information sources where the actual items are in real life, for example in a desk or a filing cabinet.
- Concrete vs. abstract : some worlds are based around “concrete” ideas, for example, forests, a road, or a card catalogue. Conversely, there is a group of ideas which seem quite abstract, although they may be based on “real” things. Bubbles, clouds, neurons and lollipops were all mentioned.
- Known vs. unknown : some worlds are envisioned as places in which to access “known” information, as the analogue of a directory structure on a person’s computer, or of their list of “favourites” or “bookmarks” on a web browser. Others are presented as the analogue of a list of “hits” from a search engine, or even more broadly as “all information”. In these cases the information presented is not necessarily known to the user. Many of the interviewees do not make this distinction explicit, but it is often possible to infer, from the model, to which category it belongs.
- Organised vs. not organised : sometimes a classification scheme is used, however informal. It became apparent in the course of the interviews that, although the interviewees were usually asked how information might be organised in their image, very few gave considered answers, so that, in fact, the concept of organising information might be quite unfamiliar to them. A library implies the use of some form of organisation, otherwise it is merely a store-room. The galaxy/solar/system/planets idea could be seen as implying a different subject area for each grouping, at whatever scale applies. The street market has stalls for different subjects, a town plan or map also implies

organisation, as do shops. It is much less clear what scheme applies to a car park, however, and the interviewees (10 and 33) were not forthcoming on the question. 10 was unused to the idea of a 3D world, and came up with a very representational model of the real world, in which clicking on an image of a car in the car park would retrieve information on the car. Since car parks are not organised by any relevant principle, this does not hold much promise as an effective tool for accessing information. 33's model is ranked by size – a larger vehicle represents more information on a topic. Organising information by this criterion seems of very limited use. A few interviewees wanted to organise by frequency of use – not a formal scheme, but one which is manifest in the Windows XP start menu, and the management tools for the desktop and Outlook, for example.

- Scene vs. path : most worlds were relatively "homogeneous" – consisting effectively of one "scene", of greater or lesser extent. However, there were four which could be thought of as instantiating a "path" or "process". This seems to be taking the modelling to a higher level – as if inserting another level of control over the information. Even if the information is classified, but particularly if it can be regarded as in some sense linear or sequential, the path metaphor would seem to offer another way of making sense of an otherwise potentially amorphous mass of information.

All these factors could be considered as facets in a classification of the worlds described, but a decision was made that, to facilitate analysis of further rounds of interviewing, only those differences which had emerged most strongly from the first round would be carried forward in alternative models.

4.6.2 Engagement

A characteristic which only emerges when considering the whole group of interviews is engagement. Some interviewees were far more expressive than others, and it appeared, subjectively, that they were either more interested in the idea, or perhaps had thought of it before. This was a flaw in the interview procedure, in that this area was not explored until close to the end of the series of first-stage interviews, when a question was asked about whether the interviewee had ever visualised information in

this way, perhaps for a previous degree. It appeared in most cases, however, that the image had been “constructed” especially for the interview.

This could be called “depth of visualisation”, or perhaps better, “development”. Sometimes it appears to be a result of the interviewee having given the matter a good deal of prior thought, sometimes it might be an idea that is developed while talking about it, sometimes the interviewer might spark further development with a timely suggestion, or a request for clarification.

4.7 Discussion of series A interviews

The first feature which became apparent was that there was a division between worlds which might be described as “realistic”, and those which seemed more “imagined”, or “fanciful”. Even within realism, though, it seems that there are degrees – a “real” library seems firmly grounded in reality, especially when it has models of computers to access online resources. However, a mansion of branching rooms, laid out in a classification order, is concrete, but has a fantastic element.

A similar “fanciful” element seems to apply to the instances of a world of “bubbles”, and the ones which relate to galaxies, planetary systems and “space” – these are real entities, but are used in an imaginative way, to serve an information access function which they would not normally have. It is true that planetary models have an internal “logic” – that of gravitational forces and the resultant orbiting behaviour – onto which an organisation of information might be mapped, but there appears to be an element of abstraction in these cases, where one order is being superimposed on another.

The participants had a very free hand as to how they interpreted the problem – a description of a 3D “world” for accessing information – and they appear to have chosen several positions on a range from representing all available information, to describing “ad hoc” worlds generated as the result of a search process. Some ideas could work equally well as either, or it is reasonably easy to see how they could be adapted to do so, while others appear to fit better with one of the two extremes. For example, one interviewee described a highway through Europe which is a historical guide to European philosophy. This model is extremely specific, and reminiscent of

the Minard map of Napoleon's campaign, cited by Chen (1999), though with much added functionality.

There is also a distinction to be made between all the information there is, or at least all that can be accessed by the model, and all one's personal information. Again, some models cope with either more easily than others.

A memo at this stage reads: "It is possible that one reason for not finding research on user preferences for interfaces is simply that design of this type is too difficult to do with a blank canvas. Maybe there is no best model. Certainly, it seems that people have very different pictures. Perhaps it depends on purpose, but that does not appear to come out in interviews, other than through some enthusiasm for a personal bookmarks application, rather than a general search tool."
Memo: Aberdeen Business School 3 February, 2005

The first phase was a purely imaginative/imaginary one, where the interviewees were working without any limitations on what they might come up with. That had some shortcomings, in that interviewees a) came up with some models which could not conveniently be implemented; b) came up with some ideas which sounded good, but turned out not to work very well (the rotating planets), though, to be fair, what did not work was the interpretation and implementation which was made of the ideas, and there might have been a better way to do this c) another question of interpretation: although there might be agreement on what was said, there might still be a disparity as to what was intended – it cannot be certain that one person's picture of a "galaxy", or even a "town", is anything like another's. There were also some (not very many) who could not come up with an image, but might still have been able to use a system, had they been presented with one.

When actual implementations are considered, some practical issues emerge. Some of the worlds do not appear to be well adapted to coping with large numbers of documents. In particular, the "space" worlds become potentially very confusing, if there are even ten galaxies, representing main classes in Dewey, say, and in each galaxy, large numbers of solar systems representing topics. One of the interviewees, number 22, had provided for "wormholes" as a means of travel directly to

documents,aend it may be that this would have to be the means of travel for “known item” searches. However, there does seem to be recognition amongst the interviewees that a large “world” necessitates a fast transport mechanism.

4.8 Relevant literature

In this section, a further body of literature will be discussed, to draw comparisons between the findings of the first round of interviews and actual instances of systems which have been developed. As will become clear, the systems appear to have been developed without user input at the design stage, and it is informative to compare them with the choices and preferences expressed by the interviewees, and discussed earlier in this chapter.

4.8.1 Taxonomy of visualisations

Chi (2000) provides a taxonomy of information visualisation techniques, which classifies 36 techniques, including many of those mentioned in Chapter 3 above, according to the abstracting and transformational operations involved in their implementation. While this is useful in its role as a classification of the systems, and builds on earlier taxonomies produced by Card (1997, 1999) and by Chi and Riedl (1998), it is of greater value in revealing the similarities within and amongst the different “families” of visualisations (e.g. geographies, information landscapes, trees) than in assisting in the development of new visualisations. As Chi and Riedl describe it, “the results of the analysis help us classify and choose how to implement the different operators in a large visualization system” (Chi and Riedl 1998 p. 61). It might facilitate development, but does not indicate a best path for that development. When the first round of interviews are considered in the light of this classification, it becomes apparent that the world models described extend across the whole range of “families” defined, and that this analysis indeed serves more a descriptive than a prescriptive role. A more promising description of the virtual worlds which were actually operational is given by Chen in his (1999) book, ‘Information visualization and virtual environments’.

4.8.2 Spatial models

Chen (1999) states that “The appeal of a spatial model is rooted in its simple and intuitive association with our experience in the physical world. Conference rooms, virtual hallways, and virtual cities are examples of the impact of architectural and urban design on electronic worlds. Users feel familiar and comfortable with systems based on such spatial models. From the point of view of a designer, it is a natural choice to build an electronic environment similar to the real world, so that users can easily adopt and transform their interactive behaviour, styles, and patterns, from the physical world into virtual ones.” (Chen 1999 p. 178)

Chen is referring specifically to multi-user worlds – “collaborative environments” – here, so the examples he gives (conference halls, etc) are spaces designed to encourage interaction. Interaction was not possible in the worlds used in the current study, because the intention was to examine the more fundamental question of what the world should be like. However, the points about the familiarity and comfortable nature of spatial models are interesting, and would appear to fit well with Robertson’s observations regarding spatial memory, as discussed in his experiments with the Data Mountain (Robertson 1998), described in sections 3.2.6, 6.6.1, and 8.2.

Having discussed the online communities, such as The Palace and Active Worlds, which were considered in Chapter 3, Chen considers GopherVR.

4.8.2.1 GopherVR

This system (see fig. 9), designed by Erickson (McCahill and Erikson 1995) has a graphical representation of the returns from the now-obsolete Gopher tool. Gopher was a hierarchical menu-style interface to documents on the World Wide Web, in which each line of a menu presented in response to a search would be either a link either to another menu, or directly to a document. “Gopherspace” was a term widely used to describe the notional “space” in which these menus and documents existed, in a usage analogous to the current use of the term “cyberspace”. Although Gopher was very successful in the early days of the World Wide Web’s first surge in popularity, Erikson listed several problems. The first he called the “lost in space” problem, where a user is unable to return to a document of interest, or to obtain an overview of his

“location” in the hyperlinked structure. Erikson felt it would be useful for the users to see a graphical representation of the routes followed. The next problem is the “grouping” problem. Like current search engines, Gopher returned search results as a list, making it difficult for users to see relationships between the documents referred to. If documents could be presented as being grouped according to subject relationship, as well as by their relevance to the query, that would lead to a better tool. The third problem was called the “browsing” problem – because the Gopher interface presented only the titles of documents, and these are often insufficiently indicative of content, it was often necessary for users to open and read the documents in order to establish their relevance. Due to the relatively low bandwidth of Internet connections at the time, this could be even more time-consuming than today, when the browsing problem is only partly alleviated by the ability of search engines to display additional document content.

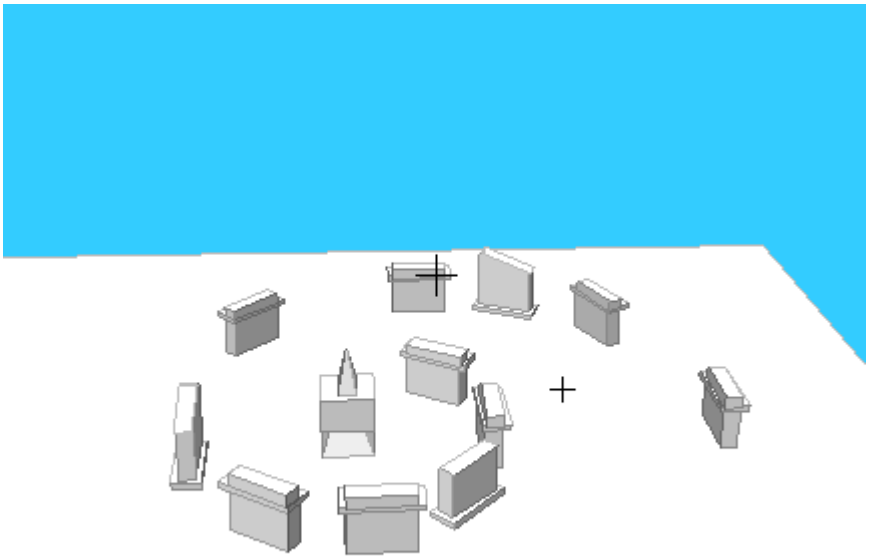

Fig 9: GopherVR

McCahill and Erickson had also identified “intriguing prospects” to be attained from a new interface. One was the possibility of using “interaction traces” to indicate the level of usage of resources. Another is “providing a sense of place by customisation”, thus allowing for “an area of gopherspace to reflect something of its contents.” (McCahill and Erickson 1995) This customisation could be performed by gopher server administrators or by users, and would mean that eventually users would be able

to recognise their position within gopherspace, by recognising areas within it: “while users may still get lost, they may begin to develop a sense for where they're lost.” Lastly, they say that information spaces could be “transform[ed] into social spaces”. Since obtaining information is an activity which frequently involves others, either as information sources or as people to whom information is to be communicated, “information access should not be isolated from other activities.”

The GopherVR “world” looks like spiral patterns of blocks representing search results, arranged in “neighborhoods”, each centred on a “root point of maximum relevance.” The tighter the coil of the spiral, the more relevant are considered the documents returned by the search. The further discussion of the design process contains points of relevance to the design of the worlds in this study, and will be considered in Chapter 5. However, the inherently hierarchical nature of gopherspace, as opposed to the unstructured world of today’s access to electronic documents, tends to limit the applicability of much of the design.

4.8.2.2 VR-VIBE

Chen also mentions VR-VIBE (Benford et al. 1995), a system by which documents are displayed as icons related spatially to representations of the keywords used to search for them. These document icons may be annotated by users, who may use the system simultaneously and are able to communicate with each other. The Communications Research Group at Nottingham University, who designed VR-VIBE, describe it as a statistical visualisation, because it is based on occurrence of keywords – documents are searched for the specified keywords, which are then counted to determine relevance. This rather simple algorithm could now be replaced by the more sophisticated techniques used by search engines, were a newer version to be designed. There is a grid on the “ground”, but this serves only to provide a reference for moving the glyphs which represent keywords. Users navigating amongst the documents are represented by joystick-like avatars, and in alternative representations, the relevance of documents can be indicated by the brightness or the size of the blocks representing them, or by their height above the 2-D planar grid. The interesting feature about VR-VIBE is that it is a completely abstract space, the content of which, and the arrangement of that content, are determined by the users’ selection of display parameters and thresholds of relevance, and their placing of keywords and

annotations. It is not persistent, however – each combination of settings would produce a different display, as would any change in the corpus of documents on which it is based.

The models which Chen terms “spatial” therefore range from the potentially highly realistic ones in the online communities, through the more abstract circles and spirals of slabs in Gopher VR, to the very abstract document world of VR-VIBE, which more closely resembles conventional information visualisation models.

4.8.2.3 NIRVE

Publications on NIRVE (NIST Information Retrieval Visualization Engine) post-date Chen’s analysis, but it is another spatial model, or set of spatial models, and it will be considered here, because the paper (Cugini, Laskowski and Sebrechts 2000) considering its evolution and evaluation has, as with GopherVR, several interesting points regarding user testing, and design.

NIRVE displays documents retrieved from a search engine, arranged according to their similarity, which is again measured according to the presence of keywords. The displays can be more sophisticated than those in VR-VIBE, because weightings can be applied to the keywords, and the display can show relationships amongst the documents, based on the groupings of keywords present or absent in each. Presence or absence of keywords is also displayed on the icons representing the documents, each keyword appearing as a coloured line, the length of which reflects the frequency of appearance of the keyword. The authors write: “We were inclined to experiment with highly metaphorical visualizations, rather than something simple and schematic, such as a grid. Our emphasis has always been on presenting the user with an overview of the structure of the result set, rather than concentrating on finding an individual document.” (Cugini, Laskowski and Sebrechts 2000) This suggests an attempt to resolve the “lost in space” problem, and possibly the “grouping” problem identified by Erikson, and discussed in 4.8.2.1, above. Although full text can be retrieved by clicking on icons, the “browsing” problem remains, however, and indeed it is difficult to imagine how this problem can be resolved when using an interface of this type. Several display formats were tested, ranging from spiral displays of icons reminiscent of GopherVR; a model with 3D axes displayed in space, with icons arranged

according to their similarity to sets of keywords which could be assigned to each icon, thus reducing to three the number of dimensions in the display; “Nearest Neighbour Circle”, “Spoke and Wheel”, and finally the “Concept Globe”. All models were tested on users, informally for the first four models, but formally for 2D and 3D models of the Concept Globe.

In the Concept Globe model, the icons, now representing clusters of documents, as described above, are arranged around the surface of a globe, with clusters which shared the same number of concepts being assigned to the same latitude. The North Pole would have the cluster containing all concepts, the South Pole would have the cluster containing none. The thickness of the box-like icons representing clusters indicated the number of documents in that cluster.

The 2D version of the Concept Globe model was a map-like projection of the Globe onto a 2D surface, and was created to help resolve some of the usability problems discovered in testing the 3D version. Design decisions relevant to the current study will be discussed in Chapter 5.

4.8.3 Semantic models

Chen’s own system, StarWalker, “is designed to maximise the role of implicit semantic structures in the structuration process of social activities within a virtual environment” (Chen 1999 p. 189). “Structuration” (Giddens 1984) is the evolution of the media space as it is used by people. The information space in StarWalker was semantically mapped onto papers from the ACM SIGCHI conference proceedings from 1995 – 1997, though other domains, or semantic spaces, selected from the ACM Digital Library, were later added. It also facilitated social interactions in its multi-user version, through the provision of user avatars, interaction amongst them, and synchronous chat facilities.

Chen says, “the underlying semantic structure is rendered as a star constellation” This has the appearance of coloured spheres interconnected by rods. “It is tempting” he says, “for users to question the nature of the model, the meaning of the links, and why they are placed in a shared virtual environment”. Chen appears to view this as a

stimulus to social interaction between users, as they ponder the relationship between the space in which they find themselves, and the subject domain on which it is based. Sub-spaces can be re-structured by users, in order to bring out relationships of interest amongst the publications depicted.

Chen then moves on to topics of user interaction, but we can draw from his analyses (or, rather, those of Dourish and Chalmers (1994), cited in Chen (1999)) the dimensionality of semantic versus spatial, and bear in mind the fact that there are also social implications and influences when spaces are multi-user. Erikson, in VR Gopher, has an implementation, albeit a little-tested implementation based on an obsolete protocol (McCahill and Erikson 1995).

Allen (1998) takes a more pragmatic view of the representation of space, and is moving towards involving consideration of viewers' abilities in the design of digital libraries. He observes that, as digital documents lack physical properties, there is no obvious way to arrange them in a two- or three- dimensional organisation. He lists a number of possible organisational principles for "analog" documents – piles on a desk for personal access, different filing cabinets or shelves, different rooms and floors in a physical building. He also notes that a hierarchical classification can give meaning to documents' spatial relation to each other. Allen notes a variety of the often-cited projects : Andrews (1994), Hearst (1995) and Wise et al. (1995), or, respectively, Harmony, TileBars and Visualizing the non-visual. Allen also notes that Vibe (Korfhage et al. 1993) and Envision (Nowell 1996) have "advanced the technology of data visualisation to the point that it can be considered for operational information systems".

Hearst's (1995) Tile Bars are also the first focus of Rao, Jellinek and Mackinlay (1995) in their review of visualisation systems. This paper refers to Butterfly, Protofoil, and Perspective Wall, Cone Tree, Document Lens, and Spiral Calendar, this latter group described as "Visualizations from the Information Visualizer", the system referred to in 3.2.1 above.

Dourish and Chalmers (1994) focus on navigation, rather than layout, because, as they say, "in the end, most information must be laid out spatially". They note that "spatial

models of navigation have been used particularly in virtual reality systems", but make a distinction between navigation and organisation. Systems can be "inherently spatial", as when information about external reality is mapped onto a computer model of that reality. The authors give an instance of maps, and a particularly good example of such a system can be seen in Google Maps, where street map information can be superimposed on satellite imagery of the Earth. It would also be possible to add information about heights, contours and services, as commonly seen on an Ordnance Survey map. Here, the information is "inherently spatial", because it relates directly to the fact that the map is a spatial representation of a real space. However, the more common case in information representation is when "an underlying *semantic* relationship between information objects is mapped onto a spatial arrangement." [emphasis in original] If objects are grouped according to similarity, or "some other aspect of the underlying information", and these groupings and relationships are transformed into spatial relationships, then "we observe not purely spatial navigation, but semantic navigation which is performed in spatial terms." If this can be achieved, then there are benefits to be gained from the fact that we are familiar with operating in real spaces, and can bring some of our abilities in this respect to bear on a problem.

4.8.4 Social models

Dourish and Chalmers' (1994) paper goes on to consider *social* navigation, in which "movement from one item to another is provoked as an artefact of the activity of another or group of others". This navigation, which includes such activities as collaborative filtering, or recommendations by pages of favourite links, is "embedded in a spatial framework" – it is analogous to real-world situations, but is separated by the authors from spatial navigation, because social navigation can take place in environments where no spatial organisation is present. One might, for example, see a text-based analogue in a world of MOOs [Multi-User Dungeons, Object Oriented]. These systems, which became very popular from the late 1970s onwards, or e-mail lists (Modern British Fiction, for example) have no spatial element in their interface, but can be tools for social navigation:

> "[s]ocial navigation can be effective in information environments organised on non-spatial lines. The observation that valuable information in a spatially-organised system may

> not be directly spatial at all leads us to look for the ways in which we can design more explicitly around semantic and social navigation techniques.
>
> This move away from the spatial model – or, rather, a reappraisal of its actual value – can help, perhaps, in moving away from some of the restrictions of spatial organisation. One problem with the physical dimensions, which are the only basis of separation in spatial models, is precisely that they *are* dimensions – geometric, absolute, orthogonal. We must either restrict our choice of information dimensions to those which share those properties, or build a system in which spatial discontinuities or inconsistencies will arise. This is problematic when semantic and social navigation are seen only to take place as a result of spatial organisation. In realising where navigation is actually semantic or social in origin, we can avoid geometrically-based constraints to which spatial models are subject." (Dourish and Chalmers 1994)

In conclusion, they state that "We should not rush towards using spatial models, nor should we shun them completely. Instead, by understanding what features of navigation and use arise in each case, and how structure, navigation and collaboration are interlinked, the designer can make a more informed decision as to what elements of spatial and non-spatial information systems are appropriate to the goals and activities of the eventual users."

Geometrically-based constraints can be avoided in virtual worlds by the use of hyperlinks. Just as, in MOOs, there is no necessity that moving "north" from one room into another, and then moving "south" will return the player to her original position, there is no such constraint when linking virtual worlds. A room can be "bigger" inside than outside, because the act of entering the door can mean that another world file is loaded into the browser, and any such file can be subjectively limitless in size. Linkages are constructed by the author of the file, and need not follow any logic related to their spatial relation as perceived by the user.

This paper, then, sounds a note of caution in making the decision to use 3D spaces, but gives some useful ways in which to think about these spaces. The three different types of spatial arrangement considered give a new perspective on what had previously seemed a relatively simple proposition – that information sources could be represented as elements in a 3D environment. The implications of this emerging complexity for the current study are somewhat reduced by the fact that social spaces are not considered, an emphasis being placed rather on personal preferences. As Dourish and Chalmers note, the necessity of balancing the "tension between two goals" of maximising the "power behind the visualisations", whereby the individual can organise and filter information, against the need in social spaces to "maintain a common orientation to data and a common structure to the space in which interactions take place" would mean that customisation of social spaces would be problematic. It might be that a distinction would have to be made between social spaces, where presentation of the elements would be relatively stable, and private spaces, which would offer greater scope for experimentation.

Harrison and Dourish (1996) are also cited by Chen, but in a paper where it seems they are more exclusively concerned with collaborative spaces. However, they point out: "With years of experience, we are all highly skilled at structuring and interpreting space for our individual or interactive purposes. For instance:

- The objects we work with most often are generally arranged closest to us. Computer keyboards, current documents, common reference materials and favourite pieces of music might immediately surround us in an office, while other materials are kept further away (in filing cabinets, cupboards or libraries)." (Harrison and Dourish 1996 p.1)

They distinguish between *space* and *place* – "Physically, a place is a space which is *invested with understandings* of behavioural appropriateness, cultural expectations, and so forth." (Harrison and Dourish 1996 p. 3)

Chen is also primarily concerned with social spaces, and with sharing, but there are elements of his work which have relevance here: "we describe a novel approach to the

design of a 3-dimensional virtual environment. We will focus on the role of an enriched spatial metaphor, in which the underlying semantics of a subject domain are reflected through the structure of the virtual environment." (Chen 1999 p. 179) That is a statement of what the present study is attempting, in a way, though Chen focuses on a specific design. He continues "[w]e show that this approach offers a framework that naturally unifies spatial models, semantic structures, and social interactive behaviour within the virtual environment". Bypassing Chen's interests in social spaces, we come to his 2-dimensional categorisation of virtual environments, these dimensions being spatial representation and spatial semantics. "Spatial representation refers to the use of textual, graphical, multimedia or virtual reality. Spatial semantics refers to the extent to which the meaning of spatial configuration is related to the information needs of users." Using this model, the type of worlds discussed in this study would be in a position close to Chen's own Star Walker model – high on the scale for both spatial representation, because the worlds are realistic, 3-dimensional, and "normal" conventions prevail, and high also on spatial semantics, because spatial positioning of items within the worlds has semantic significance. Conversely, conventional chat rooms score low on both axes, whereas Active Worlds and the Blaxxun online community are high on spatial representation – the worlds are "realistic", but lower than Star Walker on spatial semantics – location does not tend to be semantically significant.

Chen's (1999) distinction between spatial representation and spatial semantics, following on from Dourish and Chalmers (1994), and his mapping of virtual world examples onto a graph with these axes, appears to be a promising technique to follow in grouping results. It offers a way to organise the models which can arrange them on a continuum, rather than make an arbitrary split between "realistic" and "fantastic", where it would be very difficult to decide where the division should come.

Chen's own Star Walker system, the design of which is supported by his extensive review of information visualisation systems, plots high on the spatial representation axis, because it uses graphical or virtual reality imagery to convey spatiality. It also comes high on the spatial semantics axis, because the space represented has meaning – spheres are representations of documents, and are connected by rods, indicating strong semantic linkages between the documents. Chat rooms score low on both axes,

not being inherently spatial, but The Palace comes slightly higher in each, because it "inherits the meaning of places in the physical world, using photo-realistic images to convey its spatial organisation, such as the bar or the beach."

In the responses from the first round of interviews from the current study, the space worlds would come quite high on spatial representation, because they do represent a space, and because the position of objects in the space has significance (galaxies and stars are grouped by subject) these models would seem to place quite close to Star Walker. The forest models, on the other hand, have no real organisational principle, so, though high on spatial representation would be lower on spatial semantics. The town uses representations of real places, something akin to the Palace, though less photo-realistic (all models used here would score lower in that regard, compared to the greater realism in Active Worlds, for instance). It has an undetermined spatial semantic score, because it is debatable whether one could say that "the meaning of spatial configuration is related to the information needs of users." Resources in the town are organised by subject, and placed in the appropriate buildings. The organisation of the buildings themselves could conform to a "generic town", or could be by some classification scheme, so the town should probably equate to the space worlds, by that argument. The library has a spatial representation which has reference to the real world, and also has spatial semantics, in that there is significance in where an item is placed within a library which has some definite scheme of organisation. Few of the worlds are not in some way inherently spatial, simply because of the brief given to the interviewees, but the coloured films, the musical world, the OPAC, the world of packets moving past, and the multi-dimensional wheel, appear to be less "spatial" than the others.

4.8.5 User studies

The authors of GopherVR described their initial design thus: "In general, the preliminary design is based on a combination of analysis and intuition; at this point, no testing or prototyping has been done, with the exception of a few mock-ups of 3-D icons and neighborhoods generated to facilitate discussion of how to design legible 3-D icons, and how to support navigation among them. We take it as a certainty that as we proceed both implementation constraints and feedback from prospective users will shape the design in major and unforeseen ways" (McCahill and Erikson 1995). There

is, however, no evidence of feedback from the prospective users, nor, evidently, were they involved in the original design. Gopher was soon afterwards eclipsed by the popularity of graphical web browsers, such as Mosaic (Ciolek 2007)

Chen (1999) studies with interest the reactions of users to the design of StarWalker, but gives them no part in the design process: “The principle [sic] design rationale is that if the virtual environment can reflect the underlying semantic structure of an abstract information space, then users may develop more engaging social interactions. As noted by Harrison and Dourish … what distinguishes a space and a place is whether people can derive various contextual cues from the resources available” (Chen 1999 p. 189).

Since this study is intended to fill a perceived gap in the knowledge of user preferences, it is unsurprising that no literature has been found on the topic of user choices as to world design. Several designer choices as to the construction of virtual worlds will feature in the sections of the thesis which refer to the literature, and these will be used for comparison with the findings of this study, when appropriate.

4.8.6 Image schemas

Mark Johnson’s work develops the notion of “image schemas”, which are at root very simple “gestalts” - “coherent, meaningful, unified wholes” (Johnson 1987 p. 41) derived from our experience of being embodied, and which are used to help us understand the world in which we live. In contrast to an objectivist position, Johnson holds that our world is, to some extent, our own creation, and that we reach an understanding of it by means of metaphors drawn from these image schemas. For example, Johnson uses a Path schema, which has a starting point, an ending point, and movement from one towards the other, and is based on our own experiences of moving purposefully from a starting point towards a goal. This schema can be used to help us discuss and understand purposes and states, through the pairing of metaphors PURPOSES ARE PHYSICAL GOALS and STATES ARE LOCATIONS. This gives rise to our use of phrases such as “She’s just *starting out* to make her fortune. Jane was *sidetracked* in her search for self-understanding.” (Johnson 1987 p. 115) Meaning is not something which is dependent on propositions such as those used in logic, but arises from our observation of patterns in the world.

There are different ways in which Johnson's work is relevant to the research discussed here. Firstly, the usage of virtual reality explored here could be seen as provision of an alternative representation of a metaphor for a physically-grounded ontology. The purposive search for an information resource could be interpreted on the computer screen as a virtual journey from a virtual place representing a state of information need, to a virtual place representing the state of that need having been fulfilled. More simply, it could involve travel from a virtual space in which the information is not accessible to one in which it is accessible. It is possible that this re-casting of the metaphor into a representation which, though "virtual", is perhaps more literal than the examples above, could provide some users with an additional cognitive "tool" in their resources.

Secondly, although the worlds described by most interviewees were considerably more complex than the schema given as instances by Johnson, the situation to which they were asked to respond was also complex, and it might be expected that the metaphorical structures, if such they are, would be similarly at some remove from the simplicity of the image schema. Nevertheless, there are instances which could be interpreted as PATH and CONTAINER, for example. Where the schema/metaphor ontology becomes most interesting, though, is in what Johnson calls "constraints". These are "like channels in which something can move with a certain limited, relative freedom." (Johnson 1987 p. 137) The constraints can thus be seen as guiding the use of the metaphor: "Which inferences are sanctioned will depend … on the metaphorically organised background against which phenomena appear, questions are posed, investigations are performed, and hypotheses are formulated." (Johnson 1987 p. 137)

This appears to be a constructivist, interpretivist, position, in the senses that these terms were used in the discussion of the arguments for and against the Grounded Theory methodology.

4.9 Emergent theory

A memo at this stage noted the following points.

It had become clear that some non-respondents to the first call for volunteers had simply failed to understand what the topic was. For the next series of interviews, prospective interviewees would be given a talk, with images of examples of 3D worlds taken from the World Atlas of cyberspaces, in order to inform them further about the topic, and in an attempt to increase participation. (See Appendix B)

There was a danger acknowledged here, that the second group might therefore be somehow different from the first, and it was resolved to monitor responses to check that they were not noticeably different.

Differences were noted between “real” and “abstract” worlds, and between worlds which represented information retrieved from a search, and those which represented storage for personal information. In the first case, the user might reasonably expect to “find things as they left them”, whereas in the second case, results would have to have
Some sort of organisation, so that the user would know how to go about searching them. If the user is looking at the total information space, do they have their own order imposed on it, or do they opt for a “consensual hallucination” as in the fictional texts? There might also be a distinction between a personal space, like that which the librarian inhabits in ‘Snow crash’, and the “commons”, where everyone shares a common view.

If there was found to be a distinction between “realists” and “abstractionists”, then it was considered at this stage that the abstract thinkers would prove to be more interesting.

Memo: Aberdeen Business School

A greater variety of models than expected came from this series of interviews. In order to draw useful conclusions about users in general, it was thought desirable to identify common elements which would allow worlds to be dealt with in groups, rather than dealing individually with such a large number. As discussed above, there were several characteristics by which they could be grouped, for example by overall structure, as discussed in section 4.4. This would divide the worlds into those which were in some sense "urban", those which had a "space and planets" theme, and those which had growing things. There would, however, be a large number of worlds which did not fit any of these groupings. There were non-structural similarities amongst worlds, as discussed in section 4.5, but features such as colour, size, sound and motion did not occur in a large enough number of worlds to be useful in classification. It seemed at this stage that the worlds could be categorised into four types, in a way which would also include the large number of more "idiosyncratic" worlds, by treating them as being split between realistic and non-realistic, and also between organised and un-organised. This classification could cover all the worlds, and provide a manageable number of alternatives for the next iteration of the research. It was also noted that many examples of all types of world had elements of "richness", going beyond a simple short description, which could not be expressed in a simple keyword classification. The individual imagination requires individual interpretation, and the variety of worlds is more extensive than the variety of keywords assigned to them.

The theory at this stage was that: **All worlds could be classified into one of four groups, and that people would tend to prefer using a world typical of one of these groups.** This allowed the next stages of the testing to be carried out using a practicable number of demonstration worlds.

A suitable way to test this theory, and to develop it further, seemed to involve moving from a hypothetical situation, where interviewees were asked to imagine a 3D environment, to a situation in which they could experience such an environment, and seek reactions to this.

Chapter 5 Series B interviews

The purpose of the second round of interviews, which was named series B, was to use four world models to explore the interviewees' reactions to having an actual experience of using the worlds. However, the initial feedback from the series B interviews revealed consistent criticism of particular characteristics of the models and their presentation. It was felt best to deal with these issues immediately, with the result that series B was divided into two parts: B1, using the first generation models, and B2, using the modified models. The overall purpose of series B was consistent, in that it constituted a "road test" for the models derived from series A, but it was felt to be wasteful of interviewees' and researcher's time to continue with models which were obviously flawed, and merely to have the same criticisms reiterated. On reflection, it is felt that this was an instance of the researcher being "too close to" or overly familiar with the models, and as a result failing to notice problems in usability which could be relatively easily rectified. This emphasises that even though researching user preferences can play a valuable part in the design process, usability testing is still very necessary.

There is a considerable literature on so-called "immersive" VR – Bowman and McMahan describe successes in the fields of phobia therapy, military training and entertainment, before describing an ongoing series of experiments to determine influential factors (Bowman and McMahan 2007). Discussing the work of Myron Krueger, an artist who was also a pioneer in the field of virtual reality, Hansen (2006) states that immersive technologies "call upon—and ultimately, refunctionalize—the body's role as an 'invariant,' a fundamental access onto the world, what psychologists and phenomenologists have called the 'body schema'" (Hansen 2006 p. 26) . Although Case, the protagonist of 'Neuromancer', feels when unable to access the Matrix that he has fallen into "the prison of his own flesh" (Gibson 1986 p. 12), Hansen would seem to suggest that it is the very fact of our embodiment which works to maximise our experience of the "virtual".

Early in the current research the decision was made to concentrate simply on the properties of the representations, the “worlds”, rather than attempt to deal with the many issues involved in immersive implementations. Issues such as “motion sickness”, which may be related to the processing speed or refresh rate of the equipment, or to the quality of the interface hardware, were considered secondary to the main drive of the research – determining whether interviewees could or would use virtual worlds for accessing information, and how these worlds might best be designed. It was therefore decided best to leave as a matter for future research the question of which technologies would be best used for the display. Other factors here were simply expense and convenience – it is much cheaper to mount worlds on a web server, and access them through a browser on a machine with the appropriate “plug-in” software installed, or even to load the worlds into the machine, than to go to the expense of acquiring and setting up equipment such as head-mounted displays, treadmills, motion-tracking equipment, or CAVE-type environments.

A simpler process is to use the same models as those used by immersive VR, and instead display them on a conventional computer monitor. This reduces the “sense of presence”, but is considerably less expensive to implement, and has been used with great success in computer games such as Doom and Quake. (id Software, 1993, 1996) It also had the advantage of being usable wherever there was a suitable PC available, or using a notebook computer, so that the interviews could be carried out in a place convenient for the interviewee.

In neither case does the viewer see three dimensional objects. Rather, a technique called "two-and-a-half D" or “2.5 D” is used, in which the viewer sees two-dimensional shapes, scaled and rendered with perspective and shading, so that they are perceived as being components of three-dimensional shapes. Contemporary computers are capable of performing this drawing and redrawing process in “real time”, which increases the illusion of the viewer that she is able to “move around” in a real “place” (Chadwick 1999).

5.1 The models

The next stage was the development, then testing, of the representative models. The worlds were created in the Virtual Reality Modelling Language (VRML), initially using Microsoft Notepad, a text editor, and later using a specialised VRML editor called VrmlPad. The process is iterative, consisting of writing world files, testing them in by viewing with a web browser and VRML "plug-in" application – Cortona and BitManagement VRML clients were used – and then returning to the edit stage, to make corrections. Four worlds were created, with the intention of representing the major classes which had been found in the series A interviews, i.e. a) concrete and ordered, b) concrete and unordered, c) abstract and ordered d)abstract and unordered. Two worlds were "concrete" – a town, which was taken to be "unordered", in that there was no obvious rationale behind the placing of information, and a library, which was "ordered" in that the stock was arranged according to the Dewey Decimal Classification scheme. Two were "abstract", in that they were representations of real things, but of things which would not normally be considered as sources of information. The forest was unordered, in that the trees had no particular arrangement, whereas the space world was ordered by Dewey Decimal Classification.

5.1.1 The forest

The forest (see fig.10) was designed as a small grove, consisting of ten trees, each of which represented an information resource, concerning books and book collecting or Scottish universities. The models were represented as inverted green cones of "leaves", surmounting brown cylindrical "trunks". The trees were of varying heights. This was intended to represent the un-ordered and abstract worlds.

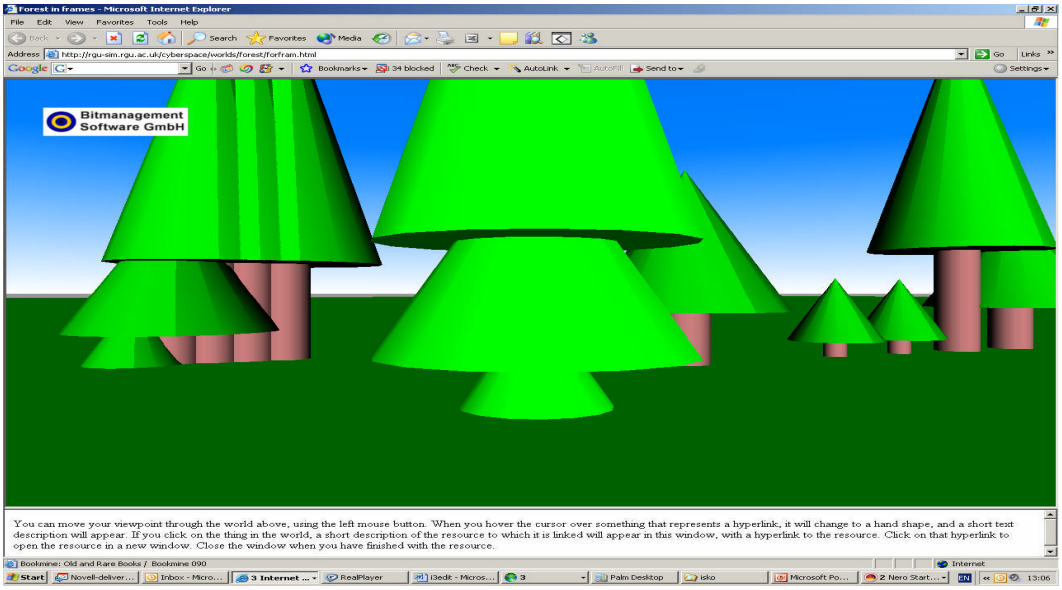

Fig 10: Forest

5.1.2 The library

The library model (see fig. 11) was of a room containing six parallel shelving units, each holding some of the same book models as were used in the town. Some experiments were conducted with adding titles to the spines of these “books”, but these proved too difficult to read. At an earlier stage, book models had been produced which could be “pulled” from the shelves, rotated, and opened to display a title, but the mouse gestures required to do this were difficult to perform, and it was felt that a simpler design, displaying author, title and classmark in the form of a tooltip when the mouse cursor was hovered over the book, would be more easy to understand and use.

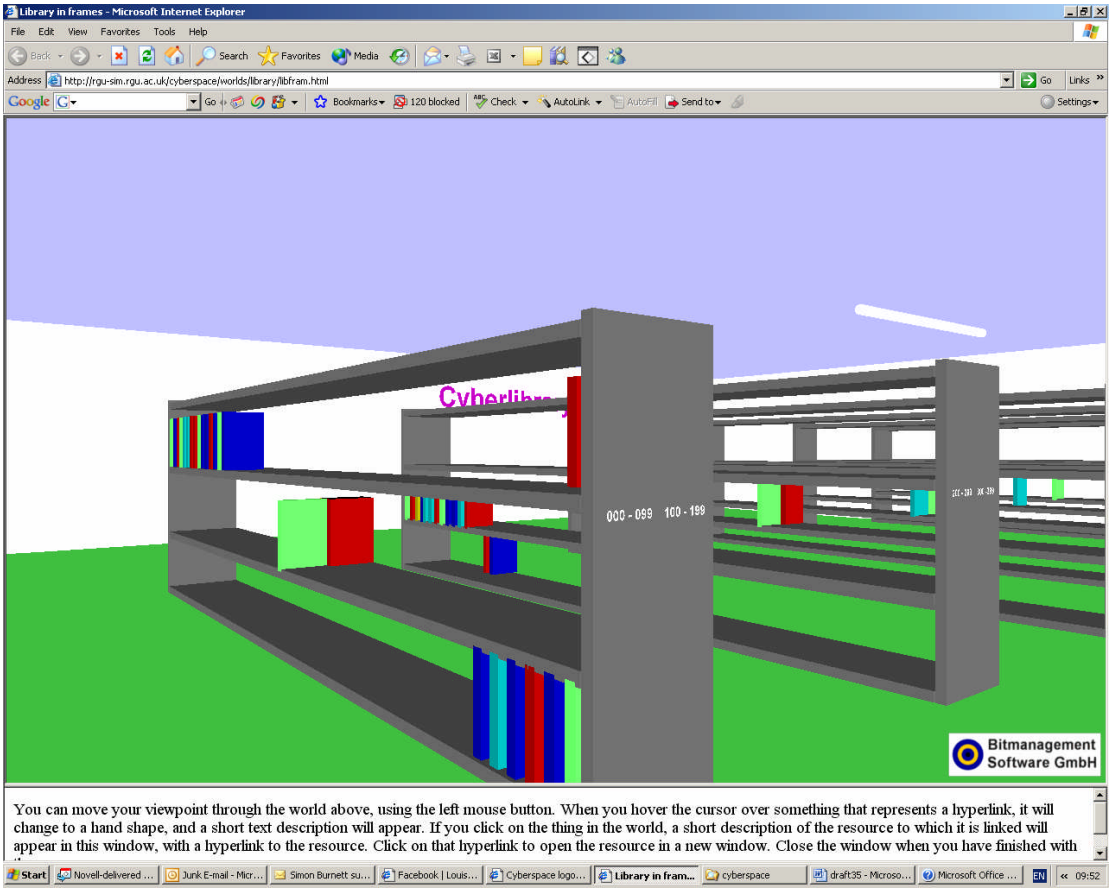

Fig 11: Library

Information resources in the library were selected from 4 subject areas – generalia, philosophy, religion, and Scottish universities, each representing an aspect of the first four major Dewey classes. The ends of the shelf units were marked with the corresponding range of Dewey Decimal Classification classmarks. The library was intended to represent the ordered and realistic class of worlds.

5.1.3 Space

In the space world (see fig. 12), one “star” and three orbiting planets per star, were each assigned one of the subject areas of generalia, religion, sociology, philosophy, and engineering. Each planet represented an information resource, and each grouping of star and planets was coloured differently. The stars were arranged in a line, in order of their Dewey major class, this world being intended to represent the ordered but abstract class of worlds.

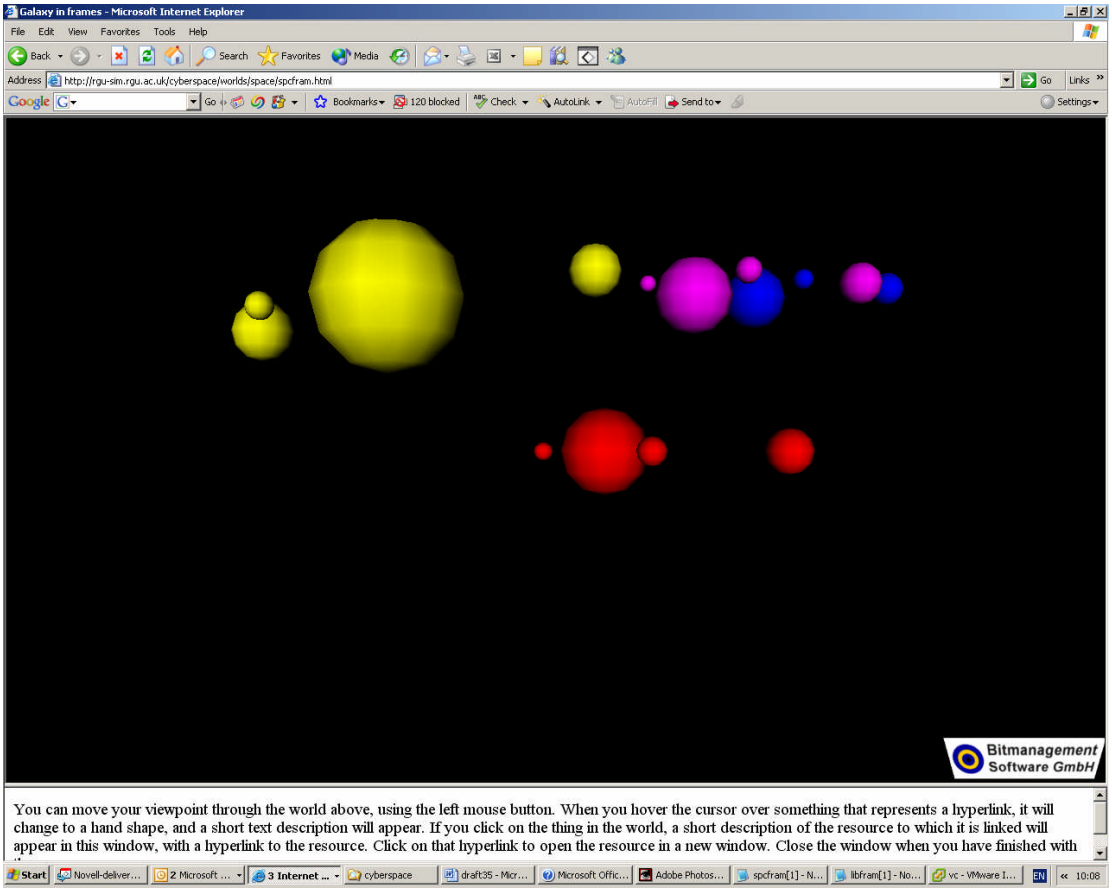

Fig 12: Space

5.1.4 The town

The town model (see fig. 13) consisted of representations of buildings, placed around a central square. The buildings were not realistic – they were extrusions of a rectangle with a missing section to permit entry. Those with resources in them had signs – “Books”, representing generalia, “The philosopher’s store”, representing philosophy, and “Religions” – indicating the subject area covered. There were also some buildings without resources, either on the edges of the square, or on one of the roads leading from the centre of each side of the square. The world was represented as brightly lit, with a blue sky, green grass and a grey road surface. The buildings were brightly coloured. Information resources in each building containing them were represented as books, arranged as if on a bookshelf. These were also brightly coloured. The town was intended to represent the un-ordered and realistic class of worlds.

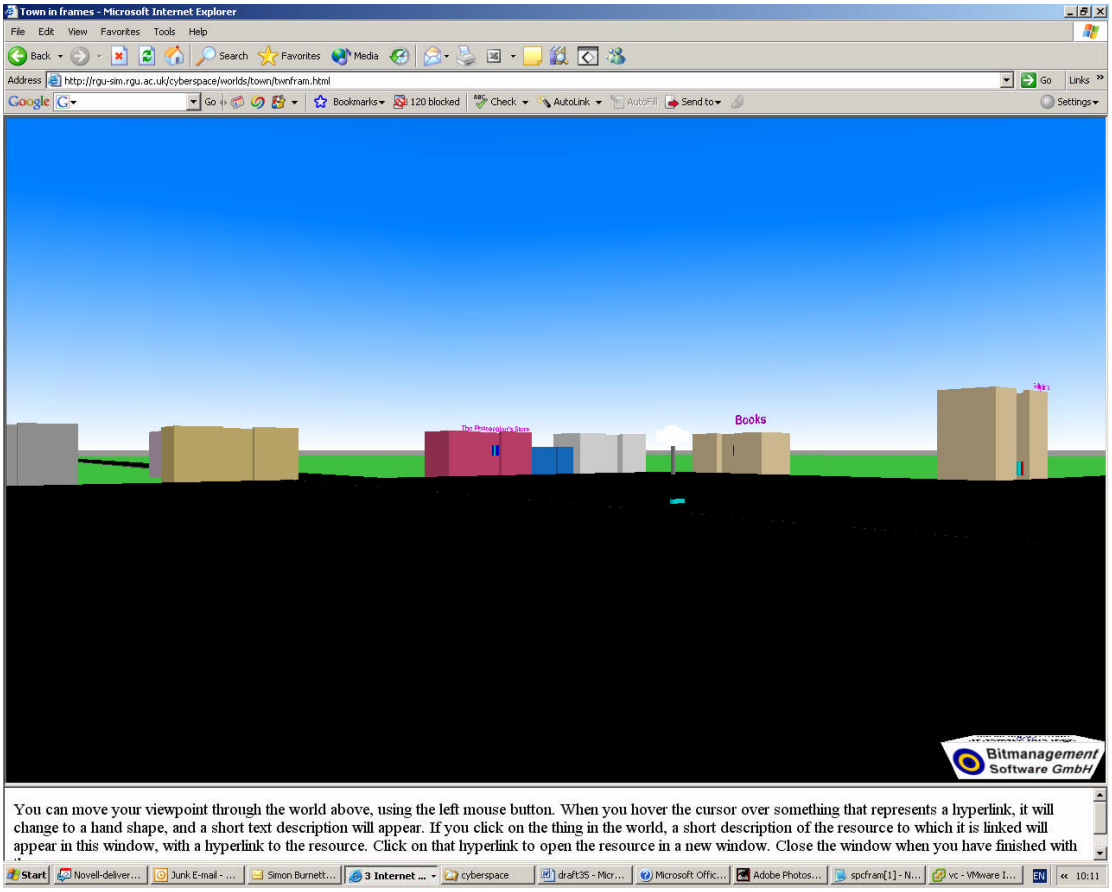

Fig 13: Town

5.2 B1 interview conditions

Series B1 interviews were carried out with MSc students from the same group of courses as those in series A, Chapter 4, though with different individuals.

The second series of interviews was carried out as the interviewees moved around in the four “worlds” which had been constructed to represent the most popular images from the first series. The worlds were accessed from an introductory web page, and it was necessary to close the world scene after each world had been tried out, and to return to the introductory page. The links to the worlds were labelled “Forest”, “Library”, “Space” and “Town”. The worlds themselves were very simply constructed, as described in 5.1, above, and contained only sample resources. Although the other three worlds remained very similar in appearance throughout the series of interviews, the Space world used here was set against a dark background, with subjectively large planetary systems, each orbiting a “sun”. In this series,

interviewees were not asked about ideal worlds, but the interviews were concerned with moving around in the worlds, and the interviewees were encouraged to comment on whether the worlds were more or less what they had expected, whether they found any features particularly easy or difficult to use, and whether they thought they might be able to use the worlds to access information.

5.2.1 B1: test findings

The testing immediately showed up some basic flaws, suggested some "low cost" improvements, and helped shape the "interview technique". The plan at this stage was just to introduce each model – forest, town, space and library, and to let the subjects use each in turn, whilst observing and recording them. These interview tapes are long and there are long pauses, people do not say much, and tend to polarise into very enthusiastic or very unimpressed (mainly the former). There was also more criticism of minor features than was expected, perhaps due to a failure to communicate properly the prototypical nature of the worlds.

This material was interesting in view of a) it being the interviewees' first reaction to seeing this type of 3D information world, and b) their responses while moving around and interacting with the worlds. The worlds thus functioned as vehicles for the discovery of user preferences within a quite restricted set of options.

Interviewee 54 liked the library, and also "like[d] the idea of orbiting things … if there were different sizes to represent different things" and different colours to show which things were related. More general comments by this interviewee were "interesting", and "makes it more fun!" However, this interviewee found it difficult to manoeuvre into the shops in the town, and also commented that the library would be easier to use if the user could "walk through" the stacks. These points relate to collision detection, and will be discussed later.

Interviewee 55 thought the library made "a lot more sense … if you're looking for something specific, and you're not in a library, and you know it is in a library … even if you didn't know the classification scheme, you could probably poke around." The town was thought to be "like a bit of a computer game, but in a way that makes it easier for people who are used to dealing with computer games." However, "the

spacey one I didn't really like much, because it was difficult to see what each revolving rock was", and asked if the different heights of the trees in the forest were "to do with hits". The heights of the trees were, in a later version, related to the sizes of the sites to which they were linked. This interviewee's general comment was, "[b]roken down into sections it's easier to look around if it's got a certain map to it, rather than general ad hoc."

Interviewee 56 preferred the town and the library, because they were "more traditional. They made more sense to me than the one in outer space and the tree one." This interviewee also thought that preferences might be due to personality types: "some people like mind maps and stuff, they work in computers, and some like trees and stuff a bit more flexible. I like my library." Generally the idea "keeps your interest a lot more", and was thought to be "like a computer game"

Interviewee 57 asked questions about the classification schemes used in the library and space worlds, and commented that the library was like a "conventional library". However, this interviewee did not express a preference.

Interviewee 58 said, "I think visually I preferred the planet one - I thought that was quite novel. I like how you can sort of wander through the virtual thing." This interviewee also commented that the library model might be useful for "bridging the gap" between people "seeing the information in a sort of library context" and the concept of virtual libraries.

Interviewee 59 asked if the sizes of the trees in the forest represented anything. The interviewee found it inconvenient to be returned to the starting point in the library, after opening a resource in the same window as the world, and enquired whether it was possible to walk through the shelves. In the space world, the interviewee commented that when worlds went out of sight, it was necessary to wait for them to reappear. General comments were that the idea was "definitely more interesting. The only problem with those might be if you were wanting to do something really quickly, you might be a bit too slow. But, I suppose if you were browsing …simply searching for information here and there, with out having to rush about, it would be quite good."

The interviewee agreed that as a way of organising personal information, this might be useful “especially with something you would know well, like in work.”

Interviewee 60 liked “the planets and the shelves”, but had little to say beyond remarking that the classmarks were “useful”.

Interviewee 61 was familiar with computer games, and gave very more detailed feedback than other interviewees. First, he remarked that the small windows in which resources opened were limited in size, and that the larger window in which the world was shown was “better”. Having become disoriented in the Space world, he proceeded to explore the control available through right-clicking with the mouse. No other interviewees tried this, and it had not been explained to them, the intention being to keep the interaction as uncomplicated as possible. This interviewee, however, discovered the Examine mode, which permits the world to be moved relative to the user’s viewpoint, rather than the viewpoint moved relative to the world. This mode provided the best way to orientate the planetary systems in the space world, so that all could be viewed at the same time. He commented, “You need more to show you where the boundaries of the thing in space are.” He also managed to change the speed setting, so that he was more comfortable with the speed of movement, which he had found to be too fast, and activated the “View my avatar” option. This proved to be useful in navigation, because it provided better orientation when trying to enter buildings. Although the interviewee did not turn off collision detection, he commented that being unable to progress because of a wall was “one of the things I’ve always found awkward about games”. Overall, this interviewee liked the town because with the “ground and the road, there’s no real way of getting lost.”

Before seeing the library example, interviewee 62 suggested, “I assume that your graphics could probably change into so if it was, say, I don’t know - a library? You could have graphics on the shelves and maybe different spines representing the different subject areas, and so this kind of model would just sort of be visual feel like you’re walking down the stacks.” He was critical of movement within the library, though, and also of the necessity to shift ones attention from a virtual object, to a different frame with brief details, and then to a new window. This last feature was common to all the worlds, at this stage. This interviewee took quite a concrete

approach to the virtual worlds – for example, the idea of associating models of books with resources other than books did not seem to appeal to him, and he consistently referred to "books" whilst in the library. He suggested that the town could represent the website of a council, with the different buildings related to different departments, though it would be difficult to tell which was which, because of the undifferentiated nature of the buildings in the model. He also suggested the model of a university campus, with buildings representing the departments, and a map of the buildings, so "you have a map and a virtual physical … the actual departments yeah, great idea." He, too had difficulty navigating in the town: "I think you're too really concerned with the getting around. I mean, it's very friendly, but you almost expect a tank to come round the corner and shoot you".

5.2.2 B1 analysis

This group of interviewees was the first to be able to test the worlds, and, in addition to constructive criticism, they gave quite positive feedback about the idea of virtual worlds in this context. Responses from each interviewee are presented in Table 4.

Table 4: B1 Affective responses

54	Interesting/makes it more fun!
55	Easier to look around if it's got a map to it
56	they're … more traditional. They made more sense to me
57	nothing
58	More interesting
59	I like the concept
60	It's good
61	Yes, I'd use it. I think computer games have potential.
62	interesting

It seemed that some common features were emerging here – space is interesting, but does not have orientation features. The forest is not organised. The town buildings are too difficult to get in and out of, but the town itself gives context. The library has organisation, context, and familiarity, but the town, or even the planets, might be more "fun".

When the B1 series of interviewees were prompted to select which world, or worlds, they preferred, their responses were as presented in Table 5.

Table 5 : B1 choices

54	Library and space
55	Library
56	Library and town
57	No preference expressed
58	Space
59	Town
60	Space and library
61	Town
62	Forest and library

Out of nine interviewees, four made a clear choice, whilst four made first and second choices, with the implication that the choice was quite close. One expressed no preference. Library was first choice three times, and town twice. Space and forest were each first choice twice.

The reasons for designing the four models used at this stage, were to provide worlds which were a) concrete and organised world, b) concrete and not organised, c) abstract and organised, and d) abstract and not organised. These results would seem to indicate a preference for the concrete, obviously organised world, as against the more abstract, less obviously organised. In the case where forest was first choice, the second choice was library. On one occasion space was a sole choice, and forest did not feature as a sole choice.

5.2.3 B1 specific problems in worlds

Common problems were identified at this stage. In the space world, disorientation and difficulty remembering the identity of moving planets were mentioned. The objects in this world were much larger than the avatar, and the planets were in orbit around their respective “suns”, so that, even when a planet was identified from its “pop-up” label,

the fact that it was moving made it difficult to track, and to remember the identity of. The space itself was black, featureless, and unbounded, which appeared to present orientation problems – after some turning around, users forgot which direction planets were in, relative to their avatar.

The town presented difficulty in that the interviewees found it difficult to enter the doorways of buildings. This problem appeared to be simply a matter of getting used to the control of the mouse in this manner, although the one interviewee in this set who professed experience of computer games also stated that he had had similar problems while playing them. The interviewee who used the "View my avatar" option remarked that this made it easier to enter the buildings.

The library caused some navigational problems also, partly because, being designed, like the town, on an avatar scale, interviewees found it difficult to navigate around the stacks, there being relatively little difference between the "size" of the avatar and the distance between stacks. Two asked if it was possible to move through the stacks, which can be done by switching off Collision detection from the right-click menu options. The main point which emerged in the library was that when an item was clicked, the resource should appear in a new, resizable window, so that the user's position in the world could be maintained, whilst the resource was examined. To explain this point more fully, if the linkages to external resources are made so that they open in the same window as the "world", it is necessary to reload the page containing the world, once the resource has been examined. Reloading the world means that the user's viewpoint returns to a fixed starting position in that world, so that it is necessary to retrace the path already taken, in order to resume the position of the viewpoint in the world, before the link was followed. When following links in a conventional web page, to resources which open in the same window, if the Back button on the browser is used, the user's point of view will normally return to the point on the page containing the link which was followed. Since returning to the starting point may mean a lot of repetitive navigation for the user, and since this detracted from the perceived realism of the experience, it became desirable to find an alternative.

The forest prompted questions as to its organisation, if any, and as to what, if anything, was signified by the heights of the trees, but was not criticised otherwise on functional grounds.

5.2.4 Changes made in response to series B1

It was decided at this stage that sufficient criticism had been offered to make it worthwhile to amend the models, so that at least some of the recurring issues were resolved before proceeding with the Series B interviews. This was done partly because the criticisms were evidently well-founded, and could be attended to reasonably quickly, and partly in the spirit of, “release early, release often”, which is a development policy commonly adopted in the open-source software movement. In essence, the sooner that new versions can be released, the more opportunity there is for them to be corrected in response to feedback. The desired feedback had been gathered at this stage, and it was thought best to respond to it, before embarking on more interviews.

The frameset in which the worlds were displayed was dropped, in response to the criticism about shifting focus, the desire to give the worlds a bigger display, and the fact that it was unsatisfactory to have to scroll in another frame to read the instructions and, sometimes, the item summaries.

An attempt to solve the issue of context was made, by importing the Space world into Town, and placing it, scaled down to a more convenient size, in the context of a “planetarium” building. This was intended to make it easier to use, by reducing the disorientation which was evident from some interviews. Another modification to improve usability was that the “planetary systems” no longer orbited, it having proved difficult for interviewees to retain the identities of particular planets, whilst the whole system was in motion. The forest was placed beside this “planetarium” building, and the library was also placed beside the town square. A view of this world can be seen in fig. 14.

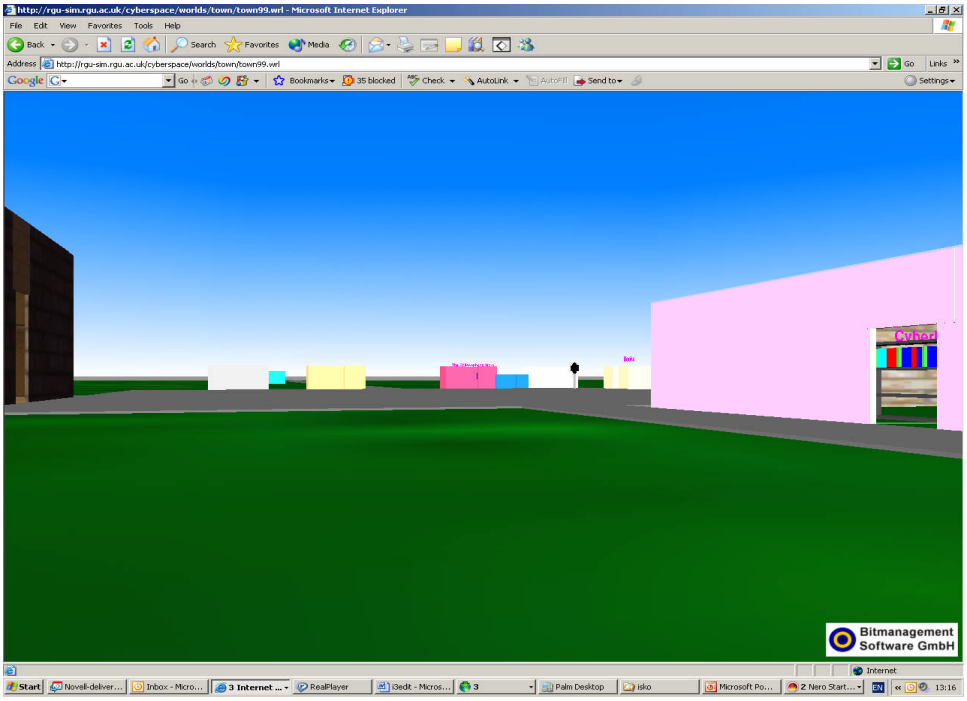

Fig 14: Adapted world

These measures were intended to allow people to make direct comparisons as to the ease of use of the different environments, in a “world” context, and it was with this model that the B2 and C series of interviews were conducted.

In the interests of saving time, and because most interviewees coped with the restrictions placed on movement by the town and library, the sizes of doorways and the spacing between library stacks were not altered. The “starting from scratch” problem mentioned in 5.2.3, above, was remedied by opening resources in new windows. This meant that the avatar’s position was maintained in the window displaying the 3D world, so that when the focus was moved back to that window, activity in the world could continue.

5.3 B2 interview conditions

The series B2 interviews were conducted with the revised world arrangements. The content of the worlds, and the resources they linked to had not been changed, but some changes in presentation had been made, as noted in 5.2.4, above. The aim of this set of interviews was again a) to note interviewee responses to experiencing this type

of 3D world for the first time, and b) to note their responses while moving around in, and interacting with, the worlds. B2 interviews had the additional aim of establishing whether the revised arrangement of the worlds was suitable to carry forward to another round of interviews. The candidates for this series were, again, MSc students from the same group of Information Management courses as had provided candidates for the earlier rounds. There were 8 interviewees in this series. The physical conditions in which this round of interviews took place was the same as for the B1 interviews, but the virtual setting was now different, as explained above. The fact that the interviewees could move their viewpoint seamlessly from one world to another, without the necessity for using the browser's Back button, or closing windows, meant that they had more freedom of movement from one world to another, and the opportunity to retrace their path easily. Interviewees were shown where the worlds were in relation to one another, and then encouraged to explore them, and to access some of the information resources

5.3.1 B2: test findings

Interviewee 63 had navigation difficulties, and found the forest particularly difficult "the trees, because you bump into them, rather than navigate." The library was thought to be "easier to take in", but the idea of "aim for a certain area" in the town was mentioned favourably. This appeared to be a reference to the user feeling handicapped in moving around the library by the presence of shelves and walls, whereas in the town square, the cursor could be used to direct the viewpoint to a particular building, and the only problem then would be "entering" the building. It is possible that a re-scaling of the library model would have eased this person's navigational difficulties, and he liked the "idea of knowing what's there and what you have to find" which might be achievable in a world customised for individual preferences. The amount of time taken up in moving around was seen as being a problem. 63 had something positive to say about all the models, except the space world – "I like things that I could relate to everyday life, rather than fantasy, as it were, like the galaxy." The idea of using a world for personal information was also appealing: "I would use it more as a personal thing, rather than just randomly searching for information, personal set-up and it's my little world, and I have things that have meaning in my usual, I would use it in that context, and I'd actually find that a lot more .. the idea of that much more exciting than using it as a search engine."

64 had concerns about navigation, principally the lack of a map, signing, and speed. When it was suggested to this interviewee that an orthogonal view might be preferred, where the point of view could be "flown" over the world, to get an overview, he responded, "A-ha! kind of like a website, with a site map, so you have the overall structure". This, though, becomes essentially a two-dimensional model, and it was felt that this interviewee failed to see the potential of 3D. From another comment about getting "stuck" in a shop, where "you can't see that, you've got to turn round", it seems that the issue of an overview was of particular importance to this individual, and though the desirability of maps is mentioned by other interviewees, this individual expressed most dissatisfaction at the lack of one. This interviewee was particularly concerned with usability issues, and was also critical of the design of the items in the world which were links to resources, in that it was not apparent which they were, until the cursor was hovered over them. This is in contrast to hypertext links, which are by convention blue, red or purple, depending on whether their status is unvisited, active, or visited.

65 seemed to require a higher degree of realism than was offered by these models : "I don't like you just building everything square. Library should be like library, bookshop should be like bookshop. You should have something more like the real world. So you don't have to actually find out what that thing is." This is a good point, and would be remedied in a more developed model. This interviewee also wanted a "3D helmet", a world with private and public areas, and a map, which could be "just 2D". This was a considerably more sophisticated world than the examples shown, where immersive 3D would be used, users would have houses off the square, in which they could arrange and access personal information, and the square would be a public area, in which users could communicate. This interviewee was the first to suggest a multi-user world, entry to which would have to be by password, for reasons of "safety".

Interviewee 66, rather unusually, liked the forest, because it "made the most" of the possibilities of the interface, compared to the library. If the size of the trees reflected the size of the resource, then this interviewee would want other features, for example

the covers of books in the library, which similarly took advantage of the representation. 66 also said moving around “should be really quick.”

67 thought the observatory (space) “quite interesting - planets, and then quite easy to migrate round”. This ease of navigation in the space world, which had not been mentioned before, might well be a result of the re-scaling the planets, and enclosing them in a building. This interviewee showed no particular enthusiasm for any model, though did think it would be better to have coverage in both the library and the town expanded to a full range of subjects, with the buildings in the town “different structurally”, depending on subject: “something with different houses that each had subjects in, or something like that. You’d go there what you were looking for, and they’d be broken down inside, aspects of the subject … houses, they could have a menu to tell you what they mean.” There seems to be a sense here of the interviewee rather reluctantly accepting that it might be possible to get a functional model, but this would be achieved by overlaying a more conventional menu or hierarchical structure with visual props.

Interviewee 68 felt that “in the library you can just skim down the aisles”, whereas the town demanded more moving around, though in the town “you could expect that you’d find what you want and other things that are sort of similar to it”. The town, however, was “actually quite good”, but the reaction to the space world was, “I think if each one [solar system] was to represent one resource. I think I find the whole thing too complicated.”

69 liked the idea of the library, “just because it was familiar”, and also chose a library as an ideal world: ” I think probably everything neatly classified, go in there, oh you could have a cyber-librarian, at the desk, so you could go up and say, I want something on the …” The interviewee was not impressed by the forest, but “liked the planets, especially as you’ve got them nice and clear.”

Interviewee 70 had previously been a computer-aided design user – “I used to do CAD and think three-dimensional.” However, this interviewee was unable to use the worlds effectively, and commented on feeling “lost”. The interviewee had also played computer games, although he had preferred games which were “More simplistic ...

slower … make up your mind without getting blasted." The only comments made directly about the worlds concerned the town, where "I think that the fact that you can walk through walls rather upsetting in relation to that area, to go through the wall." The interviewee also thought the shops were too small, and suggested as an improvement: "having the boxes big enough that you can go in, sort of turn around, and be able to see." The interviewee did not express a preference for any of the worlds, appearing equally ill at ease with all of them.

5.3.2 B2 analysis

As with the B1 group, the B2 group provided criticism which ranged beyond the structural, and related more to how they felt about using the models. These responses are presented in Table 6.

Table 6 : B2 affective responses

63	Simple
64	Interesting
65	I don't like you just building everything square
66	it's different … it's pretty, it sort of catches the environment
67	Quite interesting
68	More interesting than "your favourites"
69	the forest didn't particularly appeal
70	lost

The affective responses presented here are more mixed than those from group B1, presented in Table 4, but are again predominantly positive.

The choices expressed as to a preferred world are presented in Table 7. The ‘main choice’ has been presented here, taken from analysis of the language of the users.

Table 7 : B2 choices

63	Town
64	No preference
65	Town
66	Forest
67	Space
68	Library
69	Library
70	No choice

Here two interviewees expressed no preference (one in group B1). Library was main choice twice (three times in group B1), as was town (twice in group B1). Space and forest were again main choice once each. There is little difference overall in the responses which cannot be accounted for by the fact that group B2 had one fewer interviewee, whilst it also had two interviewees who expressed no preference. Whilst there are far too few interviews from which to draw useful quantitative data, the response to the worlds and to the idea of using them to access information, does not appear to have been changed markedly by the change in the manner of presenting them which was implemented between the B1 and B2 sets of interviews.

5.3.3 B2 specific problems in worlds

Specific problems in the B2 interviews were again concerned with movement, and will be dealt with in the following section.

5.4 B1 and B2: observations

This section is not concerned with interviewee responses, but rather with observations of their interactions with the worlds up to this stage. It has been observed that some interviewees experienced difficulties in navigation within the worlds, and an attempt

will be made in this section to investigate possible causes and to explore possible remedies.

5.4.1 Motion

5.4.1.1 Mouse

When using a mouse, the user interface for the VRML plug-in is relatively simple, and most users appeared to grasp it quickly, once it was demonstrated. Essentially, the left mouse button is held down, and movement then depends on the direction in which the mouse cursor is moved within the VRML browser window.

5.4.1.2 Cursor control keys

The cursor control, or “arrow”, keys on the keyboard may be used instead, but though this was indicated to interviewees, none elected to use this method. One interviewee tried using a touchpad, when the worlds were being displayed on a notebook PC, but found it inferior to the mouse which was substituted for it.

5.4.1.3 Direction

Moving the cursor towards the top of the window moves the viewpoint “forward”, moving it down moves the viewpoint “backward”, moving the cursor horizontally left or right rotates the viewpoint left or right, as if the viewer was turning to their left or right, and degrees of forward or backward and rotational motion can be combined by mouse gestures combining up/down and lateral vectors. Speed of motion is relative to speed of mouse motion, although the base speed can be set in the browser controls.

5.4.1.4 Modes

The passage above describes the mode of motion usually referred to as “Walk”. Other modes are also available, either through buttons on the browser interface or through right-clicking on the browser window. “Fly” allows the user to move the viewpoint away from the y-axis, and apparently fly through the space. “Study” or “Examine” – the usage varies according to the browser used – “freezes” the viewpoint, and apparently moves the world, relative to the viewpoint, rather than vice versa in the “Walk” or “Fly” modes. “Plan” allows the viewpoint’s frame of reference to be

moved smoothly along a vector set by the movement of the mouse. “Turn” rotates the viewpoint smoothly around an axis, as set by the movement of the mouse.

5.4.1.5 Experimenting with modes

“Walk” was the mode demonstrated to interviewees, though two interviewees were curious enough to experiment with other modes, when they discovered independently how to switch modes. Both had previous experience of computer gaming, and one rapidly discovered that the “Study” or “Examine” mode could be useful for user orientation, in that, as its name indicates, it enables a world to be “manipulated” and oriented so that the user can establish their whereabouts relative to objects in the world. This user was also the only one to discover that an avatar could be made to appear when using a particular VRML plug-in, so giving the user an “embodiment” in the virtual space. This interviewee exhibited a degree of confidence in using the interface which appeared considerably greater that shown by any other interviewees using the models.

5.4.2 Orientation

The VRML 2.0 standard offers the world author the facility to define the first viewpoint from which the world is seen by the user after it is loaded, and also to define “Viewpoints” elsewhere in the world. Since no other viewpoints were defined, and the largest world used was composed of four smaller worlds, there were four viewpoints which could be “jumped” to, by selecting them from a right-click menu. When interviewees were shown this, they appeared to use this mode of travel in preference to “Walk”ing from one scene to another. Although it might be assumed that this disjointed mode of travel would render the experience less enjoyable, it addresses some of the concerns about speed of motion and about navigation mentioned in chapter 5, above. If motion via the Viewpoints menu is chosen, the user’s viewpoint moves with considerable speed to the viewpoint specified, and intervening obstacles are not a barrier

5.4.2.1 Scanning

Interviewees did not appear to scan or survey a world on “arrival”, and in particular tended not to “look behind themselves”. In the solar system world, which had its initial viewpoint facing away from most of the planets, this was quite problematic.

Some interviewees appeared startled to find subjectively large planets “behind” them, when these were pointed out. Since users can travel a subjectively infinite distance in a world with no bounding features, there is always the possibility of becoming “lost in space”, once the world content is out of the field of vision. Most plug-ins have a Reset facility, however, which effectively reloads the page. Two 3D browser plug-ins were used : Bitmanagement GmbH BS Contact software , and Parallel Graphics’ Cortona VRML client. Their functionality was very similar, and the switch was made because one world began to display as very dark in BS Contact, but was acceptable in Cortona. The cause of this problem was not identified.

5.4.2.2 Context

Unsurprisingly, having “contextual” images, such as sky and ground, or walls inside a building, appears to reduce the lack of orientation experienced in black space. However, if the room is subjectively small compared to the size of the avatar, it seems that walls can be a hindrance, too, if the avatar is positioned too close to them.

Issues relating to the “size” of the avatar, specifically to fitting the avatar through gaps such as doorways, or between library shelves, could be dealt with by adjusting the scale and collision settings in the worlds, but it is felt that this might be at some expense to the “reality” of the experience.

5.5 B1 and B2: analysis

The selection of four worlds to represent the number emerging from the Series A interviews was somewhat of a compromise. It would have been difficult to express the “richness” discussed in Chapter 4 without constructing very nearly as many models as there were interviewees. The divisions into concrete and abstract, organised and unorganised, were simply an attempt to convey the most striking qualities emerging from those interviews, and in the sprit of grounded theory, the theory was developed that one of the models chosen for translation into a VRML world would appeal to any particular interviewee more than the others. It appeared at this stage that this was in fact proving to be the case, and that the decision to reduce radically the number of worlds constructed, and to construct them in a very simple, prototypical form, was vindicated by the quality of material emerging from the interviews.

Because the form of the interviews was different, the properties emerging from analysing them were seen from a different viewpoint – that of the user, rather than that of the designer. Whereas the worlds from Series A were described in terms of the common structural and non-structural elements, the Series B interviews will be discussed in terms of feedback about structural and non-structural elements.

5.5.1 Structure

An impression was received from the interviews that the respondents were tending, even somewhat against their initial reactions, to favour the more structured worlds, i.e. the library and the town, rather than the less structured forest and space. There was also an emerging sense of the need for boundaries, and some indication of where the space extends to, and what place the information occupies in the overall space. This could be compared to information-seeking, in which the seeker does not know where the sought information is, in the context of all the information available. It could also be a result of the fact that an unlimited virtual space had been artificially created, in which it was possible to wander for a long time, without finding a productive next step, or engaging with the desired information.

5.5.2 Contextualisation

Another factor emerging is to do with "context" and "contextualisation", possibly in more than one sense of the terms. There was an impression that the users, despite liking the idea of something exotic, actually found, when it came down to it, that they needed the structure and organisation of the library. This seemed to be a very telling argument against the use of more abstract virtual worlds for this purpose, because it seemed evident that it would be easier to find information in a situation where it is labelled and there is some kind of guiding, than in a less conventional setting.

However, by taking a slightly different approach to this dilemma, a more constructive picture can emerge – it may be that what the interviewees want is not just organisation, but contextualisation, in one sense at least. They may want to know not just what they are looking at, and how it is organised, but also where the boundaries are, what the extent is, what the scope is, and what the relation is of one part to another. The reason why the library is favoured may not have been due so much the

fact that it was organised in a particular way, but the fact that the user knew that what she saw was what there was available – the bounds are clear, the regions could be if the model was large enough, and guiding can be simple and explicit, in the form of signs which, because they are used in physical libraries, do not break the realism of the scene.

5.5.3 Overview

Perhaps the perceived advantage of these worlds was that there is an overview – one can see the extent of the library, or of the town, and the directions are clear, there is some guiding, which the other models lack. Dieberger and Tromp (1993) pointed this out in developing the Information City, discussed in section 5.6.1, below. This means that information seeking can be something other than linear. When the user follows links, or uses search engines (which are the alternatives available), then they are trapped in a linear structure of their own (almost accidental) creation. They cannot see how much material there is, whether they are "close" to something useful, what related items there might be, whether there is actually anything that meets their needs, until they find it, because if they do not find it, they cannot be sure that they have not missed it through lack of skill on their part, or lack of indexing, or insufficient linkage. Indeed, there is a popular perception that "everything is out there", so inability to find an item of information implies fault somewhere. In a library context, however, the user goes to the right shelf, and if the item is not there, then it is not available.

In one of these worlds, the user can see what there is, what "amount" of information there is, what's related, where she "is" in relation to what's "there", in a way that is not otherwise possible in a Web context. The real benefit of 3D may be to give the user a different "handle" on large numbers of resources. A few interviewees also wanted indications of size of individual resources. This would mean that the user could better identify and exploit what is available. The user will also be able to bring into play all the "extra" skills, instincts, responses to cues, which give a 3D environment "added value" for us as hunter-gatherers.

At this stage, then, a useful hypothesis might be that "**users will favour a 3D world interface to networked resources which enables them to contextualise or evaluate or judge resources, in terms of all available resources**"

5.5.4 Recognition, affordances and guiding

Users may have certain expectations of what they will see in certain situations. For example, in the context of a Western supermarket, it might be that people would expect to find a section of the display space devoted to fruit and vegetables, another to seafood, another to cleaning products, and so on.

In his book, 'The design of everyday things', Norman (1999) deals with "perceived affordances " – features of design which make it apparent to the user that a certain functionality is available. If the virtual worlds are to be designed to permit, or afford, access to information, then the perceived affordances they provide ought, at least in part, to relate to recognition of the required information. There will also be a need for further affordances, indicating, for example, how the information is to be retrieved. In relation to this, the interviewees were simply told during the introduction, prior to their testing the worlds, that the mouse cursor would change to the shape of a hand, when moved over an object in the world that was linked to a resource, and that clicking on that object would retrieve the resource. The B1 series of interviewees were also provided this information in the lower frame of the display they used, which was abandoned in the B2 and later tests.

The library and, to some extent, the town, have the potential for enabling the user to recognise resources, or areas in which resources are likely to be found. Where users want the buildings in the town to reflect their identity, for example to look more like places where specific types of information about the town council could be found, this could be construed as a plea for more identifiable information sources. Similarly, using a model of a university campus to represent the different departments or faculties of the university makes sense, as long as the user knows, or can recognise, which building is which. In a physical university, this requirement is often supported by extensive signage.

The library had a sign on an interior wall which read “Cyber library”. The ends of the shelves were marked with ranges of Dewey Decimal Classification numbers, and there were “placeholder” volumes at every major class division, indicating where that class would be on the shelves, e.g. “500s”.

Functional signage in the town model was limited to signs above the buildings containing resources, and these read, respectively, “Books”, “The philosopher’s store”, and “Religion”. There was also a sign reading “Café”, the functions of which were simply to lend “local colour”, and to demonstrate a feature of VRML known as “billboard”, in which a sign rotates to face the user’s viewpoint. It is envisaged that this capability might be used in more advanced worlds, if more extensive signage were to be provided.

The only sign in the forest model was one “in the air” above it, which read simply, “The forest”.

There were no literal signs in any version of the space model, although the stars and planets were “colour coded”.

5.5.5 Colour

Colour was mentioned a few times, primarily in the sense that the appearance of the worlds was colourful. 68 said, “it was certainly colourful, there was a good contrast to seeing the actual things you clicked on, they’re all very sort of primary and secondary colours” This interviewee then remarked that colours could be assigned methodically to the book-shaped cuboids representing resources. One interviewee had complained about the fact that colours were not significant in indicating previously visited sites, as is the convention with hyperlinks on HTML pages viewed in Web browsers. Several other interviewees asked whether colour was significant in regard to the space world, where in fact it was.

5.5.6 Size

The objects varying in size were the trees and the planets, because the town and library worlds both used the same, book-shaped, brightly-coloured cuboids.

Questions regarding the significance of size were asked about the forest and space worlds. Neither had been designed with size in mind as a significant factor – rather, the variations were due to the observation that trees or planets may differ in size from others by orders of magnitude, whilst this is not typically the case with books. However, interviewee responses indicated that size, as well as colour, could be useful as a means of indicating some characteristic of an information resource. Whereas colour has no obvious analogue, other than the hypertext link conventions mentioned in 54.5 above, size could be indicative of extent or importance or quality. These mappings had been mentioned in series A.

5.5.7 Sound

Sound was not mentioned in this series of interviews, although it would be an option for the communication medium in the multi-user world described by 65.

5.5.8 Motion

Interviewee 58 commented on the speed of orbiting in the space model, and said, “I think it is good to get that balance, where they’re going round at the right speed. You don’t want them going round too fast.” 59, meanwhile, appeared to think they did not move quickly enough : “you have to wait for them to reappear?”

5.5.9 Organisation

This group of interviewees were not specifically asked about organisation, because what was being sought at this stage was a general reaction to the worlds. However, interviewee 60 was complimentary about the fact that resources were organised by Dewey Decimal Classification throughout, so that the same range could be searched on the shelves in the library, or in the relevant planetary system in the space world. The two interviewees who volunteered information about their ideal worlds mentioned organisation. 65 would organise resources into private (in his building), and public (in the town square). This split of public and private resources has some implications for a practical system. As was noted in section 4.8 above, Dourish and Chalmers (1994) point out the necessity not to let the flexibility of a spatial organisation in filtering and organising information conflict with the requirement for a social space to remain relatively stable, so that there is a common understanding of the data represented and the structure of the space in which interactions take place.

This could perhaps be resolved by making a user's "own space" customisable by the user, whilst leaving the "commons" relatively static.

69's ideal world, with the cyber-librarian, would be "neatly classified".

5.6 Relevant literature

As in the literature sections of other chapters, there was no literature found which related directly to the user-centred development of 3D worlds for accessing information. However, what is relevant at this stage is to examine the literature on models and proposed models of implementations of 3D worlds for accessing information, and a comparison of features of their design with the findings of the study so far.

5.6.1 Proposed and actual worlds

GopherVR, VR-VIBE and NIRVE have already been considered as examples of spatial models, in 4.8.2, above. Since this chapter discussed interviewees' interactions with the worlds, it is now appropriate to consider literature which has greater emphasis on design for usability.

Dieberger and Tromp (1993) describe an Information City – a city-like structure which is "a metaphor for hypertext browsing in a virtual environment". The elements of the Information City are a superset of Lynch's (1960) Paths, Districts, Edges, Landmarks and Nodes – the elements which, he held, add to the "legibility" of a city, and which, in the eyes of Dieberger and Tromp, make the city a suitable metaphor for accessing large amounts of information, in the same way that the desktop has proven a suitable metaphor for accessing smaller amounts. A suggested benefit is a reduction of the "lost in hyperspace" problem, whereby users quite easily lose track of their location in virtual environments. The familiarity of the concept of a city space is intended to aid navigation, and valuable additional cues can be presented by "read wear" (the apparent deterioration of surfaces due to age and/or use) and "writing on the world" (additional visual cues given by type of building, for example). The city is organised according to "districts of interest", and each building represents a hypertext document. The authors assert that "In a real city people seldom really get lost"

(Dieberger and Tromp 1993) because there are other people to ask, and signs, landmarks, etc. Therefore "it seems intuitive to make use of the everyday navigation skills that we use in real cities to navigate a computer generated information landscape". Important points to notice are that the Information City does not appear to have been implemented with a visual interface, although a text-based demonstration version was created, and that the City has two possible applications: as "a tool to either communicate structure of an information space to the user or to explicitly create structure in an unstructured
information domain." Later in the paper they suggest that the city might develop from independently developing districts floating in a void, but interconnected, thus solving the problem of districts expanding beyond a pre-allocated space, from a pre-defined structure similar to an American city grid-pattern, or from a "deserted city" which users could adapt over time (Dieberger and Frank 1998 p. 20). These points would appear to be echoed in the current study, in that interviewees expressed interest in both spaces for accessing personal, or frequently-used information, and spaces for obtaining an overview of, and accessing, information which might be partially or completely unknown. The fact that users might want to modify, or customise, worlds over time, is also acknowledged by this paper.

The paper has figures depicting possible visualisations of "rooms" in these virtual buildings, and an excerpt from a log of a textual implementation of the model, using the conventions of the MUD-style [Multi-User Dimension, or Dungeon] multiplayer interactive computer game.

The paper also discusses navigational problems to do with transporting a user from one end of a link to the other while maintaining their sense of orientation.

There is no mention of testing, because the paper only sets out to define "an ontology of spaces and connections" (Dieberger and Tromp 1993 p. 2) but here there is acknowledgement that a) spatial "skills" are important and useful, b) there is useful additional information transmissible, c) orientation and speed of movement to the next relevant place are important factors, d) quite a simple model can be useful – the MUD script quoted presents a reasonably good impression of a hypertext information

environment portrayed in a text-adventure, or MUD format. It can be understood from the brief "log" that a user might navigate through the environment with relative ease.

The models used in this study were considerably less sophisticated than the Information City, but it did appear that the 'B' series interviewees could grasp the idea of the town more easily than those of the more abstract space and forest models. Placing the models together, by effectively putting them "in" the town, also appeared to increase acceptance. Some interviewees found navigation came more easily than others. Even though the realism of the town buildings was called into question – "You should have something more like the real world" – interviewees seemed to accept that these were models of a library, a bookshop or a church. However, more information could certainly be conveyed than by the very simple signage used. Although the whole model was small in extent, there was still evidence of people having difficulty orienting themselves, and the time taken to move around in the worlds also attracted criticism.

Andrews (1995, 2002) performs a useful overview and analysis of a wide range of work related to his own development of the Harmony browser, an X-Windows client for the Hyper-G hypermedia information system. The Hyper-G system appears to have been intended to be considerably more advanced than the browsers which have emerged as dominant forces in the interim, supporting such features as two-way linkage, which was also intended to be used in Ted Nelson's never-fully-realised Xanadu system (http://www.xanadu.net). Similarly to Xanadu, however, Hyper-G is dependent for its successful and widespread implementation on a corpus of documents with considerably more metadata attached to them than has proven to be typically the case with documents published on the World Wide Web.

Harmony's "VRweb 3d scene viewer" was used to display "arbitrarily complex objects or scenes. The models may either be of the hand-crafted or the automatically generated variety, depending on the application" (Andrews 1995 p. 101). The example given of a "hand-crafted" model is a 3D plan of the centre of the city of Graz, in which city landmarks are linked to descriptive information about the city. From the screenshot included, this realistic-sounding model does not appear very impressive, however, consisting of five or six buildings on a roughly constructed

elevation grid. Harmony is said to support both VRML and SDF (Spatial Data File) formats. SDF is commonly used for chemical modelling. As is common with 3D viewers, the user can either navigate through a scene themselves, in walking, flying, or "heads-up" modes (where icons representing movement controls are displayed as if on a pilot's "heads up display"), or rotate, translate or zoom on the scene. The Information Landscape is the example of an automatically generated model, a 3D view of a system of "collections", over and through which the user may navigate. A collection consists of documents, or of other collections, in a hierarchical arrangement. The Harmony browser can therefore be used to navigate this hierarchy, opening and closing collections, following the bi-directional links between them, and presenting a linked 2D and 3D display of the scene it generates. The 3D Information Landscape generated by Harmony can have textures added, and Andrews writes of plans to introduce 3D icons to represent document type, and author-specified icons, "for example, a model of the Eiffel Tower to represent a collection about Paris" (Andrews 1995 p. 101). It would seem that the "hand-crafted" type of model is closest to the ones used for this study, although there was always implicit in the study, as was mentioned to the interviewees, the potential for similar scenes to be generated by a computer program, as a medium of display for results from a search engine.

Benford et al. (1995) describe the VR-VIBE system, a black and featureless 3D space with a floor grid, in which representations of documents are displayed as spatially related to representations of the queries which retrieved them. Documents may be annotated, sensitivity levels set, queries "dragged" in the space to observe the effect on the document space. The emphasis of this system, however, is on multiple users, who may be embodied, and provided with audio interaction facilities. It is intended for "the co-operative browsing and filtering of large document stores" (Benford et al. 1995 p. 349). This model is most similar to the first attempt at modelling a space world in this study, and the use of a floor grid might well have reduced the disorientation experienced by some interviewees. This model appears, however, to be more closely related to "mainstream" information visualisation applications, in that it permits modification of parameters in a dynamic fashion. The multi-user nature of the model would seem to make interaction a necessity for effective collaborative filtering to take place, and it must be assumed that problems relating to updating simultaneous world views could be overcome. Although VR-VIBE might look superficially similar

to the space world, its design is both more sophisticated and intended for a somewhat different purpose.

WWW3D is a rather different and more comprehensively featured world. Documents are represented as spheres, opaque from outside, and labelled with brief title information, but displayed as wire-framed from inside, and on the inside surface of which the document text can be displayed. Links to other documents are represented as icons. The spheres can be linked by arrows representing travelled hyperlinks between documents, and "although the authors have found WWW3D quite easy to use and quickly became accustomed to the way in which web documents are represented more extensive user trials are required to discover whether users will accept such a radical departure from the normal methods of displaying the contents of web documents" (Snowdon et al, 1997 p.7). As suggested by the paper's title, 'A 3D collaborative virtual environment for web browsing', this tool appears to have been intended principally as a means of tracing browsing patterns through hyperlinks between sites. WWW3D has a feature which preserves the structure between sessions, and since the world is of the "automatically generated type", it can be seen that there is the potential to create a world representing sites which users visit frequently, and which are linked together. The paper discusses briefly the intention to add a search facility, and it would seem that this is the main feature which is lacking, in order to turn WWW3D into a tool of the type discussed in this study. However, as with many other implementations, it appears that WWW3D did not get far beyond the prototype stage. Since the authors express their concern with reaching the limits of practical computability at the time, and since this was a multi-user model, it may be that it was simply ahead of its time, in terms of the hardware and network capacity available.

Benford et al. (1999), carry out a further survey of 3D visualisations, grouped by those concerned with representing web structure and inter-linkage of pages and sites, and those representing browsing history. The latter grouping includes WWW3D and the Web Book and Web Forager (Card, Robertson and York 1996), with which a new writing team of Card, Robertson and York introduce both designs "intended as exercises to play off against analytical studies of information workspaces"(Card, Robertson and York 1996 p. 111). This might be described as a "bottom-up", rather than a "top-down" approach, and implies that these systems represent what people

actually use and what they do, rather than attempting a representation of an entire information space. This issue will be further discussed in 9.5, below.

5.6.2 Navigation

Sebok, Nystad and Helgar (2004) discuss navigation in virtual worlds, and notes that navigation in these "is typically modelled after real-world navigation" (Sebok, Nystad and Helgar 2004 p. 27). They describes this as "reasonable" given that the users have experience of real-world navigation. However, they note "[v]irtual environments lack the cues for distance, motion and direction that are present in the real environment" (Sebok 2004 p. 27), nor do they have the sensory feedback that would accompany a real-world experience. It is thus, Sebok, Nystad and Helgar argue, "simplistic and ineffective" (Sebok, Nystad and Helgar 2004 p. 27) to expect users to learn a navigational layout in a VE (virtual environment) in the same way that they do a real one.

Sebok, Nystad and Helgar list some techniques that can aid users in "knowing where they are and where they want to go" (Sebok, Nystad and Helgar 2004 p. 27) Salient landmarks, signposts, maps, and "visual momentum" (Sebok, Nystad and Helgar 2004 p. 28) a continuity in the appearance of the surroundings, are all listed as helpful to navigation.

Sebok, Nystad and Helgar also consider modes of movement: When the VE is a close match to reality, the user "would follow only routes; he would be unable to walk through objects or to fly"(Sebok, Nystad and Helgar 2004 p. 27). Sebok, Nystad and Helgar point out that this means that some of the advantages available through the use of VR are denied the user, who cannot get survey knowledge by flying to the top of a scene, or save time by walking through walls. They acknowledge that these techniques have not been evaluated for actual effectiveness, however.

They state that a system rich in features "will almost certainly lead to a less usable system than one with a number of reasonable constraints" (Sebok, Nystad and Helgar 2004 p. 31)

5.6.3 Speed

Speed/ease of use/interface issues, such as the difficulty of navigating with the mouse or touch pad, arose several times, more frequently, as might be expected, in those who did not play computer games. As well as feelings of frustration becoming evident, there were issues emerging which would not be remedied by simple familiarisation. The time taken to access information would obviously be a factor, and several interviewees remarked that this would tend to make such an interface unusable for them.

Speed of movement could be perceived as too slow, instead of too fast. The plug-in settings available on the BitManagement plug-in could be modified to change speed of movement, and this was done on the one or two occasions when the interviewee was becoming uncomfortable. Otherwise, the only control used was the Viewpoints option, which allows very fast transitions to selected viewpoints (one in each "world", in this case).

Dieberger and Frank (1998) state that "[i]n conventional space, movement causes effort proportional to the distance and navigational means available, However to effectively use a spatial organization scheme shortcuts through space are essential. These shortcuts may break this relationship between distance and effort to travel. They appear as something that lies outside the underlying metaphor and therefore we call them *magic features* [emphasis in original] … magic features provide the necessary shortcuts to make the metaphor efficient … Controlled and very limited breaking of the metaphor seems to be a principle in all successful spatial systems" (Dieberger and Frank 1998 p. 603). The Viewpoints facility can be used in this way, but on a simpler level, it is expressed by interviewee 54, who said, of the library model: "if you're going to have it sort of virtual, then I want to be able to move through the bookcases."

Two interviewees experimented independently with the controls, and found combinations of settings better suited to them. As well as increasing the speed of the avatar's motion, these interviewees successfully changed the mode of motion (from Walk to Fly or Examine) to give themselves greater control over their motion in the

worlds. It was felt, however, in the light of their reactions to what they were actually shown, that presenting all users with the range of options available would tend to discourage many of them.

On the other hand, the intention that the interviewees should have similar experiences, so that it would be easier to compare their experiences meaningfully, may have meant that more confident interviewees were denied a fuller experience, in the interests of avoidance of "overloading" the less confident.

There were two possible instances of this, both concerning the Examine mode of the plug-in. Use of this mode gives the effect that the world, rather than the avatar, is moved and manipulated by mouse gestures. The world can be rotated, and moved closer to or further from the observer's viewpoint. This proved useful as a means of orientation, particularly in the case of the galaxy world in the B series interviews, where many interviewees found it difficult to orient themselves relative to the different star systems. By using Examine mode, the viewpoint could be moved to a distance from the star systems at which they could all be seen in relation to each other, and approached from a convenient angle. This reduced the chance of a user being surprised by turning around and discovering that a large planet had been close behind them, as happened in one case in series B. The Examine mode, or combinations of it and the Pan and Rotate modes, could also be used to provide a map-like view of the combined worlds, a feature which was referred to as desirable by several interviewees. It would be more desirable to place the map in a separate window, and to have a means of indicating the user's position on the map, but the time and programming skills that this would require were thought to render it impractical. This combination of uses of modes could be seen as offering a more accessible alternative.

5.7 Planning for series C

Regarding the feedback element of the interviews, it was important to remember that the details of individual models should not be seen as major problems. It would be better to "optimise out" annoying or obviously bad features where it was relatively easy to do so, but the details were not important, and it was just as important not to create features that attract just because they are attractive rather than useful.

It was intended that the next phase of interviewing would be more reflective. Interrupting the sequence of the interviews to permit a rewrite of the worlds was felt to be justifiable, on the evidence of the B1 interviews, but for series C, the intention was to try to get interviewees to talk for longer about the experience, about whether this was the kind of tool they could use in a real information access situation, what alterations could be made in order to make it better, and other issues of this type which might emerge from individual interviews. If responses in those sorts of categories could be elicited, then a better feel could be had for common strands. In fact, once interviewees in the next group had seen and interacted with the models, the focus could probably move away from "real" models, and back to hypothetical ones, to the "ideal worlds", because now the interviewees would better understand what was being discussed.

It was intended to seek answers to questions about how the interviewee felt about the idea of a spatial interface, whether they would be happy to use one designed by someone else, or whether they would like to decide for themselves what it should look like. However, efforts were made in conducting the interviews not to use "leading questions", which might unduly influence the course of the interview, or "put into people's minds" the ideas of the interviewer.

The focus of the conversation also had to be shifted from establishing which of the sample worlds the interviewee preferred, which was not the main focus of interest, to discussing whether this would be a workable way of accessing information, and what improvements they would like made. Care had to be taken to remember that this stage was not concerned with identifying a "favourite", but with exposing the interviewees to a range of possibilities.

5.7.1 Windows and frames

Some of the criticism in the series B interviews was directed at aspects of the user experience which could quite easily be improved upon. These were, in any case, features which were of an experimental nature, and included because no previous testing had taken place. For example, in early versions of the worlds, when a user clicked on an item in the world which represented a resource, the web page associated

with that resource opened in the same window. The result of this was that, when the user had finished looking at the resource, and used the Back button on the browser to return to the virtual world, the world would be re-loaded from the server, and the user's viewpoint returned to its starting position. It soon became apparent that this was not a satisfactory arrangement, and provided an experience inferior to that of web access using a conventional browser, when the result of clicking the Back button is to return the focus to the place on the preceding page from which the link was followed. This could be particularly frustrating in the virtual world, where significant time might have been spent in finding the resource in the first place.

Another version used a frames website, with the virtual world in one frame, and a short set of instructions in a narrow frame below:

"You can move your viewpoint through the world above, using the left mouse button. When you hover the cursor over something that represents a hyperlink, it will change to a hand shape, and a short text description will appear. If you click on the thing in the world, a short description of the resource to which it is linked will appear in this window, with a hyperlink to the resource. Click on that hyperlink to open the resource in a new window. Close the window when you have finished with the resource."

This worked, but was criticised on the grounds that it interposed too many stages between identifying the resource and retrieving it, and that it was necessary to shift one's focus of attention from the item, to a "tooltip", a small text box which appeared when the mouse pointer was "hovered" over an item, to a description in another frame, and finally to the website to which the item was linked. Also, in order that several items could be examined simultaneously, it had been decided to fix the size of the new windows. This was unpopular with the interviewees, because it gave a poor view of the target websites, and the windows could not be resized.

The lower frame, which had been created to compensate for the fact that labelling items was difficult to achieve satisfactorily, was subsequently removed (after version 13). Unfortunately, this also meant that the instructions disappeared, but there was a corresponding increase in the size of the display of the worlds. It should also be noted here that the use of framesets is deprecated by many web designers, due to them

causing accessibility problems for some users, and the fact that some browsers do not support them.

Eventually, JavaScript was written to pop up a new, resizable window when a link was activated, as this appeared to offer the benefits of preserving the user's position in the world, allowing reasonably fast access to resources, and allowing more than one resource to be accessed at the same time. It did not preserve the user's focus in the same window as the item clicked on, and, since labelling items in the worlds had proved problematic, tool-tips were still used as the initial means of conveying author, title and classmark information. There was some resultant disjunction of focus, but this appeared to be too complex a problem to solve satisfactorily at this stage, and was accepted as one of the limitations of the study.

Experiments had been made earlier with books in the library which could be slid from the shelves, rotated, and opened to display the author and title information on the first "page", but these behaviours were difficult to program, and counter-intuitive to operate.

An immersive display, using a data-glove, might be designed to bring items "closer" to the user, and allow information to be read from them, but again, though titles were added to the spines of some items, it was felt that the operations necessary to position the user's viewpoint sufficiently close to the item for the titles to be legible were too much to ask of the interviewees, in what was, after all, a prototype model.

5.7.2 Types and classes of information

Interesting distinctions which had emerged at this stage were those between private and public information, and between favourites and search results. The first of these could be seen as analogous to the distinction between one's own files and a public repository, and would be important in a "storage-oriented" model; the second would be analogous to the distinction between information resources frequently used by an individual – the "favourites", and information returned as a result of a search – the "hits". This could be called the "search-oriented" model. It now became clearer that the initial description of worlds "for accessing information" was ambiguous, at best.

However, it was decided that the most rewarding course would be to let this choice rest with the individual. Only one interviewee, in series A, had stated outright that the design of the environment would have to depend on the type of information being accessed. Others had addressed the question from another perspective, by saying, for example, that a car park would be useful for finding information about cars, or the town for accessing information about a town council, or the forest for information about trees.

A decision was made not to distinguish between whether the worlds would be used for accessing personal information, information on a particular topic, or information in the widest sense. The forest was an example of a space that was not obviously formally organised, but, on the other hand, it was, in at least one interview, regarded as being usable as a space for personal information. If the world represents a person's garden/forest/desk, they do not need to have its arrangement be clear to everyone else.

The point about a world giving one the capacity to see information "in context", works for a situation where the world is not displaying frequently-used information, that the user has organised themselves, but a body of information that they are trying to find a way to deal with, or find a path through to where they want to get to, or just to get an impression of what is there. It is interesting in itself that some people did understand the topic as being about different "classes" of information, e.g. the personal and the universal, the subject-specific and the general.

Although the class of information was left open, it appears that people may have designed their worlds with regard to which class of information they wish to retrieve. If it is information that is personal in some way, they may use a personalised model, with perhaps idiosyncratic organisation (the house, the office, the forest, the desktop with frequently-used items closer to the front). If the scope is "all information", then the favoured models become the library, the town, the galaxy. Then there are the odd ones (clouds, lollipops, etc) which, on re-examination, appear to be much less specific as to what the information actually concerns.

On the whole, though both are interesting, the "all information" class is more generally applicable, because it could potentially be a viable interface (there are a

couple of minimal examples “in the wild”) and because it is still to some extent configurable. If there is a requirement for information represented as a town or as a library, then that should be a matter of passing the appropriate parameter to a script, and having the result generated programmatically. If users want to create their personal space, that implies providing the ability to move things around.

On the other hand, the focus is not on doing what the developers of other systems did. The idea is to get people to use their imaginations, to think what it would be like to use a 3D world, and to give them some samples to try out. The samples are based on what the users said in the first place, and only a workable number have been implemented, but they are free to try them and make what comments and suggestions they want – an approach which seems to be lacking in the literature found so far.

5.8 Emergent theory

Preferences regarding structure and help in navigation were now coming to the fore.

A memo at this stage discusses at some length the feedback from series B users, particularly those from the B1 group.

> I felt pretty down about the criticisms from the B group, particularly 61. I think, though, on reflection, they are giving me good feedback –I’m just being too “precious” about my little worlds. The users don’t have any axes to grind, they’re being honest, and yes, some of the “features” could do with improvement. I told them the worlds were just proof of concept, I asked them for honest feedback, and I shouldn’t be surprised when I get it.

Memo: Aberdeen Business School, 30 March 2006

It was recognised that some negative feelings had arisen in the interviewer as a result of perceived negative criticism of the models from the interviewees. In order that a further series of interviews could build on what had taken place up to this stage, it was felt important to note the criticisms, and the version of the worlds to which they applied, and to move on to the next stage, the issues themselves having been resolved for series B2. The criticism itself was less severe than had been perceived, and the causes of it were either easily remedied, or could be lessened by placing greater

emphasis in the introduction to the next round of interviews, on the prototypical nature of the worlds.

Two points of interest emerge here, however. Firstly, the approach of the methodology, with its cyclical nature, means that frequent examination of the data can provide insight to the interviewer's reactions, as well as to those of the interviewees. Secondly, the approach taken in the introduction to the interview can be adapted, as could the content of more structured interviews than those used in this study, to reflect changes in emphasis appropriate to different stages of the study. Sample introductions for each stage are attached as Appendices A, B and C. It was decided at this stage that the next round of interviews would shift the focus away from the detail of the implementations of worlds, because although useful feedback had been gained, it was apparent that the worlds in this study could not be developed to high quality standards, given the resources available. The emphasis would shift more towards experiential questions, such as how it felt to move around in the worlds, how the interviewees felt about the idea of a spatial interface, and whether they would be satisfied to have a spatial interface designed for them, or would prefer to take part in the design.

A point which emerges here is awareness that some of the interviewees' responses have caused negative feelings in the researcher, that these have been identified, and that insight into this reaction could be beneficial to the study, in that any future occurrences could be identified, and in practical terms, the introduction given to each subsequent interviewee laid greater emphasis on the prototypical nature of the demonstration worlds.

A further memo discusses who should constitute the next group of interviewees. It notes that the non-professionals from the first two rounds had provided, amongst other information, the "bucket of words" which could be explored, developed, and perhaps extended in a further round of interviews. Although a distinction had emerged between private and public information, or between favourites and search results, as noted in section 5.10.2, above, it was felt that there was a need to re-examine the transcripts for material which was indicative of reasons for liking or disliking particular worlds. It was felt that these reasons might include the lack of an overview,

difficulties in navigation through doors, or the lack of information in the worlds as to which factors (e.g. size or colour) were significant. Although no further theory emerged from this re-examination, it contributed to the overview of all series of interviews discussed in Chapter 7, below. A decision was also made at this stage to prepare an introductory email (see Appendix C) which could be sent, both to introduce the topic of the research, and to solicit participation. It was felt that this could cut down on lengthy explanations before interviews, and increase the possibility of interviewees having given the topic some consideration prior to the interview.

The decision to use members of staff is, in grounded theory terms, an example of "theoretical sampling" – finding a sample who are the best to explore a particular aspect of the research question. What was required at this stage was a group who had the same common "universe of debate" as the first two, but who were more experienced in accessing information, and also more experienced as communicators, and who could add to the depth of description of their chosen worlds. The reference to a "bucket of words" is evocative of a methodology for constructing a faceted classification, which was seen, at the time of writing the memo, to be a very similar process to the open and axial coding techniques of grounded theory. The achievement of "theoretical saturation" similarly, could be thought of as akin to facet expansion.

A review of the interviews in the second round showed that 54 wanted colour and size to be significant; 55 suggested the height of the trees could be to do with hits on the associated website, and referring to the town, said a world was "easier to look around if it's got a certain map to it"; 58 wondered "how it would be if you were looking for something quite quickly"; 59 asked about sizes of trees; 61 was very concerned with collision detection and knowing where boundaries were; 62 thought "you're too really concerned with the getting around."; 63 thought it would be too time consuming due to difficulties in moving around to be used for information retrieval, but could see its potential for personal information; 64 found it slow; 65 wanted more realism and public spaces; 66 liked the size of the trees being significant; 67 commented on the lack of ease of use, and the desirability of maps; 68 on colour and size and complexity; 70 on navigation, particularly in the sense that "you can get in, turn around, and be able to see."

This summary of the largely non-structural concerns from the Series B interviews would seem to indicate that there is an interest in exploiting aspects of the worlds such as the significance of the size and colour of objects. Although objects in the worlds were brightly coloured, it was not suggested to interviewees that either colour or size was significant – all such suggestions came from the interviewees themselves. Since planets and trees were of different sizes, and since the planets were grouped according to colour, this may not be particularly surprising, but it is an indication that people might be prepared to deal with a virtual world in which such factors are significant.

Time used in moving around and speed were recurring concerns, and references to computer games could be taken to suggest that the experience of moving around in these worlds might be acceptable for leisure purposes, but would not be so for actual work, for example. Speed of motion in the worlds is on a par with that in contemporary 3D computer games, due to the simplicity of rendering the VRML models, compared to the greater sophistication of the games' "engines" – the software environment in which they are created. Some interviewees could handle only a limited amount of complexity in a world, which might indicate that the impact of a complex and novel environment was excessive.

An allied and recurrent concern was navigation, both in the sense of wayfinding, and in the sense of moving through the spaces. Interviewees found it difficult to orientate themselves, even in the relatively simple scenario when all worlds were adjacent to each other, grouped around the town square. There was a frequent expression of difficulty in finding their way into buildings, and moving within them, colliding with walls and bookcases, or in one case of being unable to move because the avatar's back was in contact with a planet which the interviewer had not seen.

The addition at this stage to the overall theory is that **there is generally an enthusiasm for the idea and the potential of using 3D virtual worlds for accessing information, but that this is tempered by reservations as to the practicality of using them in this context.** A specific example of potential is the recurring question as to the significance of factors such as size of objects in the worlds. Concerns are principally related to speed of use, and to ease of movement within the environment.

Chapter 6 Series C interviews

The next round of interviews, labelled as series C, used staff as subjects, because, having got responses from non-professionals, or from people who have not been obliged to deal with accessing information as part of their working lives, a picture was now developing as to the types of world that interviewees would describe. Using Glaser and Strauss' (Glaser and Strauss 1967) procedure of "theoretical sampling", it was next considered useful to interview people who were experienced in working with information, and who were also professional communicators. Staff have interests other than work-related, and there was no intention to confine them to discussion of subject-specific domains, unless these came up in the interviews. However, see section 5.10.2 for a discussion of issues surrounding types and classes of information.

6.1 Interview circumstances

The models, or "worlds", used were likewise far from realistic – they represented more a "proof of concept", or a prototype, in the sense of a "software prototype" – a working model which can be discarded and improved upon. It was emphasised to interviewees that the particular details of particular worlds were far from being at a perfected stage, and that, indeed, there were obvious flaws, which there was no intention to rectify at the current stage of development. For example, the "trees" were stylised models, each consisting of a cone atop a cylinder, with textures of leaves and wood grain, respectively, applied. Instead, the worlds were there simply to convey the idea of what "moving around" in such a world, and using it to access information, might be like.

In series C, interviewees were looking at the same "world" as in series B2 – all the smaller worlds from series B1 amalgamated as described in 5.3 above. Interviewees were shown how to move around in the world in "Walk" mode, using the mouse, and how to switch between viewpoints, using the right-click menu. They were then left at a PC to explore the world, but the interviewer stayed in the vicinity, so that once the interviewee had stopped exploring, the interview could take place.

This strategy was adopted as a response to a perceived discomfort of some interviewees at being more closely observed while they explored, and was explained to each interviewee before they were left at the PC. They were also told that help was nearby should they have any problems, and there were several instances when windows were inadvertently closed, and the interviewer was able to reset the model so that testing could continue.

6.1.1 Interview content/direction

Interviews were again very loosely structured, but insofar as the focus was directed, this was less to the detail of, or issues with, the examples shown, and more to the ideal worlds of the interviewee. This is an example of another cyclical feature of the study – it moved from eliciting ideals to testing examples, then improved the examples, tested them, and moved back to ideals. Interviewees typically gave an initial response which indicated which of the models they preferred, and why, and were then encouraged to discuss their ideal model, with a question such as, “Now that you’ve seen examples of different worlds, if you were having a world designed for you to use for accessing information, what would it look like?”. Interviewees were reminded that their world could look like anything at all, and that the worlds they had seen were simply a sample drawn from earlier interviews, and selected partly on the basis that they were fairly easy to code reasonably quickly. An additional element in this round of interviews was that it was mentioned that, as suggested by Dieberger and Tromp (1993), and discussed in 5.9, above, there might be the possibility of users picking up cues from the virtual environment, and using skills conventionally thought more relevant to “real” environments.

6.2 Analysis

The analysis and discussion of the final series of interviews will be carried out in the same order, initially, as that of the first series, reflecting the fact that in both series, the design of “ideal” worlds took priority over issues of usability: series A did not have models to try out, and though series C did, they were asked to concentrate on their ideals, with the models as proofs of concept.

As indicated in the previous section, interviewees in group C typically first discussed their reactions to the models presented in the "amalgamated" world described in section 5.3, above. They usually selected one or two of the "component" worlds – planets, town, forest and library – as their favourite, and justified this choice either by mentioning features they liked about that model, by mentioning features they did not like about other models, or both.

Thus, there are responses such as, "I didn't understand what the forest was" [71], "I think the width of books a bit narrow" [81], "the experience of space I think can get in the way of the information retrieval objective" [82], and "I mind not having words" [92]. These relate to the models demonstrated. Not all interviewees discussed the models directly, or mentioned a favourite, but those who did not would sometimes use points about the demonstration models when discussing their ideal model.

Since these responses were not solicited on a user-by-user, world-by-world basis, their main value is impressionistic, in that they convey the stronger and more commonly held reactions to the demonstration worlds. This would be of value, should any of the demonstration models be developed further, but the principal use of the responses in this series of interviews is in revealing more about the interviewees' reasons for selecting their ideal worlds. It was not intended that the interviewees be asked to select their favourite model at this stage, rather that the models be used as a seed or an inspiration to give context to discussions of the desirable and less desirable features of virtual worlds.

Table 8 : Series C choices

71	Library
72	Library
73	Mind map
74	Shops; shop assistants; tree
75	Villages, communities
76	Library
77	Campus; scuba diving
78	Book of hours
79	Mind maps
80	Map (Scotland)
81	Garden
82	No world – boring but efficient Jakob Neilsen
83	Library
84	Library
85	town
86	Building(s)
87	Library
88	Not comfortable
89	No preference
90	filing system
91	Airport
92	Garden
93	Not developed enough
94	Library; Sci-fi
95	Library; fish; second-hand bookshop
96	Library; tree
97	Library
98	Garden
99	Town, galaxy; shopping
100	Town; countryside walk
101	Town
102	Spiral staircases; quilt

The analysis in Table 8 reflects the fact that the interviewees had already tried out the model with the four different models exemplified in it, generally referred to as galaxy (or space, or planets), town (or buildings, or shops), forest (or wood, or trees), and library. Most of the interviewees have selected one of the models presented as their

first choice, and this would appear to justify the decision to conduct the first round of interviews on a theoretical basis, without actual models. It would appear that the interviewees' choices tend to be confined to the examples available. Subsequent choices are separated by semi-colons.

There was less focus, here, on the usability of particular models. Some interviewees in this series commented briefly on the models, and most mentioned one as their favourite of the four. Then most went on either to opt for something like one of the four as their world of choice, or to describe one or more preferred alternatives. Three of the thirty did not see the idea as being workable.

The worlds described here by the interviewees are noticeably less varied and generally more "realistic" than in series A. This might be related to the fact that the more realistic examples shown were, by far, the most popular, which, in turn, might reflect the slightly different population – staff, rather than students, and a slightly older age group. These, however, are questions for investigation in a further piece of work.

The approach taken here will be to discuss first those interviews where the interviewee decided that they would not be able, or willing to use this type of interface. Then there will be a discussion of cases where interviewees had preferred worlds which did not match one of the models presented. In many instances, these will be a second or subsequent choice of the interviewee concerned, and therefore one they have chosen in preference to a first choice amongst the models presented. Then the cases where a model named as one of those presented will be examined, and differences from the model noted. These comprise about one third of the interviews at this stage. Next, the same features will be examined as have been in Chapters 4 and 5, so that comparisons may thus be drawn amongst the series of interviews. Finally, some additional characteristics of the series C interviews will be considered. Conclusions drawn from the interviews will be considered in Chapter 7.

Despite the greater opportunities for drawing comparisons which are offered when more than one interviewee selected the same, or similar, preferred worlds, an attempt has been made in the current analysis to give equal weight to all interviewees. The

result is that there tends to be lengthier discussion of those models where the interviewee has supplied more material to discuss.

6.2.1 No world

Four interviewees in Series C: 72, 82, 88, 89 and 93, decided that they would not want to use a virtual world interface at all when accessing information. The interviewees discussed here, together with two from series A discussed in section 4.1 above, and the one from Series B discussed in section 5.6 above, form quite a small group in comparison to the total number of interviews. However, it is informative to consider them here, because the reasons they expressed for this decision varied, but their views are actually more strongly-expressed versions of opinions which also emerged in other interviews.

Interviewee 82 had previously been involved in developing a "virtual museum" project, "and we didn't go for the 3D immersive option because we wanted the people to be able to find things in a more systematic sort of way so I think the sort of simulation of reality in a sense gets in the way of the benefits of things you can do within an information retrieval system because it's simulating the restrictions of the real world and the need to actually look around." The interviewee felt that the idea would be useful for engaging people in an educational context, but would not be an interface which one would want to use every day. The interviewee admitted, "my virtual world would look something like Jakob Neilsen's website … very very boring but efficient". Jakob Neilsen is a web design theorist, whose web site [http://www.useit.com/] famously contains almost no graphics, so this remark was considered to place this interviewee in the "no world" category.

Interviewee 88 got "lost" in the town, and did not manage to navigate effectively in any of the areas: "I found it difficult to get into the doorway of say the planetarium and the positioning of that, I found that awkward too, I thought which way shall I go so I can't see me using this as a system or being all that comfortable with it." This reaction was very similar to that of interviewee 70, from series B.

Interviewee 89 was familiar with the concept of virtual worlds, and was in fact carrying out a study of economics in Massively Multiplayer Online Role Playing

Games (MMORPGs). The high quality of the displays attained by those games may have led to this interviewee's remark that "I think it's a very good idea, but it's going to have to be well executed. At the moment, it's not user friendly enough for me to want to use it all the time. That's why I probably wouldn't use it because it's not easy at all." The interviewee complained of having "poor hand/eye co-ordination" and had problems with the objects representing resources being too close together. The overall decision was that "none of them grab me and none of them put me off either."

93, though not sufficiently impressed by the interface to choose any of the demonstration worlds, which he found "unexciting" and "a chore" to use, considered that a James Bond or Star Trek world might have potential, and complained that "sometimes when I'm looking for information I open this up I don't quite know immediately where to go and now I open up my research folder and there is about twenty folders within that as well, none of which communicate with each other or influence each other in any kind of a way and there is no mechanism for that to happen other than the old style cutting and pasting." This interviewee wanted an interface that offered the potential to make research more exciting, and did not see the point in replicating a very basic representation of such mundane environments. The interviewee mentioned as an example that if a "Star Trek or James Bond freak wanted to do something like that whatever, that would be potentially fun."

Interviewee 72, conversely, thought the idea would be "great to play with", but would not be something they would want to use to access information: "I do a Control-F to find what I'm looking for, type in Law Journal, 1997, quick topic - is it on the list, is it not on the list I don't want to spend time going up and down the aisles, checking out where it is. The same as any library, you go into a library now, you've got a computer there, type in what you're looking for, it comes up and then it tells you, OK it's between 100 and 199, this aisle, this place. Great for playing with, I would say, not great for access." This interviewee, who had experience of designing three-dimensional objects on computers, was also critical of the appearance of the worlds: "the problem is the amount of detail you need to put in, to make it look half decent, you need to put an awful lot of detail in".

Whilst the reported reactions of these interviewees are each of interest in themselves, these responses can also be seen as constituting a key criticism of the methodology.

Because the methodology adopted had a cyclical nature, with each round building on the previous rounds, there was no provision made to deal with those cases which did not conform to the implicit expectation that the preferences of the first round of interviewees would be reducible to a small number of models, which could then be tested with further rounds of interviewees. At each stage, a small number did not conform to this implicit expectation, and, although this was not a quantitative survey, and it was carried out for a relatively small number of users, it would seem reasonable to assume that, for larger numbers of users, there would also be larger numbers of those who would not regard the idea as viable.

The difficulties themselves appear to resolve to: questions regarding the speed and efficiency of operating an interface of this type, compared to the conventional type; questions relating to the quality of the representations; and finally, questions as to the users' abilities or inclinations to operate the interface.

It is evident that further studies would be required to resolve these questions, and that the current study might have gone more deeply into consideration of these individuals as constituting a distinct group, or groups. For example, a further study might investigate these users' cognitive styles as compared to the larger groups, or compare their aptitude in using other computer simulations, or compare their spatial skills, or simply investigate their satisfaction levels when using traditional interfaces – it may be that they see no need to change a satisfactory system.

It appears that some users may have experienced excessive cognitive load, as described by Paas, Renkl and Sweller (2003). Kirschner suggests that minimal instruction is not a workable plan, and it may be that more interaction with the users should have been undertaken (Kirschner, Sweller and Clark 2006). When the transcripts are examined with this possibility in mind, it is evident that there is some evidence for “overload” – interviewee 54, for example, says “it’s not easy to always see what’s there … it’s easier to look around if it’s got a certain map to it”, and 60 says “I got really lost, there, for a second”. Perhaps 65 sums up this reaction best: “You should have something more like the real world. So you don’t have to actually find out what that thing is.”

All these factors could be influential, and others might well emerge in a further investigation, but it must be acknowledged that this type of interface is unlikely to be acceptable to everyone, and that alternative provision would always have to be made, as is the case with other interfaces designed with accessibility in mind.

6.2.2 Preferred worlds which did not match a model

The following subsections consider the cases where an interviewee's preferred world did not match one of the models (space, forest, town, library) which they were encouraged to explore before the interview proper began. 6.2.2.7, the quilt, and 6.2.2.8, the staircases, were both suggested by the same interviewee, but it is felt that both are developed in sufficient detail to make them worthy of consideration.

6.2.2.1 Garden

Three interviewees - 81, 92 and 98 - chose a garden as their preferred world and as their only choice. 81 commented favourably on the library: "I think a library is very clearly structured and you are able to find things." The desire for structure extended further: "My ideal kind of environment would be a garden … but then I would need structure within that garden in order to find things." However, there was no other detail about the garden forthcoming.

92 chose a garden because "I thought there was enough diversity because it would have to be something where there was an opportunity to diversify", and stressed the importance of colour in that choice: "I think colour is quite important and with a garden you can get different colours." As to type of garden: "you could have a woodland garden or a structured formal … garden and all that sort of thing and it depends the way your mind goes, but to me colour is a good category and link rather than numbers and …numbers would suit me but I think it's thinking visually and I like it." This appears to be another assertion that the preferred type of interface is a matter of the personality type. The distinction here is between visual and numeric, but a visual/textual split is identified by other interviewees, for example 78, who liked a memory palace, but disliked mind maps. It then appeared that 92 might require more than simply a static garden. She established that there could be an area of the garden in which a user herself could "plant" resources, analogous to saving "bookmarks" or "favourites" in a browser, and enquired "And would it rearrange your garden, say in my case to suit your usage, if you were using a particular area?" This idea of different treatment of commonly used areas also came up in the series A interviews, for example in the desktop world proposed by interviewee 4. A resource not used very often could be in "[t]he wild garden at the bottom you could fight your way into."

Having established the possibility of a personalised garden, 92 then said, “I think it’s very appealing, much more appealing than these kind of structures that we know and love. I suppose it’s converting this into logically [sic] and maybe everyone’s logic is different.” The implication is that the garden is not excessively structured – the reference to “structures we know and love” was understood to refer to libraries, because of the teaching area shared by interviewee and interviewer.

The garden described by 98: “I’d love a garden yes, I quite like that sort of swoop round effect so yes I would prefer a garden I think a compost heap … not the fountains and statues but I think it’s a good concept, maybe needs a bit more extrapolation to sort of how people would use it on an individual basis because I mean you’ve got it there as bits of information, but you could, I think people using this probably could develop it a bit themselves and customise it for themselves.” This is evidently a call for a customisable world, and for an interesting reason – “I have to say that I’m not a particularly organised person and for anything that would help me organise where I’ve got things would be a bonus, but it would need to link into something meaningful for me so that I could probably organise things in a garden better than I could organise them in a library, do you know what I mean.” Here, 98 seems to be defining the granularity, or fineness of detail, with which she prefers to work, as well as perhaps indicating a preference for a visual, rather than a numeric, metaphor.

It appears, then, that gardens offer structure, though without rigour, and also have the potential for the arrangement being changed to suit the user. There can be different kinds of garden, or different areas, such as a kitchen garden or a wild garden, within the same overall structure. They are also places where colour offers a natural principle of arrangement.

6.2.2.2 Mind maps

Two interviewees, 73 and 79, did not express a preference for the models demonstrated, but chose “mind maps” as their preferred world design. 73, who had been very enthusiastic about the idea of 3D worlds in this context, as discussed in section 6.3, below, wanted “almost a bit like a mind-map, perhaps, where you’ve got something, maybe yourself as the focus, your world as the focus there, and the various

main branches coming out from it, so it could be, your work, your home life, your hobbies, key areas emanating from a central point. And to me, I think that would be quite powerful, I particularly like using the technique of mind-mapping, so something like that works well for me, and I think is quite powerful, so my world, if it was something along these types of lines, I could see perhaps using maybe a mind-map, yourself as a central point, and the various elements protruding from there." This is obviously a very individual image, although it is possible that it is essentially a different way of expressing the same essential design as one of the more abstract models from series A. However, the content here is clearly personal, whereas the personal information in series A appeared to be represented by models of familiar spaces, such as "my home", and "my office". This interviewee is abstracting one step further than that.

79 liked the idea of a mind map, but expected that the need to annotate elements of the map would be difficult to achieve, because "I suppose the difficulty there would be if you have shapes and distance between shapes and sizes and so on you would have to be very explicit you have to keep an explicit legend." It did appear, however, that this interviewee might have been thinking of the mind map model more in the context in which he usually used them, as a communication tool. While this would be a valid use of the medium, and one which does not occur elsewhere in the interviews, it would not be strictly relevant to the issues being addressed.

78, in one of the more striking examples of negative feeling, had said, "I think this is just me being a bit precious, I really hate mind maps, they really irritate me." 78's preferred model was a memory palace. The comment occurred whilst the interviewee was discussing personal methods of organising information, and the interviewee's objection appeared to be to the formalisation of a method of creating mind maps: "why should I use the system that they said de Bono or whoever it was come up with?" This incident is mentioned because it shows that negative feelings can be aroused if people feel they are constrained to use methods of organising and subsequently accessing information, which are not to their liking.

6.2.2.3 Campus

A university campus was the initial choice of interviewee 77, who extended the idea of a campus that had previously been mentioned by interviewee 62, to be a metaphor for the "Virtual Campus" which is the name Robert Gordon University gives its online learning environment. "that would be much more interesting walking round a university campus and going off to your lectures and your lecture theatres could be modelled for instance and you are actually drawing stuff instead of having to go through the rigmarole of uploading stuff and then ploughing through that in a lecture, you know as you go through you've maybe got dates of the weeks of the lectures or the materials that you have downloaded to look at and then it can have … visual links to get you into other areas and naturally explore that subject and study rather than just put a screed of text onto a screen which is what we are doing and I don't think that enhances learning, I don't think we learn by reading alone."

This is certainly a virtual environment for accessing information, and might have the pedagogic advantages claimed by the interviewee, who also showed enthusiasm for multi-user possibilities, in the form of a chat room modelled on a student canteen or union.

6.2.2.4 Scuba diving

While the initial choice of 77 had been a university campus, her preferred world represented scuba diving :" you just float around almost motionless and weightless lovely you just go at your own pace and plod along nice and gently and come across things … backtrack if you wish". This appears considerably less organised a world than the campus mentioned in 6.2.2.3, above, but 77 explained, "I'm not a researcher so I'm not going to get excited about the idea of being able to go and explore and research but the idea of teaching and learning and having different visual effects and different ways of getting into it I think it's a really really good idea." It would seem that this interviewee had sufficient vision to imagine not only personal usage if the idea, but also where it might benefit others, thus displaying more empathy than most interviewees, who, to be fair, had only been asked about personal preferences.

Interviewee 95 had mentioned fish as the first personal world: “the fish model for me is quite appealing as well, you could have different fish representing different things. You would be the only one that would understand it, I suppose that’s the whole idea of this that you create an environment that suits your personality”. This does not explicitly have the diving element, but seems to be a very similar model.

6.2.2.5 Map (Scotland)

Interviewee 80 was enthusiastic about several aspects of the idea ¨”I think it’s nice to have something that’s visual you can organise things either work or personal in a very creative way as well. I think the whole concept is very interesting and I think it certainly makes it far more alive with the use of colour and I suppose depending upon what kind of person you are visual cues like this can work better for you”. However, this interviewee was somewhat doubtful as to whether this type of model would be as successful for work-related information as for personal information : “I think for personal things like books and particular websites or favourites list I think this would work well, but I don’t know how it would work if you were to have on a professional basis your own work material and then personal interest things you know how you can organise them with similar format to what you do at work with favourites and organise it that way …When you go into the library it would be quite helpful to have like a shelf that was all your work related bits and pieces and perhaps a shelf for all your personal things so that for myself I find it quite helpful to have things that are very organised and things are quite easy to find”.

However, after this critique of the library model, the interviewee decided on a map of Scotland as a favourite model: “I’m into hillwalking and mountaineering and that I would tailor it to my personal interests by having the Munros where you could actually have a map of Scotland divided into different mountains and tailored to that, again that would be a personal preference and it if was for work, I would have more business like images”. There is again a preoccupation here with separating personal and work-related information.

Before selecting the map, the interviewee had commented that moving through the space was like “the concept of wandering through a house” and described how different kinds of information related to different rooms in the house, for example,

cookery websites to the kitchen. It seemed that all the information here was personal, whether personal and private or personal and work-related. The idea of a search space, or a space for representing all information does not come into this interview, the main attraction being that "I do like the organisation of it, I think it's neater and tidier than boxes as it were so that you can find things". Because the library and the house were mentioned in passing, they have not been included in the table.

6.2.2.6 Book of hours

Interviewee 78 spent some time describing how she divided people into those who have a "sensing preference", meaning that "they use the five senses and look at what is there", or whether their personality type is "intuitive": "actually most people who engage with PhDs tend to be intuitive preference because they are interested in ideas and the play of ideas and the big picture." It seemed initially that the interviewee was attracted by the idea of a memory palace, a model which had previously been described by interviewee 52, but when the model was explored further, it transpired that the attraction was its mnemonic function, the interviewee having had problems remembering Latin, Greek and French under exam conditions. Although the interviewee identified with the personality grouping she described as "intuitive", the world she chose as an ideal was something similar to the Duc de Berry's "Très Riches Heures" – a richly decorated book of hours, comprised of 15th century paintings, and intended as a guide to prayer : "they put these fantastic idealised pictures of these medieval castles which probably never even existed then that they are all turrets, flags and twiddly things and beautiful people on horses going past and they used these books … as a way to get through the day … and I'm thinking that if I had something like that which was as gorgeous as that I could click on easily then I would be more inclined to use something like that."

This is one of the less conventional images in the later interviews, and although it was unclear how the idea would work in practice, there are examples of "virtual books", for example in the British Library, which appear to turn their pages when clicked on, and could be linked to resources in the manner implied here.

6.2.2.7 Spiral staircases

One of the most complex ideas to emerge from any of the interviews was interviewee 102's picture of interconnecting spiral staircases. Although this was not the interviewee's preferred model, it is considered sufficiently interesting to warrant inclusion on its own merits. The interview began with the interviewee expressing some concerns about being unable to find a path back to where the search had led her before: "if you are navigating in that world it would be nice to be able to always come back so in a sense I would like it to be slow so that you never feel you have gone too far". From observing librarians learning, the interviewee had a mental image : "I saw them in a way on this spiral and every now and then they went off something in their imagination [sic] and I sort of visualised this room where they went to research around that and that actually might even take them off out of that room and into something completely different if they got inspired by something and the resources could be either from the appearance of their own virtual resources that they got themselves or they might have to go externally to get it and if they fell out of the room as it were they would probably … I saw that as being … learning, but not where I wanted them, so they had left my spiral if you like and they had gone into another spiral of learning". This idea was developed during the interview into an image of interconnecting spiral staircases, which shared common landings: "I saw them having to go back down in order to retrieve resources that they had used before because of a connection somewhere else so that there this was this constant to-ing and fro-ing and then bringing in these other spirals of other areas if you like that they liked to take." The interconnected nature of the spirals of research or learning was the important point here: "it's that kind of interconnecting that I think is quite important so that was sort of quite clear." The notion of interconnectedness and the ability, or even necessity, of being able to retrace one's steps reliably do come across very clearly from this interview, and it is this, more than the staircase image, which makes an impression. In some senses the feeling is similar to that of the last sense of the "trail", discussed in 6.5.4, below.

6.2.2.8 Quilt

102's preferred idea was somewhat like a quilt. This interviewee had been one of the original pilot group, and had been attracted by a model in which blocks, representing

university web sites, were arranged in a black space, which was marked out by regular horizontal and vertical grid lines. The appeal of this space, over more conventional worlds, had been that, “there’s not this feeling of getting lost, you’ve got a sort of something to work with”. Consequently, when choosing an ideal model, this interviewee said, “I would go for something like a patchwork type of thing with colours so that they are all interconnecting so that you could move them around so in a sense its quite a flat idea but you could those sort of whatever they are shapes that make up this sort of patchwork represents something and then possibly you could open those possibly in quite a traditional sort of leaf like way to flick through what’s in those.” It was suggested, and agreed, that this model might resemble a “tangram”, a geometrical game in which simple shapes are moved around on a flat surface to form other shapes. There is also a book-like quality expressed in the idea of “flick through”, which might associate this world with the book of hours discussed above in 6.2.2.6.

6.2.2.9 Twigging

This expression, apparently coined by the publisher Curtis Benjamin, the late president of McGraw Hill, was used by interviewee 74. The concept relates to the growth of disciplines, analogous to trees, which may throw out branches, or sub-disciplines, which then grow “twigs”, some if which survive to become branches, and some of which will die away with the passage of time. 74 said, “I like that. I like the concept of a tree, as in branches. The sort of idea that you could have like a tree, the trunk is biology, and then ecology is a branch and you go along the branch and then there’d be plant ecology, as a twig. This is the concept of twigging, which you … from some publisher, in America, who had that idea - twigging when you have facts that twig, you see you go along the branches.” Although this is initially expressed as a tree, it is obviously different from the “trees” world other interviewees described, and is closer to the tree described by interviewee 30, who had a relatively simple hierarchical model as one choice. Twigging appears to fit with the path/process models from interviewees 29 and 46, discussed above, in sections 4.4.8 and 4.5.5.3.

Later in this interview, the similarities between twigging and Chen’s later work were discussed. Chen’s work is discussed below, in section 8.2.2. The interviewee also

related both ideas to resources of the “if you liked that, you might like this” type, such as ‘Now read on’.

6.2.2.10 Airport

As a frequent traveller, interviewee 91 spent a lot of time in airports, and felt that “if you had the inside of an airport and had different pictures of aeroplanes or something would be fascinating for me, but it’s probably not necessarily fascinating for the majority of the population.” When it was suggested that an airport could be quite a frustrating environment for many people, the interviewee responded, “a check in area might be you could classify under one group of data, and the security search on something else, it’s just that, I suppose that’s because over this week I’m going to spend at least seven no I shall be going through airports, different airports at least nine times in seven days so I means it’s the sort of thing I can conceptualise perhaps more easily than a galaxy.” This does not appear to be one of the more fully developed ideas, and the interviewee acknowledged the fact that it might have only personal appeal: “I’m sure there are other things - car enthusiasts might see a dashboard of a car or something.”

6.2.2.11 Villages

Interviewee 75 was primarily interested in accessing personal information organised to personal requirements, “and then categorised down into things like travel and so on.” This interviewee found the town idea stimulating, and used it as the basis for an ideal world: “I would probably, you know, if it was travel, work and so on, I would have symbols with shapes representing each of these. You know, perhaps they could be little villages, each one representing a different area, and you walk into that town or village, and then that breaks down into its own separate areas, you know. As I was speaking about recreational pursuits, travel, information about that, etcetera, etcetera. Some of which would cross-link through. Perhaps it could be a series of villages which are kind of growing together, if you like, sort of satellites, whatever would be linkages across, as well. A bit of a community, really.” The term “community” as used here did not seem to imply inhabitants, but a grouping of villages. However, this interviewee went on to talk about the younger generation as “digital natives” who are more at ease with computer technologies, and to refer to information access in this environment: “it’s almost primitive in a way too, though, it’s this kind of hunter-

gatherer thing still going on, to some degree, so you're touching on that, too, and just the way we've always, how we've evolved, as well, you can see in our external world and how we pick things all over the place, often subliminally, and pull them together. Common focus." The references to behaviour and "subliminally" would seem to correspond to the observations of, for example, Dieberger and Tromp, regarding humans' "strongly developed spatial cognitive abilities" (Dieberger and Tromp 1993 p.5). These relate to world design as discussed above in section 5.6.

6.2.2.12 Shops and shopping

Shops and shopping made several appearances in, or as, interviewees' preferred worlds. They are dealt with here as entities separate from the town context, that is, as entities which are important as themselves, and not just as being some of the elements which go to make up a townscape.

One of the simplest shop-type ideas came from interviewee 95, who had a preferred world involving fish, but observed that one of the attractions of a second-hand bookshop was that occasionally there are serendipitous finds – items which are not being searched for, but are nevertheless useful or attractive. This idea appears to be a restatement of that expressed by interviewee 77, who had noted, as discussed in section 7.3.1, below, the advantages of having an overview of material. Further discussion of the second-hand bookshop idea centred on the possibility of customising the environment by adding features such as aging and wear, to emulate the additional cues provided by these attributes in the Information City of Dieberger and Tromp (1993), discussed in 5.6.1, above.

Interviewee 74 was the most enthusiastic advocate of shops, despite being unable to navigate the avatar through the doorways of the shops in the town setting. However, it was possible to see and activate the shop contents from outside the door, however. "Now that would be really good, to actually go in the shops, and then like, because your databases tend to be sort of bookish, there are online shopping databases, things like that, and you ought to just sort of do it, shops it would be good." 74's main reason for preferring shops was an association with the idea of assistance, a topic which is covered in section 7.3.3, below, but there were also supplementary reasons:

“I like the idea of this is Philosophy, and then you have History, or you could have Parenting, or Cookery, or whatever, in individual shops. I like that.”

Interviewee 99 liked the idea of shopping, partly as a reaction to feeling disappointed in the experience of online shopping as it was implemented currently: “maybe a shop might be quite a nice idea because people think in terms of shops and I think it’s quite sad they are making huge amounts of money out of online shopping but no one has actually done anything to be creative about that, it’s really incredibly dull and you know for some completely naive reason I’d envisaged before I ever tried Tesco online shopping that I’d somehow be there physically going round and round, it would be a terribly interactive process.” The opportunity to build in interactivity seems here to be a possible compensation for the time-consuming process of moving around, which had been seen as a negative factor by some other interviewees.

Shops, then, can be perceived as places which are demarcated as to subject, but in which there might be serendipitous discoveries. They may offer assistance, and the process of shopping can be rewarding in itself. They can offer a route to the information in databases which is less threatening than the conventional means of access.

6.2.3 Preferred worlds which matched a model

6.2.3.1 Forest

Interviewee 100 favoured a world based on, but not identical to, the forest. This interviewee preferred “a countryside walk … just going on your forest you could walk through different areas”. This interviewee also noted that “if you could plant your trees could you make your own links”, thus recognising the potential for customisation. It was decided to include this interviewee in the current category, because the world described builds on the forest, rather than being a complete non-match with the models demonstrated, as those in section 6.2.2 above are considered to be.

Otherwise, the forest did not feature as a preferred choice in any of this series of interviews. Interviewee 71 asked “but would the ones that were trees be related to

trees?" and agreed that the forest and the planets were "too abstract" to represent information in general. Interviewee 91 was similarly literal: "the forest represents to me a model for the environment, agriculture etc. but you could actually have a number of elements that you would go to if you were looking for specific selection of data." 76 felt that "I like the forest the least, I think, just because I couldn't work out the significance, I felt there should be some significance, in terms of the size of the trees, and how they're arranged, and I didn't quite get that." Interviewee 85 said "the forest idea I didn't like very much but I felt it needs to be developed more, probably". This interviewee was enthusiastic about the idea of customising a personal world by adding objects: "so add a house or a forest … but my ideal way would be like that so I would maybe start with organising my world and then being able to change that around". The idea of a forest is not completely unacceptable, then, but it would be arranged according to personal preference. This is a factor which had not been fully considered in the design of the forest "world" – it could make most sense to the person arranging the objects, but would not be very meaningful to anyone else. Interviewee 99 objected to the forest because it was difficult to move around in: "it seems to be more difficult to actually see how you are going to get round it, you know what I mean, it's just more difficult to orient". Here, the facts that the trees were not arranged in a particular pattern, and that movement could be impeded by a tree, appeared to cause some frustration.

6.2.3.2 Space

Interviewee 94 favoured a space world, but not of the type demonstrated. This interviewee, a science-fiction enthusiast, would have preferred a much more developed model: "just say generally sci-fi so you could have little planets and little people and little space ships you know all those things." It was decided to include this interviewee in the current category, because the world described is identifiable as space, rather than being a complete non-match with the models demonstrated, as those in section 6.2.2 above are considered to be. It might well be that, given more time and programming skill, the space world used as a demonstration could have developed in this fashion. This interviewee's role for spaceships is also a contribution to the transportation issue, which will be discussed in section 7.1, below.

Otherwise, the space world did not feature as the preferred choice in any of this series of interviews, but did feature as a joint choice, from the models, of interviewee 99, who was ambivalent between the town and the "galaxy": "I tend to like the town actually or possibly the galaxy in some way rather than the library or the forest. … the galaxy was quite straight forward, I thought, I felt as I was looking round it, but not particularly meaningful until you went over it and saw what was in there." However, as will be seen in the next section, this interviewee actually appeared to favour the town.

6.2.3.3 Town

The town was a joint initial choice for interviewee 99. It was the initial choice for interviewee 100, and was the only, therefore preferred, choice for interviewees 85 and 101.

As mentioned in section 6.2.3.3, above, interviewee 99 was ambivalent between town and space as a choice from the initial worlds, but eventually appeared to favour town. The interviewee's reasons were:

> "The town I could see how you could incorporate kind of conceptual links with the buildings or whatever … even a shop would be better [than the library] you know from my point of view, it depends upon how universal you wanted it to be in subject terms I suppose, but the town and the community around it I think you could do lots of exciting things with and you could have all sorts of different levels and types of materials or different groups and it could actually be linked quite constructively to people's lives"

This interviewee also expressed disappointment with the way that online shopping had developed, seeing it as having more potential interest in a 3D format, as discussed in section 6.2.2.12, above.

Interviewee 100 felt that the town was “a nice idea”, but felt that a 2D representation of a wall, with bricks linked to resources, would work just as well, and “would take up less space than a street”. This interviewee also noted a feeling of “seasickness”, so despite the interviewee’s engagement and readiness to contribute ideas extending or amending those presented (see also section 6.2.3.1, above), it appears that some adjustment to the experience of using a 3D world would be necessary for this person.

6.2.3.4 Library

Ten interviewees selected the library as their initial choice, and seven of these retained it as an ideal.

6.3 Affective Qualities

A large number of qualitative words were used here, generally positive regarding the overall idea and its potential, but more negative regarding the business of moving around and navigating in the particular models experienced. Negative terms were also used concerning current systems, which were categorised as “boring” (Interviewee 73, a library) or “dull” (Interviewee 93, Windows folders; interviewee 99, web directories, online shopping), compared to the “interesting” (10 interviewees), “fun” (3 interviewees) “appealing” (2 interviewees) possibilities of 3D worlds. The positive words cited above are a small sample of those encountered.

Interviewee 73:

> I think it’s certainly a novel approach. Somebody who’s not from the library discipline, I think it maybe sexes up the approach to information gathering. For those of us outwith that sphere, it’s maybe sometimes quite wrong, but often [what] they think is “library – boring, mundane, quiet, tedious” – you can pigeonhole things, often quite incorrectly, but I think this approach makes it more … three-dimensional, more creative, I would say that, [I] might be wrong but my thoughts are that it would particularly appeal to people who are of a sort of very holistic persuasion, people maybe creative people, designers, engineers, and that, who often think in sort

> of more three-dimensional approach, and I think it's not so much whereby a traditional information search and physically going into a library and going along to the shelf and book number, and all that sort of stuff is very procedural in its approach, this is also procedural, but I think it's put across in a way that I think some people of this type of persuasion would find quite exciting, so I think it jazzes things up and I think it may turn people on to information searching that might previously think "ach, it's very boring and systematic, clinical" and all that sort of stuff, and I think this is quite a – I suppose it's refreshing, approach.

It would be fair to summarise the interviewees' response to the idea of using the worlds for accessing information as very predominantly positive. Here, and in the next chapter, can be seen a great advantage of the grounded theory technique. Analysis of the interviews gives access to people's feelings and emotions in a way which would be difficult, if not impossible, to reproduce by other means. The fact that the responses were free and unforced, and were not simply choices from a predetermined list of options, led to the opportunity to identify an affective dimension of reactions to the worlds which had not even been considered during the selection of the methodology.

6.4 Common features – non-structural

6.4.1 Colour

Colour is frequently mentioned as a desirable quality for a world. It has been mentioned above that 71 would want to change the colours of the world. However, it appears that 73 does not consider colour to be a primary feature in his mind map: "presumably people who are creating the software for this, you'd need to be, perhaps, cognisant, if it's going out to particular people, if they have perhaps any form of colour blindness, or something like that, perhaps it would obviously need to be built into it, but yes, I think it would be one, attractive; two, powerful; and three, not so much a gizmo, but quite an appealing kind of mechanism to engage people."

In addition to the aesthetic appeal, 14 interviewees, in all, asked whether, or assumed that, or suggested that, colour could have significance, either in the model worlds they tested, or in the ideal worlds they imagined. In fact, in the test worlds, colour was only of significance in the space world, where the colours of the star and planet groupings were related to the subject area (the major class of Dewey) of the resources to which they were linked. This would appear to indicate a willingness to deal with metadata other than textual (e.g. the names of the shops) and spatial (e.g. the placing of the star systems)

6.4.2 Size

Several interviewees asked if the size of the object – tree or planet, because all books were the same size – was related to the "size" of the resource. Those who asked regarding the trees were told that the height of the tree was related to the size of the resource; those who asked about planets were told that the size was not related. In both cases, this was true, although in fact the judgement of "size" of the resources linked to the trees had been purely subjective. However, it was never questioned how the "size" judgement had been arrived at. In retrospect, this appears to be a possible example of the use of spatial abilities, as discussed in 5.9, above, with the difference that, in the case of the study, individuals were attempting to use their abilities in ways which had not been designed into the model – they were prepared to take on more metadata than was actually supplied. This finding is obviously similar to that of the preceding section, 6.4.1, but the point is reiterated because size is a spatial property, and these are of particular interest, because of the idea of innate ability to deal with them.

6.4.3 Sound

Interviewee 77 asked if sounds could be assigned to objects in the same way that colours or shapes or sizes could, but did not elaborate. In VRML, sounds can be assigned to events, or can be activated by the proximity of an avatar, so that reasonably sophisticated effects are achievable. Interviewee 80 wanted different sounds for different areas, though what world model these were areas of, had not yet been decided : " It would be good if you could have interactive music for each section as well, for a serious part you could have some sombre music, for somewhere else

something upbeat." The world under consideration could well have been a library, because the notion of a "section", or "a serious part" makes more sense there.

6.4.4 Motion

Motion of the world, rather than the user's, or avatar's, motion in the world, was mentioned infrequently with regard to interviewees' "own" worlds. 95, who wanted a library display of items which could not normally be accessed physically, added the refinement of rolling stacks: "in terms of making a virtual representation of that area and it could be quite sort of good to have the rolling stacks actually move and that's what we are saying and give people the feel that they are actually using that area in reality." The motion in the space world, examined by series B interviewees, was found to interfere with usability, and was therefore suppressed for the final series of interviews. It is not a property of the world which appears to occur to many interviewees, but it could be tentatively concluded that, were it to be used, it should not be used as a property of items with which it is necessary to interact in a controlled manner. For example, a rotating signpost, such as the café sign in the town square, does not move perceptibly, but is always facing the user. This was not commented on. It might be that moving artefacts such as clouds would add to the sense of "reality" experienced by users, though this was not tested. It seems clear from the 'B' series interviews, however, that clicking on a moving object to access information serves more as an irritant than a benefit to the user. Despite this, there are interviewees who imagine worlds in which movement would seem to be implicit, such as the stars, planets, galaxies, or an undersea world with fish. The ability to move things, in the sense of moving "artefacts" within the world does get mentioned, however, in the context of customisation.

6.4.5 Navigation

81 said of the library: ". I think the width of the books is a bit narrow, that's how I find it quite hard to click on the links sometimes if they are very close together." This interviewee, on the other hand, found the viewpoints helpful in orientation: "you get much more perspective [indistinct] so it helps you to learn how to navigate … I think its something you need to play around with and get used to."

91 was more philosophical “I don’t have a problem say moving around the galaxy or even making the various elements of the galaxy larger or smaller by managing to manoeuvre the mouse, but it’s getting out through that door that becomes a problem, but then if you are only operating in one … galaxy or forest or town or whatever, then your navigation is just presumably within that one model.”

Interviewee 71 made a more general point about the size of a world. This interviewee was one of those who felt that the time spent navigating within the world detracted from its value, and remarked that, although a map would be helpful, working with a large database, such as the ones hosted by the online provider Dialog, would be impractical. “I wouldn’t want things to be so far apart. I didn’t really like walking between really distant things unless it was completely separate units of information, then so you wouldn’t be going to more than one, at any one visit, because I don’t really enjoy trying to use the mouse to navigate around so much. I’d rather that things were just there.”

6.4.6 Appearance

The level of detail, and the general appearance of the worlds attracted some criticism, although it had been made clear that these were “proof of concept” models. In one case, the level of detail issue was mentioned, but the interviewee considered the format inappropriate for accessing information in any case. Interviewee 72 just felt it unsuitable – “Would I want to access information this way? No, I’d like to play in this way. I wouldn’t like to access information this way. Personally speaking, yeah?”
In another, the interviewee required more detail in order to evaluate at all. Dieberger and Tromp write “[a] city that consists only of similar blocks with little or no differentiation is difficult to use even when plenty of structural elements (like paths or landmarks) are available … If buildings look differently, possibly giving an indication of their contents (like proxies), age (building style), and use (using read wear) then finding a certain building in this environment will be much easier.” (Deiberger and Tromp 1993 p. 10) Or, as interviewee 72 puts it: “I would like to look [sic], maybe not the world, as such, but the landmarks, i.e. the library, or the pub, or whatever, to look like … the library. To look like the pub.” There is obvious opportunity to provide more information of this type, and this is a reiteration of interviewee 65’s

opinion, discussed in section 5.3.2, above, that “Library should be like library, bookshop should be like bookshop”.

6.4.7 Collision detection

There was a split on collision detection. Some wanted to “walk through” walls and bookshelves, some found it disorienting when the Viewpoints function moved them through obstacles. Usually, moving through obstacles only emerged as an issue when someone tried to do it, and failed. This is a property which is easily modified in the plug-in control, so it can be set at World level, but it can also be modified within the VRML code. For example, the default setting is that collisions between the avatar and other nodes (excepting IndexedLineSet, PointSet, and Text) are detected by the browser, so that the avatar cannot “enter” the geometry of the node (Carey, 1997). However collision detection can also be set at node level, affecting all “children” of a particular node, so that it would be possible to make one building and its contents collision detecting (and therefore impenetrable), or set just the walls, or just the doors, or even just the bookcases, to have the property. Because of the VRML file structure, the author has a great degree of latitude in many respects, of which this is just one instance.

6.4.8 Social context

Although the idea of the virtual worlds was not introduced as other than single-user, and the models constructed were single-user, some interviewees mentioned that multi-user features would be welcome. There were also some characters who might be called NPCs (Non-Player Characters) in a gaming context, or “daemons” in a computing context (see section 7.3.3). These included the market vendors, the librarians and the shop assistants.

6.4.9 Two-dimensionality

Some interviewees chose models which were essentially two-dimensional. The book of hours chosen by 78, and the quilt world of 102 could both “flick through” a third dimension, but are not essentially 3D. The wall of bricks proposed by interviewee 100 was even more clearly two-dimensional: “I mean you could have a brick wall with each brick or big brick could have a word on it or something like that would be quite easy for clicking on and getting your links you know. It would take up less space than

a street." These do not seem to be extensive worlds, but neither are the virtual library catalogues described by interviewees 25, 31 and 36, nor indeed the PARC-type perspective wall described by interviewee 39. There are two factors here – first, the "dimensionality" of the image the interviewee imagines is not apparent from the interview, and secondly, these might be flat artefacts in a three-dimensional world. After all, the fact that a wall takes up "less space than a street" assumes a three-dimensional context.

An alternative interpretation would be that these interviewees fall midway between the enthusiasts for the 3D world idea, and those who feel they would be unable, or unwilling, to use such an interface at all. It might be that this is the case with interviewee 100, who said, "it appeals to aesthetic nature but as I say I'd feel terribly seasick by the end of it", but the people who did not want to use this type of interface had objected mainly on the grounds that it would slow down their work, or that the representation was not sufficiently sophisticated to be usable. The other interviewee, 88, had problems with navigation and orientation, and had apparently lost patience with the control mechanism: "I found angles and the positions difficult and at one point I realised that I had actually gone somehow got round the back … because the writing was back to…front. So I don't know how I managed to do that but it's probably moving it around too fast."

6.4.10 Other systems

In the course of the series C interviews, several interviewees referred to other systems for accessing or organising information, and to computer gaming, the use of 3D technologies for other purposes. Collected here under the "Other systems" heading are references to search engines and computer games, and to pre-existing filing systems. These are grouped because they are systems different from the 3D world in one respect – the search engines and filing systems are not 3D, the games are not for information access – but related in another respect – the games are 3D, the search engines and filing systems are for information access.

6.4.10.1 Google and other search engines

A number of interviewees referred to search engines, most often Google, for purposes of comparison. Interviewee 67 felt that using a world for the equivalent of a personal

bookmark list would not be satisfactory: “For the bookmark one like you’ve presented now, well you’d have a speciality now which particular things you were trying to look for at the time, you know, navigating one would be maybe a bit more difficult than using a normal search engine.” 78 found the challenge of selecting an effective search strategy for Google rewarding, and found that the quality of imagery in the test worlds was insufficient to outweigh that satisfaction. The idea of an “overview” of material as being superior to a list of hits will be discussed in section 6.5.1, below. Interviewee 94 also discussed the fact that the process of selection in the creation of a virtual world could lead users to “proper information as opposed to the sort of junk that’s out there.” It was observed that this might have to be at the expense of automating world creation, although it might be possible to base automated world creation on the results from a human-mediated catalogue service, such as Yahoo.

6.4.10.2 Computer games

The subject of computer games came up fairly often in the interviews, most interviewees not being enthusiasts, and several citing their lack of skill in controlling the mouse as the common reason for navigational difficulties in the virtual worlds and their poor performance at computer games.

A keen computer gamer, 87 pointed out that “I’ve seen me spending a lot of time driving around places that I’ve probably never visited and I don’t know if I’m ever likely to go like Chicago, actually getting a feel for the streets and where I’m going and if I was plonked into the middle of Chicago I would probably be able to work out roughly where I was on the strength of that kind of information … I mean no amount of looking at Google maps or anything else is going to acquaint you with that degree because you are not engaged … with the virtual environment.” This refers to the game Grand Theft Auto, which has extensive simulated street scenes, in which much of the gameplay takes place. Here, the interviewee has turned the question round – using virtual environments to help learn navigation in real ones is rather a different exercise from what was examined in this study, but this interviewee’s point about engagement with virtual environments is relevant. A greater degree of engagement may be the factor which stimulates the additional abilities mentioned by Dieberger and Tromp (1993).

91, on the other hand, remarked on the contrast between the real-world and the gaming experience: “the one thing on this that I was finding difficulty with and it’s probably because I’m not a computer game player, although I can drive a car at 100 miles an hour and keep it on the road, I cannot drive on the simulators in the fun fair or somewhere, but the problem I was having was navigating, I am one of those who need some instruction to make sure that you can navigate effectively.” This inability to orient oneself in a virtual world appears to be a problem associated with several of the interviewees who said they had not played computer gamers, or rarely did so, but others in this group blamed poor mouse cursor control instead. It appears likely that both of these are factors.

It can be seen from Active Worlds that initial clumsiness in using the interface is overcome, just by watching the apparent ease of motion of those customised avatars belonging to more experienced users, compared to the greater incidence of clumsy movements by the “default” avatars assigned automatically to guest users who have not yet selected an avatar to suit them. Interviewee 71 said, “it feels like it’s sort of the next step on from how we currently would use information. I think I’d have to train myself into seeing this as the way to do it, rather than – it doesn’t feel like an entirely natural way of doing it, but I can see the benefits of doing it this way”.

Interviewee 75 said, “I find it takes me a wee while, just to get used to the feel of the mouse in doing it, but, you know, it’s … I can see how easy it would be to use it, and I think I would probably get up to it quite quickly”.

6.4.10.3 File systems, folders and trees

A number of interviewees expressed a wish for a virtual world to represent a pre-existing file structure, usually on their computer, though there was speculation as to the possibility of integrating paper-based resources as well. Interviewee 90 wanted to manage a variety of data: “I think it’s a great way to manage data. I mean now that I’m thinking about all the different folders and files that I’ve got and information that’s maybe just sitting in a folder but yet is not categorised, do you understand what I’m getting at?” 98 said, “I think it is a useful way to retrieve files yourself rather than the conventional way, so I certainly think for some people it would be an enhancement rather than how to store information at the moment.” Interviewee 68

found the idea of favourites lists had appeal: “I think it’s good for grouping resources, because it’s all folders in your favourites it’s more interesting than your favourites” 90 liked the idea of icons applied to a file structure “I mean, I’m not sure this is what this would give me, but if you could imagine normally I have got all these folders … and have got to go and try and find this file that I’m looking for, but see if it was better categorised and it was … something about icon mixed through it, almost like you’ve got there for example in the library”.

6.5 Extending the idea

An interesting feature of the C series is that some interviewees extend the original idea. The description that interviewees were originally given to base their imaginary worlds on, was of a 3D world in which one’s viewpoint could be moved around by moving the mouse cursor, where one “would be able to move around things, or indeed to move things around”, and in which “clicking on something would retrieve the document, or information resource, represented by that thing”. This is a deliberately “flat” description, because it was felt that the 3D world concept might be enough of a novelty for many people to cope with, and that it would be easier to get people involved in discussion if they were not over-awed by too many new ideas at once.

Series A had free choice as to the design of the worlds they envisaged, and series B generally confined themselves to addressing problems, or admiring features, of the demonstration worlds with which they had been presented. Interviewee 62 suggested a 3D interactive map of a university campus, 65 extended the town to a multi-user world with private buildings, 69 added a “cyber-librarian”, and there were several suggestions that some kind of map would be useful, but, despite the interviewees being asked what they would like a world designed for them to look like, none described anything very different from the models they had been shown. The decision to progress to the series C interviews with a different group of interviewees appears to have been justified by their being more forthcoming, or possibly more inventive, about the worlds they described. There were several “extension” features which emerged, namely overview, alternative access, assistance and trail.

6.5.1 An overview

Interviewee 77 suggested that being able to get an overview of the material also allows discovery of related material of which the user might not have been aware. This idea is also expressed by this interviewee as “very handy when you’re actually stuck for something to search on, and you’re wanting to search on something, to have something visual to do” – a way of browsing which is more likely to result in a useful outcome than the alternative of “type in a search string of goop.” Here is an interviewee’s expression of the concepts of contextualisation and overviews discussed in 5.7.2 and 5.7.3. Irrespective of the model itself, and 77 discussed four which had not previously been chosen, the visual display adds dimensionality to a search – it gives the opportunity to browse and discover related material in a more free way than a conventional library arrangement, as well as offering the possibility of recognising related material which could not be identified by from a display demonstrating only one form of order.

Interviewee 91, frustrated by the large numbers of links typically returned by his Google searches, thought it useful that this type of interface could display subjects in the context of other subjects. This interviewee used as an example a “star system” from the planetarium model, suggesting that in the system representing Religion, one planet could be Christianity, and one, Buddhism, enabling a searcher to narrow down searches. Whilst this was not expressed particularly well in conventional information retrieval terms, it can be imagined that an enquiry relating to prayer, for example, might result in regions of those and other planets being highlighted as worthy of further exploration. The useful point here is that search engines usually display results as lists, ordered according to some, often inexplicit, frequently proprietary, algorithm. These results are typically ordered by “relevance”, however this is calculated, and may offer other options such as ordering by date, but do not typically order results by subject. This is a consequence of the operations of the engines, and the lack of suitable metadata in most documents, but does little to enhance the experience of the user, particularly if he is not an experienced searcher. The implications of an improvement in this aspect of the search experience would include the facility to operate some kind of automatic classification, or to derive a classification from sites such as Yahoo!, where there has been human intellectual input.

6.5.2 Alternative access

Interviewee 95 suggested using a world of this type as a means of providing "realistic" access to closed stacks in a library. The situation here was that the library in which the interviewee worked had limited space, and so was obliged to keep some of its stock stored in rooms to which there was no public access. The interviewee suggested that a library world might give the users an experience of this stock comparable to that of browsing the stock to which they did have physical access. This is an extension of the purpose, rather than of the world model itself, but it again shows an interviewee taking the initial idea a bit further than had been suggested in the introductory material. This is in some ways similar to 77's idea, discussed in 7.2.3, above, of having a "true" virtual campus, rather than a web-based means of delivering text.

6.5.3 Assistance

Interviewee74 introduced the concept of "assistance" and assistants. This notion of having a "non-player character" to assist the user had been considered at the early stages of planning, but had been reluctantly abandoned, due to the difficulty of programming a convincing character. Interviewee 95 had suggested the library might be "Just like the holodeck and you could presumably have a librarian that you would click on and fire off an enquiry to a real person who perhaps would respond back to you." The assistant appeared in other interviews in the guises of a market trader (interviewee 51), a librarian (e.g. interviewee 95), a "cyberlibrarian" (interviewee 69), and here as a shop assistant. The difference here is that the concept of assistance is made an explicit part of the experience of shopping in a way that it is not necessarily a part of the experience of visiting a library. The other characters are there to help, but are not so central to the process.

6.5.4 A trail

Interviewee 75 had the idea that a user might leave a "trail", which would be of interest to "statisticians, and all these other people, wanting to know, do people come here, what is it, where do they come from, what do they look at along the way." This idea is of value in several ways. Firstly, from the point of view of world design, analysis of patterns of movement might help provide information for more useable worlds, in a similar way that patterns of movement of pedestrians help town planners

design better urban spaces. This might be of relevance in multi-user environments, in particular.

Secondly, the trail idea might also be adaptable to “collaborative filtering”, or “social filtering” applications, where recommendations to a user of items they might find interesting are based on preferences expressed, or items viewed, or purchases made, by the user themselves, or a peer group, or simply a number of other users. An instance of this type of filtering can be seen in Amazon’s “Customers who bought this item also bought**”** feature.

Thirdly, there is the viewpoint of the marketing analyst, whose interest is in the “click-through” behaviour of users responding to advertisements on web sites., the designers of individual sites would be interested in where users have “come from” – what linkages or other paths brought them to that particular site. At this stage in the design, where the information sources concerned are web sites, there will still be, and probably there always would be, linkages directly between sites, so it would be of interest to the designer to know if a user has arrived from a linked site, or has navigated there from a virtual world. This also has a bearing on metrics such as Google’s page rank – “this is a measure used by the Google search engine to rank results, and is a score out of 10 derived from the number of links to a site.” (Smith 2004)

Finally, there is a trail in the sense that it was used by interviewee 27, a “trail” could also be useful to the user – part of the problem of being “lost in cyberspace” is that of not being able to “retrace one’s steps” to a web page that had previously seemed of interest, or to a node offering links which seemed promising but are as yet unexplored. 27 described this as “[a] breadcrumb trail, find out where you’ve been before, so you can go back to that link” This interpretation also has the sense of the trail of string left by Theseus in the Labyrinth – a way of imposing order on an alien environment.

It can be seen from this section that the “virtual worlds” concept provides a good basis for stimulating a discussion on user interfaces, and possibilities for extending them which are not necessarily limited to interfaces of this type. There are interesting ideas

emerging here, some of which will be considered at greater length in section 6.6, below.

6.6 Literature

From the analysis of the series C interviews, it would appear that the topics where the literature can usefully be drawn upon at this stage are concerned with navigation and design. In all cases, the fact that the worlds demonstrated were at a rudimentary stage of development means that there is considerable work to be done in order to achieve a more finished product, but there are guidelines towards further development which can nevertheless be identified.

6.6.1 Navigation

It was apparent that, even though the demonstration worlds were simple in design, some users found it hard to orient themselves, and a more complex or extensive design, which would be necessary for fuller subject coverage, would soon lead to users having difficulties with navigation. It is therefore interesting to examine the literature in order to establish whether there are design principles which could be employed to reduce such difficulties.

Dalton (2002) deals with wayfinding, navigability, and landmarks. She explains that Ingram and Benford (1995) "speculate that the use of city-like environments may serve to be useful metaphors when designing navigable abstract worlds". Ingram and Benford are concerned with aiding user navigation by placement of aids in the environment. The LEADS system is generated "on top of" a pre-existing information visualization. This means that, in the context of the current study, the system might be applicable to a world "automatically generated" as the result of a query, rather than a world of the "hand-crafted" type (see section 5.6, above, for discussion of this distinction). Districts are defined by data clustering algorithms, landmarks are places in the centre of triangles formed by connecting the centroids of three adjacent districts, edges by dividing the line connecting elements of different districts, and paths will be evolved by tracking usage of resources within the districts. At the stage the paper was written, this "evolution" of paths was not yet feasible, so they were formed by connecting the nearest neighbour nodes in adjoining districts. An "optional

axis object" – apparently something akin to a 3D compass, and a history/backtrack facility would also be provided. In a later paper, Ingram, Benford and Bowers introduce the concept of "intelligibility" - "A system is intelligible to the degree that what you see immediately around you gives a good guide to where you are in the whole system … [i]n an intelligible area your global location is essentially predictable from local information" (Ingram, Benford and Bowers 1996).

Another passage from Ingram, Benford and Bowers is reminiscent of Card, Mackinlay and Robertson's observations regarding information cost, discussed above in section 3.2.1, and below in section 8.2:

> "In principle, these subtle inter-relations between access, lines of sight, navigability and probabilities of social encounter can be exploited in the implementation of suitably designed or evolved virtual villages, towns and cities which could serve as CVEs [Collaborative Virtual Environments]. In this way, city (etc) metaphors for virtual environments may produce gradients of accessibility for information and computational resources distributed about them, rather than insist that accessibility is an 'all-or-none' matter determined by the possession of a password or some other access key. Our argument is that this features [sic] may fall out naturally in the design or evolution of virtual settlement-like spaces as a product of their configurational properties." (Ingram, Benford and Bowers 1996 p. 6)

Card and his colleagues listed observations from previous studies, identifying, amongst other phenomena, the efficiency of hierarchical arrangements in reducing the cost of information access, in both natural and artificial systems. This seems to be echoed by the "gradients of accessibility" phrase. Ingram and Benford prefer "software simulations over human experiments or 'field trials' at this stage", on the grounds that the cities modelled by the Virtual City Builder are not detailed nor closely tied to real applications, being rather an experiment in how weighting factors in building aggregation affect the eventual structure and thus "intelligibility" of a city.

Dalton develops the concept of “intelligibility” with regard to Alpha World, the first and largest of the Active Worlds group of virtual communities, which is discussed further in section 3.3.4.3. She concludes that whilst AlphaWorld is intelligible on a local level, this is not the case at a global level. In other words, it is relatively easy to navigate within a small region, but, due to the independent development of these regions, and to the fact that motion can be accomplished by “teleporting”, the world as a whole has low intelligibility, so it is not so easy to picture a region in the overall context of the world. Of course, as Dalton notes, the city model for the structure of AlphaWorld is encouraged by the infrastructure of highways, and the instructions given to users, who are advised to “clone” an existing piece of structure, such as a stretch of highway, and to cover the piece of “territory” to which they are laying claim. There is an implicit assumption that a city-like structure will emerge. This necessity to “occupy” areas with placeholding structures also appears to result in a large number of areas which are only minimally developed. For example, there are facsimiles of the exteriors of chain franchises (e.g. Subway) which are undeveloped inside, but may be attempts at a variation on the “URL-squatting” which became a popular speculative enterprise in the late 1990s. Dalton also summarises criticisms of the features (landmarks, districts, paths, nodes and edges) described by Lynch (1960) as important, though these elements are used by Dieberger and Tromp (1998) in their Information City, because they allow users to “easily learn .paths, to describe and remember routes and locations”.

Robertson et al. (1998) describe experiments with the Data Mountain, a 3D desktop virtual environment, showing that a system can be “designed specifically to take advantage of human spatial memory (i.e. the ability to remember where you put something)”. The Data Mountain is discussed in more detail in section 3.2.6.

In summary, there do exist design principles which would allow users more easily to make sense of virtual worlds, and it seems likely that these could be employed to help reduce the disorientation reported by some interviewees.

6.6.2 The library as model – Cubaud and Topol

Cubaud and Topol (2001) strip much of the "library as building" element from their virtual collection, preferring to concentrate on the appearance of the volumes themselves, and relieving the user of the necessity to move their viewpoint, because "navigating in a 3D content can be difficult for inexperienced or occasional users. To ease the interaction, users can manipulate the books of our 3D digital library without moving the point of view … We consider that it is useless to faithfully reproduce the various steps of a book selection. In a virtual world there is no need to 'walk' to a bookshelf then 'turn' to face the books for reading their titles before choosing one". This is an issue which emerged most obviously in series 'B' interviews in the current study, with interviewees wanting to "walk through" bookshelves, and had also appeared in interview 11, discussed in section 4.4.6, above.

Some of the design decisions were due to the nature of the digitised items – book dimensions were scaled to allow for good quality rendering of the texture scanned from the physical items, the number of virtual volumes corresponded to the number of physical volumes. However, "a roll-over event creates a tooltip beneath the book giving a short bibliographic data. A mouse click opens the book in a new window". These behaviours were implemented in the test worlds in the current study, and attracted some criticism. Cubaud and Topol also conclude that "Because of the many scripts needed to manage complex interactions, VRML is not the right language for creating online 3D applications". Their system used extensive Java scripting, and does indeed seem to have been of some complexity (it is no longer accessible online). "We are waiting for users feedback before enhancing the current prototypical application. In the HCI domain this kind of spiral approach is often used. Users' needs are collected to build a prototype and the users feedback are used to enhanced it." Reference to Cubaud, Thiria and Topol's earlier paper, cited in this one (Cubaud, Thiria and Topol 1998) does not, as might be expected, demonstrate collection of "users' needs", although it does give an interesting example of the type of the "many complex information tasks [that] can be simplified by offloading complex cognitive tasks onto the human perceptual systems" (Robertson, Card and Mackinlay 1993). "Knowing the subject (physics) and recognizing French XVIIIth century binding style, an expert may infer that the six alike volumes on the upper right corner are

Nollet's "Lecons de physiques". The bottom shelf contains only XIXth and XXth centuries bindings. The big one on the left side is typical of Ecole Polytechnique textbooks. There are only 50 books on these shelves, but these "visual heuristics" are already more efficient than reading a textual list. "

In this paper, Cubaud, Thiria and Topol describe an arrangement which generates an image of the covers of a collection of books on the internal vertical surface of an upright cylinder, with the user's viewpoint being on the axis. They write, "Our alpha tester team will include the library staff and some expert patrons of the library antiquarian collection." This testing, however, appears to relate to the time taken to rotate the cylindrical display, so that the desired item is presented to the viewer, and is not concerned with the actual design of the display. It is interesting to note that this model would appear to fulfil the requirements of interviewee 11, discussed above in section 4.4.6.

As the preceding section provided evidence that virtual worlds could be made more "legible" or intelligible" to the user, this section has discussed some techniques by which the library model, specifically, might be made more easily usable.

6.6.3 Library as metaphor

It may be, however, that there is more to the library models chosen to be the ideal worlds of the interviewees than just a very simple representation of a building, for example. It may be that what the user does by invoking the library, or the town, or the shops, is to try to call down the mythos, the metaphorical attributes associated with the model. Stefik (1997) makes these points with regard to "the Digital Library Metaphor, which awakens the archetypal *keeper of knowledge* or conservator within us, and reminds us to gather and preserve knowledge for future generations" (Stefik, 1997, p. xxii). Stefik also considers the roles played in the traditional library by writers, editors, publishers, catalogues, classification schemes, literacy, authority of the printed word, and intellectual property. "The traditional library … is, therefore, far more than a place for storing collected knowledge; it is part of a social system involving social roles, literacy, and intellectual-property law – all of which are implied and assumed in the digital library metaphor." (Stefik 1997 p. 8) These points

will be seen to have significance in the next chapter, when comparisons are drawn across all series of interviews.

There are many further discussions of the library as a metaphor for accessing digital resources – for example Munoz-Martin, Aedo and Diaz (2001) discuss the creation of a prototype library, their advocacy of the library model being due to the improved access it could give to documents which are, otherwise, not organised at all. There does not appear to be any evidence of this system being developed beyond the prototype stage, however. Ackerman (1994) criticises the use of the "digital library" metaphor because, he says, "this current use of the "library" metaphor considers only what is possible with specific types of technology, and then *restricts the meaning of the metaphorical referent to that narrow conception*. That is, we do not see the technology as restricted because we redefine the social phenomenon to include only what is technically possible" [emphasis in original] (Ackerman 1994). The digital library provides only the information retrieval function of a "traditional" library – the "many social elements" are missing, and Ackerman argues that this misuse of the metaphor is "dangerous".

6.7 Emergent theory

As can be seen from section 6.2.2, above, a number of world designs which had not been previously encountered emerged in the series C interviews. A garden, a map, and shops appeared, all of which had been encountered in series A, but in addition there were at least seven new models ("scuba diving" and "underwater" seeming to be quite similar).

At this stage it could be concluded that theoretical saturation had been reached – that "no additional data [were] being found whereby the [researcher could] develop properties of the category ... as he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated." (Glaser and Strauss 1967 p. 61) The reason for this confidence is not that no new world descriptions were emerging from interviews – although there was a much lower frequency of novel descriptions in series C interviews compared with series A – but that, if the ideal worlds continued to have in common the elements, or combinations of the elements, of familiarity, selection, mediation and beauty, then the emergence of

new specific instantiations of these elements does not compromise the saturation of the category.

A lot of people were very literal – a forest would be a good world to use for access to information on environmental studies (suggested by interviewee 91) or space for access to information on planets, or indeed a campus for access to information on the Virtual Campus (suggested by interviewee 77). It is not necessarily a bad thing, but it seems that perhaps many people are not ready to use an abstraction.

Given the popularity of the library model, even amongst people who were not normally advocates of libraries, the interviews at this stage seemed to be suggesting that this was a clear favourite. It was realistic, and it was organised, hierarchically, but there was no obvious reason, other than perhaps a lack of imagination, why it should be so popular. It could be seen from the diversity of worlds in series A interviews that lack of imagination was not a problem, so the question remained why so many people chose the library model, either before naming a different ideal, or as the ideal.

At this point, the emergent theory seemed to be "stuck". It could be expressed thus, as an amalgam of the two previous emergent theory passages:

All worlds could be classified into one of four groups, and that, for some reason which is yet unclear, people would tend to prefer worlds from one of these groups. **While there is generally an enthusiasm for the idea and the potential of using 3D virtual worlds for accessing information, this is tempered by reservations as to the practicality if using them in this context.**

This appeared neither very conclusive, nor particularly interesting, and prompted further immersion in the data, recommended by grounded theory as a means of increasing theoretical sensitivity. The results emerging from this further immersion will be discussed in Chapter 7, below.

Chapter 7 Comparative analysis of series A, B and C

The purpose of this chapter is to examine common features across the three series of interviews. In chapters 4, 5 and 6, analysis has concentrated principally on the interviews belonging to series A, B and C, respectively. However, just as each stage of the grounded theory methodology builds on the previous stages, it seemed probable that more insights might be gained by looking across all series, in order to discover common factors and differences which might add depth to the emergent theory.

7.1 Choice of model worlds

A slightly greater proportion of interviewees liked the idea of the "space" worlds than liked them in practice. Of course, these were not the same individuals, but three from the fifty-three series A interviewees mentioned a "space" world, two from the eight series B interviewees opted for the space world, and only one from the thirty series C chose a "space" theme as their eventual preference. This disparity, however, might easily be a result of difficulty in implementing a demonstration world which was both somewhat convincing, and useable. Individuals' images of "space," "planets," and "galaxies" would have to be more closely examined, and might turn out to be incompatible. Neither "space" model was particularly satisfactory, even as a prototype, but this in itself serves as a warning that models may not be as simple as they sound. Another possible scaling for this model, which might have worked better, would be to use a Milky Way-type image, literally of groupings of galaxies at different densities, the user being permitted to "zoom in" on areas of particular interest, and examine smaller systems within a galaxy. Unfortunately, the time and resources available would not permit development on this scale. Space, however could be accepted as showing some sort of order, by the interviewees who favoured it. Interviewee 94 resolved the navigational problem by means of spaceships with destinations marked on them, which could be used to travel between systems. This is an unusual idea on two counts: it is one of the few uses of a vehicle in the interviews, and it also interposes another stage in the search process. Since this interviewee expressed a liking for the TV series 'Babylon 5', a fast craft might be expected, and it

is possible that the time spent in this type of scheduled travel would compare favourably with navigating in a large city, in “walk” mode.

The forest could also have been criticised for its lack of resources, but the most common question seemed to be whether the height of the trees was related to anything, and, if so, to what? When it was explained that the height was related to the size of the resource, most interviewees appeared content with the response. None inquired as to how the size of a resource might be measured, an attitude encountered previously with the car park model, in which the notion of differently-sized resources was taken for granted. This rather small and haphazard grove was intended to represent natural woodland, but, on reflection, something more akin to managed forestry, with orderly same-species groupings, varying only in height, might have been a more usable design. Some interviewees took a concrete approach, and acknowledged that a forest model might be useful for finding information about trees, and it was also remarked that a forest was not a place normally thought of as being a source of information.

Some interviewees focused their attention on one model they liked, or disliked, and some gave, often valuable, criticism of all four.

When the “free but informed” responses (they were free to choose any ideal world, and had seen the demonstration ones) of series C are compared to the A series of interviews, some correspondences seem to emerge. It would appear that the “simplification”, or “abstraction” of the variety of worlds imagined in the A series interviews into four examples was partially successful, in that most interviewees decided, with varying degrees of enthusiasm, that one or two of the worlds were potentially usable. However, when encouraged to imagine ideal worlds more freely, it appears that a similar selection of models again emerges – there seem to be examples of the same ideas occurring again. For example, there are recurrences of the shops/shopping model, but with added emphasis on the value of an assistant. The idea of a librarian as assistant had come up in series A, as had the idea of a helpful market trader, but interviewee 74 brought it out most explicitly: “I think of a shop as somewhere where you get stuff, but where you’re helped, you see, and so a shop seems to be more helpful than say a tree or a planet … I get completely lost on all the

databases, and the idea that there would be a friendly face offering assistance is still something I associate with shops more than trees or planets, and I think that would be essential."

A memo written at this stage expresses the following argument:

> The series A interviewees presented a diverse range of ideas, which were generally characteristic of concepts they knew about (e.g. Buddhism), things they liked (e.g. lollipops), or places with which they were familiar (e.g. a library). There were also other models which were more difficult to categorise in this fashion. It might be that the floating blocks world presented by interviewees 2 and 3, which was specified as being similar to the graphics at the beginning of a television news programme, indicated a preference for information coming from a reputable source.
>
> The series B interviews were mainly concerned with usability issues, since that was the essence of the interview brief (See Appendix B). There was, however, a tendency for these interviewees to declare a preference for a certain model, or models, and there is more content in the interviews than these elements alone.
>
> Series C are more expansive in expressing themselves, which was part of the rationale for their selection through "theoretical sampling", as discussed at the beginning of this chapter. When presented with the four models (space, forest, town and library) they seem to tend to choose one of the "organised" worlds (town or library). This may be for the reasons put forward by Stefik (1997), who suggests that a library is good because the information is pre-vetted: produced by authors, then filtered by publishers, then librarians, and mediated to the user in a traditional, understandable way. This

> is, perhaps, a more acceptable interface than the unmoderated and unorganised world of networked documents. It should, perhaps, have been realised earlier that the very model suggests pre-selection, whereas trees and galaxies are "wild".
>
> Series C, then, tend to choose a world with which they are to some extent familiar. They are academics and academic support staff, so it is not very surprising that, of the choices available, they tend to choose a library as a place to access information. The series A interviewees were not, at the early stage of their courses when the interviews took place, particularly library-oriented, with the exception of two who had worked in libraries. Therefore, many of them did not have a library as a familiar place, and presented ideas reflecting other places with which they were familiar, for example "my house" (interviewee 9), or "a typical high street" (interviewee 50). This is not true of all interviewees – some, such as interviewee 23's hierarchically-arranged mansion, are more literal representations of a classification scheme; some, such as interviewee 27's bubbles, were more abstract.

Memo: Aberdeen Business School 29 September, 2006

Shops, of course, are labelled or branded, as are campus buildings. If one is familiar with airports, one recognises their characteristic features – an airport has to have certain places, such as check-in desks, in it, or it is not an airport (assuming that this is a modern, national or international airport). The same principle holds for libraries – the model need not represent "my" library, as long as certain generic features are in place, and certain conventions hold.

The other type of preferred world which series C interviewees chose could be seen as one in which they would have some degree of control, or design rights: "my ideal garden" (interviewee 98) or "my house beside the town square" (interviewee 85).

In summary, series C preferred either a world they would accept as it stood (e.g. the library – interviewees typically did not want to change that much, except in regard to increasing stock and signage) or a world in which they had control (e.g. the garden, or the memory palace).

What appeared to have happened here was that a study which started out to discover user preferences in the broadest terms, had failed to see beyond the obvious. Where non-structural features were examined, these were considered as relating to the worlds. The interview with 74 exposed a hitherto unexamined aspect – what using the worlds felt like to the user. Responses such as "interesting" and "fun" had been noted, for example in section 7.3, but these are at a different level from 74's response, which reveals something of what a user needs to get out of the world, for the use of the world to be satisfying. It also opened the possibility that the important factor, or factors, might not be simply structural or related to the common non-structural features discussed in sections 4.5, 5.5, and 6.4, above.

7.2 Series A and B: Familiarity

When the interviews were analysed for terms denoting familiarity and comfort, a surprising amount of material emerged, that had not been apparent in the first analyses, which had focused more on world types and on reactions to using the models. There was only one from series A, possibly because those interviewees were working with a "blank slate", but this one made familiarity a priority:

> 09: "Well, it's obviously quite difficult to imagine things like this, but ... the way I would like it first of all, to be something familiar, something that I'm living with difficult to explain, really. Well, you know, maybe um, something that we already use in our computers today, or even like a homely feel to it. I don't know. Like the virtual world would be similar to … well, I would build it similar to my personal surroundings. Something like that … I think that if I should choose between the computer world that we're given today and a more personalized, like homely world, I think I would choose that one."

The terms “familiar”, “homely” and “personal” are not too often associated with software, perhaps because software for the mass market cannot easily be given these qualities, though it is worth noting the successes of the spreadsheet and desktop models, both based on metaphors for things found in real-world offices.

In Series B, the interviewees had seen world models which they might potentially recognise, and the library proved popular. Here, it is a surrogate for a real library, which can be accessed when the user is elsewhere:

> 54: “It makes a lot more sense, when you have something like this, like if you’re looking for something specific, and you’re not in a library, and you know it is in a library”

Here, the fact that it is a library apparently outweighs the potential obstacle of not knowing the classification scheme. Perhaps this is reliance on good signage, or perhaps recognition that not many users do know the classification scheme in the libraries they use.
54: “That would help, but even if you didn’t know the classification scheme, you could probably poke around …”

“Traditional” is the preferred term of interviewee 55, applied to both town and library. The models were traditional only in the most abstract sense, so perhaps “recognisable” would have been a more appropriate term.
55: “I preferred that one [town] and the library one, just because they’re … more traditional.”

Interviewee 55 sounds quite conservative, but contented with a familiar environment, and the use of “my library” emphasises that: “I think it depends on which sort of person you are – some people like mind maps and stuff, they work in computers, and some like trees and stuff a bit more flexible. I like my library.”

56 again favoured the traditional: “I preferred that one and the library one, just because they’re … more traditional. They made more sense to me than the one in

outer space and the tree one." This idea of "sense-making" also emerges in the interview with 60, who required better contextualisation of the resources available:

> "I got really lost there, for a second. I've got no idea where the planets are. You need more to show you where the boundaries of the thing in space are. I'm facing away from the planets, obviously, but I don't know where they are they should be down here, but they keep waggling around, you need to sort of represent the limits to the space and the planets, to tell you where you are, and it would make more sense, but while there's not many of them …"

Interviewee 57 spoke of: "… traditional sort of things where people are seeing the information in a sort of library context … a nice little introduction introducing an idea, the concept of virtual libraries." A "nice little introduction" might be "nice" because "little", but also because it is in some way comforting that a virtual library can appear to have some of the features familiar from a physical one. One such feature is, of course the shelving, as interviewee 53 noted: "I feel I should be going round them [bookshelves in the library] Can you go through them?" This shows the juxtaposition of the limitations of the physical format with which the interviewee is familiar, and the realisation that there may be more possibilities open in the virtual domain. It is apparent from the interviewee's tone of voice on the recording of the interview that the idea of "going through" the shelving in a library is a novel and intriguing one.

62: "I assume that your graphics could probably change into so if it was, say, I don't know - a library? You could have graphics on the shelves and maybe different spines representing the different subject areas, and so this kind of model would just sort of be visual feel like you're walking down the stacks" – at this point, the interviewee is still looking at the town, not having seen the library.

Simplicity was also seen to be a good thing:

62: “The library was better, in that it was more straightforward, and the books were just in stacks.” The word “straightforward” appears to imply that the user knows what to do, when confronted with books in stacks. This perceived benefit is echoed by interviewee 65, who expresses the familiarity requirement somewhat differently: “You should have something more like the real world. So you don’t have to actually find out what that thing is.” Having a familiar interface is thus a means to reducing the cognitive load on the user.

Here there is an association between information, books, and the library.
63: “it depends from a literal point of view whether you’re actually thinking about looking at books, you kind of think to yourself looking up books within a library, so from that point of view, that makes more sense.” The library is the natural home of books, and the mental leap required is therefore not too great. Influence of individual differences on application design for individual and collaborative immersive virtual environments.

63: “I like the way the library was, it’s just a bit more difficult to navigate round, but the idea of the library is kind of easier to take in. It depends on … the concept of the library works better, when you’re actually thinking about looking at books.” Here again is an association being made between “thinking about looking at books” and the library. It is an easy idea to take in, because it is familiar, but this interviewee has decided independently that they are “looking at books” – the resources linked to from the book models were not themselves books, but web sites.

Interviewee 69 was enthusiastic about the idea, and quotes from that interview could serve as a summary of this section:

> Interviewer: “And the library’s one that appeals to you?
> 69: I think so, just because it’s something familiar.”
> 69: “I think probably everything neatly classified, go in there, oh you could have a cyber-librarian, at the desk, so you could go up and say, I want something on the … it’s a bit like logging on and using … Information from the web, being

classified would be very useful, and also a librarian would be able to filter out all the junk"
Interviewer: "Any main improvements?"
69: "Fill the shelves up, definitely. And a librarian."

This exchange mentions several of the features which have been regarded positively: familiarity, assistance, organisation, and filtering. Probably all of these, but certainly the latter two, can be taken as properties "implied and assumed" by the digital library metaphor, as noted by Stefik (1997) and discussed in section 6.6.3, above. There is an implication that if the subject coverage was to be completed, and the "cyber-librarian" added, interviewee 69 would be quite satisfied with the interface.

7.3 Series B: Customisation

Interviewees were not asked specifically about customisation, although they were told that a world for accessing personal information was an option, and that this could be organised by the user. Two of the interviewees saw advantages in being able to organise their worlds. Interviewee 63 appeared to favour having complete control over world content: "I quite like the idea of that … [you] have your own little virtual world, and you set it up, and you put things in. I would be likely to use something like that as well"

Interviewee 65 appears to see customisation as a guarantee of quality: "My suggestion would be, you would have your own world so the user knows ... they can access that safely."

7.4 Series C

With this rather rich vein of evidence showing that preferences in series B might be related to the familiarity of the world, the next step was to re-examine the series C interviews, and pick out properties of this type. Since the focus in this section is on the properties, rather than on the models, the same properties will be discussed where encountered in association with worlds of any type, although examples related to particular worlds will be provided where appropriate, by way of illustration.

7.4.1 Series C: Familiarity

The first property to be searched for was familiarity. As discussed in 7.2, above, it had featured quite prominently in the B series of interviews, where mention of familiarity might be inspired by the first encounter with some more familiar and less familiar environments. By this interpretation, the fact that there was only one mention of familiarity in series A would be due to the fact that series A interviewees were describing a world or worlds of their own invention, and that familiarity was therefore a "given". Series C, however, could experience the demonstration worlds, and – again, by this interpretation – might be motivated thereby to mention it explicitly as a desirable feature in an ideal virtual world.

76 "I'd like one that I felt comfortable in, and didn't get lost in, and that I felt like I said before, I think the best that … the library was easiest to have an overview of where everything might be, where I could find things"

Interviewee 71 said, "I like the library, the concept". And 71 would like to be able to collect result sets from different queries – "could you query it, and just get the books you wanted out of that query, and then go on? … Because otherwise, if it was a huge library, then you'd spend forever wandering around, like you do normally, actually". This adds to the idea of the library some of the functionality normally associated with online database hosts, such as Dialog, or later-generation online public access catalogues (OPACs).

75 could be interpreted as taking the idea of familiarity considerably further, by returning to an earlier stage of human development, specifically to the hunter-gatherer and villages: "it's almost primitive in a way, too, though, it's this hunter-gatherer thing still going on, to some degree … we pick things all over the place, often subliminally, and pull them together". This is in response to the interviewer's mentioning that some authors suggested that faculties otherwise unused in interacting with computer applications might be brought into play when interacting with a 3D virtual world (discussed in section 6.6.1, above). This idea was mentioned in all the series 'C' interviews, but this particular interviewee was the only one who addressed

it specifically. The interviewee then went on to discuss leaving “information trails”, as discussed in section 6.5.4, above.

Interviewee 78 said: “I think I personally quite like rooms and corridors, going round courses, but equally I quite like grids, and you know the grids in your original thing, I quite liked that … perhaps I would go for something like a patchwork type of thing … I was probably thinking of quilts because that’s … I do that”. The familiarity here is not to do with a specific structure, but rather with a type of pattern – a sequence of rooms and corridors, a grid, or a quilt.

Interviewee 96 made a point which could explain the variety of worlds chosen as favourites: “I’d probably go for the library, just being more familiar with this kind of structure ... certainly, the library makes perfect sense to me, I suppose that is reliant on the background knowledge of the users to a certain extent”. In a sample of academics and support staff, it is not surprising that a library should emerge as a common familiar place, in number of instances. However, the shift in emphasis means that now it is the familiarity, rather than the place, which may be the important factor.

97 certainly seemed at home with the idea of the library: “that library one seems nice and easy to understand, you are not hunting around, you are just sitting at your desk, you are not walking around looking … you know how to look for something in a library, browse, you know ... the library one, I suppose it’s like there’s every concrete concept there … libraries are something that everyone does every day … it’s not a big jump from what you would do anyway”. This response certainly indicates the interviewee’s inclination to use a familiar world, but also reveals that they are not a typical user, even in the target group of this study. The assumption that “libraries are something that everyone does every day” is indicative of a rather cloistered outlook, but it is still interesting that someone with this outlook should be attracted by the non-traditional interface.

102 expressed the advantages of a library as familiar, and as a gateway to resources: “In terms of the worlds, yes the library is familiar but in a sense because it was … a bit unexciting but if you wanted a serious …you need some kind of familiar book to do it so covers, books on shelves, those sort of things do provide a sort of common

element with what you are used to, a gateway to other people's resources". Here we see what could be a simplified re-wording of the conditional matrix from section 1.0. The familiarity of the interface (in this case, a library) is an advantage because it provides a way "you are used to" which gives access to "other peoples' resources". It can be a familiar way to cope with the increasing amount of information to which we have access.

7.4.2 Series C: Organisation and structure

Another desirable factor expressed through the library model was organisation. Again, this is not limited to libraries – shops are organised, gardens can be, towns may be – but from this particular group of interviewees, it is not surprising that the library struck many as the epitome of organised information. A closely related term is "structure" – both organisation and structure are aids to finding things, and are regarded positively by the interviewees.

76 said: "I feel most comfortable about the library, because I feel it's so kind of obvious organisation of things." Organisation was a frequently mentioned positive factor, perhaps because, as the next quote implies, "organising" is seen as being something that is done with information: 76: "if it was something that was broader – like a library – or, … the office … something that I'm familiar with in terms of organising information already. Then that would help me, perhaps, work my way through it".

95 reiterates the comfort theme: "a library is very comfortable for us … we are naturally information people anyway … in terms of how I organise things and like to have things organised, the library model fits very very well". The interviewee recognises that there are people other than "information people", but notes that "information people" are comfortable with the library.

80: "When you go into the library it would be quite helpful to have like a shelf that was all your work-related bits and pieces and perhaps a shelf for all your personal things so that - for myself, I find it quite helpful to have things that are very organised and things that are quite easy to find, so it saves you time, and I think the interactive element is something that ... I didn't initially like it, but then, when I got used to it, I

did" Here is someone adapting not only to the interactivity, but also the library, and moving smoothly into customising the library, by having a personal area. This interviewee was particularly interested in storing pictures (of mountains, friends, pets, as well as business topics), and had as an ideal world "a map of Scotland divided into different mountains

Moving on to structure, interviewee 81 also moves away from a library model: "I think a library one is very good, because it's very clearly structured and you are able to find things … I think the more abstract, the more difficult it is to find exactly what you are looking for. My ideal kind of environment would be a garden …, but then I would need structure within that garden in order to find things". Here it is apparent that the structure, rather than its substrate, is the important factor.

83 shows that structure could be as simple as collocation of resources: "I maybe preferred the library because all the shelves were kind of in the same place", whilst 84 has a particular subject area in mind: "I mean, I think the idea is brilliant. I think it would be fantastic to go into a library and find all the business management … it makes it more user friendly, I think".

Interviewee 87 was enthusiastic about the 3D worlds idea, and saw it as having potential to attract users to information resources: "the thing runs very smoothly, and it's not too difficult to work out where you are"
"what you are actually using, exploiting, which you can't exploit very readily in a normal kind of 2D environment, is the ability to recognise where you are, where you've been, where you might want to go and actually inviting you to explore in a kind of what I think is quite inline with the original idea … in a universal library and actually getting back on that track, as opposed to the way we've gone, which is sort of being led off to links between documents and so on"
"I suppose the obvious one is the library/bookshops and so on … I think that would be ... that would work really nicely"
"I can see, for a sort of, maybe a younger body of students, undergraduates, whatever, having tremendous fun, for actually sort of getting over the hurdle of, 'oh, it's all too much, and I can't find my way around' to actually have something like this … I think it would be tremendously powerful"

94 saw a similar possibility: “I think it’s quite an interesting idea, I think it is the kind of idea that would appeal to young people and perhaps make them use sites like the library a bit more frequently, because it would be a bit like a lot of their games” This is another angle on familiarity – if we take “the library” to be our information resource, then the familiarity of a means of interaction might be an attractor, in addition to the familiarity of the model.

90: “I can understand the concept of a village ... town … city … and contained within it were all the different sort of areas that you would tend to find”

92: “I would probably go for an informal garden, because that’s what I’d like to have, but whether that suits a categorisation type form, I don’t see why not, it’s just like having an untidy desk or a tidy desk ... I think it’s very appealing [the idea in general]” . This interviewee shows that structure and organisation can be very personal things.

For 98, the perceived benefit lies in having a world which is not a library, but which is personally “meaningful”: “I would prefer a garden … I’m not a particularly organised person, and anything that would help me organise where I’ve got things would be a bonus, but it would need to link into something meaningful for me, so that I could probably organise things in a garden better than I could organise them in a library”

It seems that interviewee 99 misses the structure of a shop in existing examples of online shopping, and sees some possibilities in using that structure for accessing information: “maybe a shop might be quite a nice idea, because people think in terms of shops, and I think it’s quite sad they are making huge amounts of money out of online shopping, but no-one has actually done anything to be creative about that, it’s really incredibly dull … I’d envisaged … that I’d somehow be there physically, going round and round – it would be a terribly interactive process”

7.4.3 Series C: Customisation

None of the demonstration worlds provided any affordances for interaction, other than by activating links associated with objects in the worlds. The fact that interviewees

expressed a desire for customisable worlds could be taken as an indication that they were dissatisfied with the worlds as presented, or simply that they preferred to use systems of organisation particular to themselves, rather than dealing with an imposed system. It is also part of the library and shopping metaphors that the user goes out in search of resources, and either uses them whilst "away from home", or retrieves them and arranges them in a manner of their own choosing.

Comments were made about the desirability of a world that could be changed, or customised. The suggestion that it would be possible to "pile up" virtual objects in a way that was personally significant met with general approval. Interviewee 71 expresses some common ideas:

> I'd want to be able to reorganise everything, as well, so if there was some kind of way that you could change the colours or change the layout so that you made your own world, and modified it, sort of like developing your own filing system.

Interviewee 102 points out that there could also be negative aspects: "Well I certainly like to move things around and I also like the fact that unlike a pile on your desk you can move the cursor … and get a sense of what's there without fiddling with the order if necessary. If you did have the ability to change for yourself you might also get side-tracked."

With regard to user involvement in design, this customisation aspect seemed to occur most frequently. Perhaps users balk at involvement in the early stages, but can cope with the idea of "fine-tuning" a design, in much the same way as people will become involved in decorating or home improvements, but not so much with architecture, or will specify optional extras for a new car, but not venture into chassis design.

7.4.4 Series C: Assistance

The idea of assistance had previously arisen when worlds included a helpful market trader in Series A, and various examples of librarians. However, interviewee 74's requirement for assistance was more clearly stated, and the idea of a shop as "somewhere … you're helped" was central to that world. Interviewee 69's "cyber-

librarian" is another example. The idea of assistance, or mediation, is another element in both the library and the shop metaphors. A closely associated idea is that of maintenance of quality – "a librarian would be able to filter out all the junk". Again, this is a feature which is part of the metaphor, for shops as well as libraries – the stock may be assumed to have passed some type of quality control.

7.4.5 Series C: Presentation

Several interviewees commented on their wish for a working model of the 3D world to be of higher quality than the prototypes they were shown. Interviewee 89 put it thus: "I think it's a very good idea, but it's going to have to be well executed, at the moment, it's not user friendly enough for me to want to use it all the time." Higher quality worlds would include better graphics, improved ease of movement, and a degree of interactivity – the ability to move items in the world would be necessary for customisation, for example, and the ability to interact with other characters would be necessary to implement an assistant. However, as interviewee 87 pointed out, "if you did go to a lot of bother, then you probably still wouldn't satisfy because people are still looking for the bird in the tree or the sun to set or something like that." Kjeldskov et al. (2005) describe extensive multi-modal testing of a mobile guide system, and explain that no one testing method is successful in detecting all the issues identified with its performance. It seems probable that similar extensive testing of the virtual worlds would be beneficial.

7.5 Emergent theory

Overall, Series A interviewees expressed preferences which tended to be limited to their ideal world – some favoured colour and fantasy, some favoured considerable organisation, and it was from these groupings that the four test worlds were drawn. Series B were more concerned with usability, and began to raise issues of familiarity. Series C, having seen demonstration worlds, then went on to be more reflective in their expression of preferences, and it was amongst this group that the majority of "affective preferences", relating to factors such as familiarity, quality, and assistance appeared.

Users in the study appeared willing to suspend disbelief to the extent that they would accept the possibility of a realistically “transparent” interface. The models they saw were at a very low degree of development, but it seemed they could imagine something much more usable and realistic, so to this extent the models were successful.

The interviews with staff are qualitatively different from the interviews with students. First, they appear more positive, and are more receptive to the novelty of the idea. Second, they are more voluble – as professional communicators, it might be postulated that they find it easier and more natural to express themselves verbally than do students from a mixture of previous experience. This, of course, has negative aspects, as well as positive ones. There are interviews where an enthused staff member takes the interview topic off at a tangent. However, on balance, the greater preparedness of the academics to communicate led to interviews which were typically “richer” in content.

The other unexpected feature of the third phase of interviews was that they could be interpreted as “echoing”, or developing further, the models which had emerged from the first set. The word “interpreted” is important here – it will be described in the Findings and Analysis section that this is a further act of interpretation, based on the techniques developed in the first phase, and is therefore subject to the same caveats mentioned above. Subjectively, however, this correspondence was quite striking, and appeared to validate the selection of categories from the first phase.

It seemed that saturation had now been reached – no new ideas were emerging, and there was no evidence of the “idiosyncratic” worlds encountered in series A. It would appear possible that the experience of navigation in a demonstration world has a limiting effect on the elaborateness of the ideal worlds proposed, or it may be that the experience reinforces the attraction of familiarity. In any case, the theory had now changed from a design-based theory, which predicted that users would favour particular types of world design, to a quality-based theory.

In keeping with grounded theory methodology, this conclusion was “member checked” with the series C interviewees. This is a passage from the email which was sent first:

> As a matter of fact, the worlds everyone chose were quite few in number, and by far the most popular were libraries (though not with the librarianship lecturers) and gardens (though not with the gardeners, perhaps). Shopping also featured strongly, though I wouldn't speculate about that ;-) There were also some really good one-offs, which I won't mention, because I'm ethical about the anonymity issue. However, after lots of transcription, etc, as above, the conclusion I've come to is that people want a world that gives them a feeling of familiarity, perhaps reassurance, or a sense that they're being helped in their choices. Maybe it's because we have to deal with such a huge amount of information these days, we like to put it in terms of an interface we can deal with confidently.

. There were no contradictory responses, and some interviewees provided additional information in support of the theory. One response emphasised organisation:

> The concept of your 3D world was rather exciting. I would see this fitting into my life but rather than it be like 'Second Life' - that rather strange site where you live in a virtual world, I would prefer for my 3D world to be an organisational tool, where there is a strong focus on visual identity of the site. Somewhere you can have 'front doors' to eg 'My credit card/my finances' where all your Word Documents/credit card bills etc can be stored. This could also be used in terms of 'rooms' like you had. And then for hill-walking/climbing etc I would have all my photos and articles related to that in there. So it would be a very logical system, with the visual component of say, the home page for Virgin Money to be there but having the ability to use this within my 'IT home

> area' if that makes sense. It would need to have real use to me in my personal and home life for me to use, or see real value, in something like this.

Another agrees: “I agree with your conclusion. My main requirement from a visual info environment is that it is well structured so that I can find things in a logical place and so a library-type environment seems appropriate” And another: “I agree with your suggestions, I do support the library idea.”

This text was part of a second email sent to the series C interviewees:

> When it comes to choosing a design for a 3D virtual world for accessing information, people will value worlds which have the elements of familiarity, pre-selection of the information contained (as to quality), and mediation (help, should it be needed, in choosing the appropriate item of information). Does that ring true or false with you? It's a bit more than in my last message, but it fits better with what people selected: a library and shops have all these elements (at least implied, if not in the models you saw), a garden has the first two, planets and forests don't really have any.

This reply comes from interviewee 81, who favoured a garden model:

> a garden according to the French model of Le Notre offers an ordered landscape but, at the same, we know that it can take us somewhere which is hidden or not immediately visible, due to some deliberate effects of optic illusion. It is an environment where we can feels safe and in control of our steps. Yet, we anticipate that there is something unknown to discover.

Another interviewee responded:

> Agree absolutely - these are the key ingredients. Ease of access to the information in terms of clarity of instructions is also important. What people would also want is choice - a range of "products" from both domestic and international sources. Also, I think that people like to see something different.

The interviewee who had chosen the Book of Hours model was not in complete agreement, however: “I would agree with the second two but not necessarily the first as something unfamiliar might be more intriguing and so motivate me to seek out more information.” Interviewee 99 provided extensive and helpful feedback:

> I would agree that familiarity is important in that the world makes sense on some level as an analogy for information - and if it's something esoteric or meaningless like classmarks then people have no intuitive connection or way of interpreting the significance of what they're seeing. Familiarity also engenders comfort and confidence in the user. The shop idea is interesting in terms of quality - as there is a learned response to certain shops or outlets or brands that tells the shopper a lot about the quality they will encounter in M&S or Harrods or Primark - you know what you'll get and sometimes you want the cheap and cheerful and sometimes you want the high quality but expensive and perhaps more challenging - like expensive research data? Libraries have been more built on the sense that everything in there is quality in some way - or perhaps even that you don't distinguish on quality except in separating - rather dubiously in my view - high quality classic literature from genre fiction. I suppose you could have different kinds of libraries open to users - but how many people relate to different kinds of libraries in the way in which librarians do? I don't think planets and forests can do any of this - except in a very abstract way. Mediation is possible in both the shop and the library model - as you could very readily

> incorporate the assistant in both contexts in a meaningful figurative way - and you could have different levels of service in different shops. In Harrods you could have your style counsellor and in Primark you would be lucky to find anyone except at the till and even then you'd have to wait in a queue

Interviewee 101 said:

> Yes, it all seems to fall into your sentence, familiarity, pre-selection, mediation. I wholeheartedly agree about the issue of familiarity. I personally feel much better in virtual reality when there are elements that I can recognise.
> The issue about quality is important as well. I think folk are becoming more aware of the fact that not all information that is obtained at the click of a mouse is 'good' information. Therefore, having a virtual world where the information is screened for quality will be valued.
> Finally, you're right about the amount of information available, it can be overwhelming. I must admit my heart sinks when I Google something and it returns thousands of hits. Some sort of mediation would be helpful.
>
> The Library and the shops were good worlds for me. Trees and gardens are more nebulous and less comfortable.

Taking into consideration the comparative analysis of the three series of interviews, the conclusion was reached that the previous statements of emergent theory, whilst being helpful in shaping the final theory, had concentrated too much on factors of organisation, abstractness and usability which, though not insignificant in determining preferences, were found to be of less importance than a group of features which might be said to be more closely related to the users' perceptions of the worlds, than to the finer points of their design. On completion of the comparative analysis, the emergent theory was:

When expressing preferences as to the design of 3D worlds for accessing information, people will specify worlds which have the elements of familiarity, clear organisation or structure, customisation, assistance, quality of information and quality of presentation.

Chapter 8 – Contextualisation with other work

In keeping with grounded theory, once the development of the theory has reached a certain stage, the time comes to integrate it with the literature. This was felt to be of particular value in the groups of documents considered in this chapter.

The findings of the current study will first be considered in the context of two distinct bodies of earlier work: the works of fiction which inspired many attempts to create "cyberspaces", and the work of the Xerox PARC researchers, which has been so influential on other researchers in the field of information visualisation.

The inclusion of fiction is justified on the grounds of both its influence, acknowledged by the large number of citations of the works appearing in citation indexes, and by Glazer's assertion that an array of fiction could provide categories for grounded theorising, as cited in 2.2.2.1, above.

8.1 Parallels with fiction

While it was possible for the interviewees to fly past the planets in the original space world, and indeed to have flown above and around the other models, this mode of travel was not demonstrated to them, because insofar as the worlds are designed, they might be seen to be more of the "Snow Crash" than the "Neuromancer" school. The Metaverse is designed by the hackers, and other users are constrained by its laws. The Matrix, conversely, would appear to be a product of the software running on the cyberspace decks used by Case and his ilk, the "console cowboys" (Gibson 1986 p. 39). This software interprets government, commercial, and other systems, and their counter-intrusion software, in such a way as to make them navigable by the jockeys, so that Case's system is a strategic one, whereas Hiro's is more recreational in intent, and is designed for the mass consumer.

The idea of the mass consumer is also important in that the current research was not intended to suggest or establish an alternative to established Information Visualisation tools, which are designed for use by information analysts in the fields of science or

finance, for example. What was being sought here was discovery of the preferences which might lead towards the design of a model, or models, for an information environment suitable for anyone, not a finely-tuneable data analysis toolkit, like some of those described in the literature. This makes the Snow Crash approach more appropriate, in that users can operate in an “enhanced reality” – an environment which is, at least to some extent, naturalistic. This approach seemed to be justified by the choices of the series A interviews, which are predominantly of this type. However, there is no necessity for these to be the only means of accessing information in this fashion – Stephenson writes that Metaverse developers can build “special neighborhoods [sic] where the rules of three-dimensional spacetime are ignored”(Stephenson 1992 p. 23), and such effects can also be achieved using VRML. However, since a large part of the purpose of the Metaverse is social, it makes sense that the most-used parts of it have a basic familiarity.

A suitable analogy might be that of the desktop metaphor now so familiar to computer users through its adoption by Apple and Microsoft. Rather than the unfamiliar medium of the command line, the user can interact with her computer's resources by manipulating (via a mouse) representations of items familiar in the context of an office : files and folders, wastebaskets and typed documents.

8.2 Parallels with PARC

Inclusion of the PARC material is justified because the cyclical nature of this study led back to two papers (Card, Mackinlay and Robertson 1991), (Card, Robertson and York 1996) which had previously been considered, in Chapter 3, as providing examples of information visualisation models. However, the theory having been developed, it becomes interesting to compare and contrast it with the underpinning of some of the work done by the PARC team.

From the interviews in the current study, it would seem that what these users actually want is not “synthetic generation of new designs based on analytical underpinnings” (Card, Mackinlay and Robertson 1991 p. 8), but an environment with which they are more comfortable. This does not reflect on the suitability of the Information Visualizer for its intended market, and neither does it invalidate the analytical

underpinnings, but it is interesting to re-interpret some of Card, Mackinlay and Robertson's observations in the light of the theory emerging in this study.

First is the observation about hierarchical arrangement of parts of a system being most efficient. The 3D world models can conform to this, insofar as the caching arrangement demonstrated in Card, Mackinlay and Robertson's office example is relatively easy to replicate. It is more doubtful whether the hierarchical arrangement of efficient information processing systems such as the eye could be replicated here, but there is the potential for the optimum efficiency of the user's own information processing system to be facilitated by devices such as "read wear" (Dieberger and Tromp 1993), and districts, landmarks, edges and paths (Dalton 2002). These features were discussed in sections 5.6.1 and 6.4.6, above.

The second observation is concerned with time to gather, as related to time to access, information. In a 3D world, the user could identify the material they need to use, perhaps borrow it from the library, or roam the shops with a list – after all, taking things away is part of the metaphor – and once it has been collected, it can be arranged to be easily useable. This seems a good justification of the customisation approach – it might be impractical to customise a virtual library or a shop, and this would work against the metaphor, especially if the world were to be a social space. This is a practical example of Card, Mackinlay and Robertson's observation about information cost and the scholar – it takes time, and therefore cost, to gather information from a large and "remote" set, and this was an issue which counted as negative with several interviewees, who doubted the practicality of using the 3D environment for work. However, once the information is gathered and arranged, there are potential benefits in having it readily available. It is also the approach which Robertson takes with the Data Mountain (Robertson et al. 1998).

"Locality of reference" is the subject of observations three and four. The use of small, though not necessarily exclusive working sets of documents – could be achieved by simply having collections arranged in different locations in a world, or each in its own world. Space is free in virtual worlds, if equipment and access costs are discounted, it is unlimited, and travel using viewpoints within a world is nearly instantaneous. "Travel" time to other worlds is constrained by network conditions, if the worlds are

stored on remote machines, but a practical solution in keeping with the first observation would be to store workspaces locally, and access materials remotely only when necessary. Switching between workspaces can thus be very fast. The fact that materials may be common to more than one workspace is not a problem affecting electronic documents, although if annotating or editing of “borrowed” documents were permitted, some form of versioning system would be desirable.

The fifth observation, that information systems “tend to adjust themselves” for greater efficiency, can be dealt with by extending the idea of “system” to include the user. If this holistic view is taken, it could be said that the customising user is so adjusting the system. In practice, users might want to reuse structures analogous to the “favourites” or “bookmarks” which feature in World Wide Web browsers, or to a favoured set of reference works in a physical workspace. A self-adjusting system might highlight, or move closer to a workspace, documents which are frequently cited, sites which are frequently linked to, or apply some other metric and strategy to enhance efficiency.

Reduction of detail is covered by observation six. Higher levels of a system have greater abstraction. This would appear to be a good match to the overview feature mentioned as desirable by several interviewees. The user does not want to be “swamped” in processing too much detail, but can “stand back” and see a whole range, or virtually get an “overview” by using the flight mode of a VRML plug-in.

What has not been addressed is the variety of tools which the Information Visualizer provides, each suitable for a different organisation of information. This will ultimately be a decision for world designers, and it may be that different worlds are necessary, perhaps borrowing features from the PARC models. Interviewees did mention models which resembled a wall, a landscape, buildings and various hierarchical structures, and these are all close to the PARC visualisations. However, buildings were used for hierarchically as well as geographically organised information; landscapes for geographically as well as linearly organised data, and the wall was of bricks labelled with words associated with links, and had no arrangement defined by the interviewee.

This may indicate no more than that the interviewee group did not tend to take the organisation of information into account, but most interviewees were not considering

information on specific topics, or with specific organisation. Where a specific type of organised information was considered, interviewees appeared to make the effort to choose an appropriate representation, and provide some rationale for doing so, as was the case with all the instances mentioned in the previous paragraph.

Chapter 9 Conclusions

Lincoln and Guba (1985) write: "[l]ocal conditions, in short, make it impossible to generalize. If there is a 'true' generalization, it is that there can be no generalization. And note that the 'working hypotheses' are tentative both for the situation in which they are first uncovered and for other situations; there are always differences in context from situation to situation, and even the single situation differs over time … Constant flux militates against conclusions that are always and forever true; they can only be said to be true under such and such conditions and circumstances" (Lincoln and Guba 1985 p. 124)

Faced with the problem of organising information resources in a 3d virtual environment, the person will "fall back on" a familiar setting, which enables them to interact with the resources in a way with which they are at ease. In Grounded Theory terminology, the phenomenon is the expression of preferences, the context is the array of resources, and the conditions are the feelings of uncertainty, unfamiliarity, and so on. The consequences would be that they get a world they can deal with. The contribution to knowledge from this would be: Do not attempt to create anything too elaborate or abstract to begin with – aim for the familiar, but leave scope for personalisation and customisation, because users will soon want to tailor the world to their emerging preferences. Table 9 summarises the hypotheses emerging as theory at each chapter of the study, and how these were tested.

Table 9: Hypotheses and tests	
Hypotheses	How tested
Chapter 4 **All worlds could be classified into one of four groups, and that people would tend to prefer using a world typical of one of these groups.**	four model worlds were created, which were then used with Group B
Chapter 5 **There is generally an enthusiasm for the idea and the potential of using 3D virtual worlds for accessing information, but that this is tempered by reservations as to the practicality if using them in this context.**	Tested by further exploration of the idea with Group C
Chapter 6 **All worlds could be classified into one of four groups, and that people would tend to prefer a world typical of one of these groups**. **While there is generally an enthusiasm for the idea and the potential of using 3D virtual worlds for accessing information, this is tempered by reservations as to the practicality if using them in this context.**	This is a summary of the previous two, as testing continued with Group C
Chapter 7 **When expressing preferences as to the design of 3D worlds for accessing information, people will specify worlds which have the elements of familiarity, clear organisation or structure, customisation, assistance, quality of information and quality of presentation.**	Tested by 'member checking – confirming results with interviewees

9.1 Contribution to knowledge

What, then, is the value of the current research when it comes to making a contribution to knowledge regarding the design of virtual worlds for accessing information? The study reveals something of the preferences of a particular group of people, at a particular time, and there is no claim that this group is in any way representative of the population as a whole. In fact, they were selected specifically

because they were thought to be more familiar than the average person with the concepts and processes involved in accessing information.

It might well be seen as predictable that these individuals, who work as staff or students in an academic environment, and some of whom actually teach or study librarianship, will tend to choose a model of a library as their ideal virtual world for accessing information. This would actually be to overstate the argument, because none of the staff teaching librarianship chose a library, and many of the students who chose a library were not students of librarianship.

However, the findings of this study tend to provide an underpinning for the success, in Second Life, of library services resembling real-life libraries, despite the fact that there is no constraint that this should be the case. It also provides a theoretical basis for the design of other virtual models than libraries, because it began with no assumptions. Had the interviewees been asked to select amongst pre-defined models, even if they had overwhelmingly selected one of the options, there would be no way of knowing that this option was the best model possible, only that it was the one preferred of those offered. The grounded approach has brought out the fact that there may be factors involved other than particular structures, and that these factors are such that they might not otherwise have been considered by the designers of virtual worlds.

It appears that familiarity is just as important as structure, so in a world of one's own design, both these factors can be covered. In a designed world, there would have to be either a balance, or enough of one to compensate for a lack of the other.

There is a desire for clear organisation, either by a classification scheme, as in a library, more loosely by topic, as in shops, or by a personal arrangement.

People often appear to want their information to be mediated. It is part of the metaphor in both libraries and shops that a selection based on quality has been made, and it is a common criticism of the internet that no quality control of information is possible. The corollary here is that selection can be difficult to distinguish from censorship, but the success of America On-Line (AOL) would appear to substantiate

the perception that many users are prepared to sacrifice some freedom of access in the interests of ease of use and of quality control.

The other important aspect of mediation is assistance. Again, this is not a feature required by everyone, but there is a definite demand from some. While this phenomenon may have been perceived as symptomatic of a lack of training, or simple inexperience, setting it in the context of professional mediation shows it in a different light. A successful library user will know when to ask a librarian for assistance; a successful shopper will call on the skills of the staff. The fact that people will choose a virtual environment with this feature "built in" gives us a significant insight into their relationship with the world of information.

Even when a choice was made from a limited range of models, the grounded approach revealed a widespread desire for customisability of the particular model chosen, and also a readiness to extend the model. For example, worlds can be enhanced by providing the ability to leave a trail, or a library can be enhanced by having the sought items move towards the user.

Finally, there is the issue of quality. In the same way that people require quality of information, they also want a high-quality interface. A "cheap and cheerful" version may be usable, but, in addition to a more aesthetically pleasing experience, there is also the potential to offer enhanced functionality by exploiting latent skills. The abilities to remember where one put something, or to observe wear and tear caused by use may operate at almost subconscious levels, but can be used to add value to the experience of accessing information.

In summary, investigation aimed at discovering user preferences in this area is a worthwhile exercise, and provides the theoretical underpinning for a different approach to the design process than those which have been tried before.

9.2 Evaluation of research approach

The research approach adopted was that of Naturalistic Inquiry. As explained in section 2.1.3, this iterative methodology is intended for examining "real world"

situations", but not ones which are necessarily "everyday". The iterative approach allowed each "cycle" of interviews, analysis, literature review and discussion of emergent theory to build on the previous one, so that lessons could be learned and theories explored and extended, without the inflexibility inherent in a more conventional survey.

The methodology was probably the only one which would have been capable of yielding the results achieved. Although quite time-consuming, due to the necessity to arrange, conduct, record, transcribe and analyse interviews, it is felt that no other methodology could have provided the depth of qualitative material that revealed not just a preferred world, but, on closer examination, a set of potential criteria behind this choice.

Grounded theory is open to many criticisms, as described in section 2.2.5, and must be seen as flawed in some degree – it is doubtful whether it can really be theory-neutral, there is a question about interviewees' intentionality, there may be some constructivism, and there are also questions regarding the validity of interpretation. However, in this study, the use of grounded theory techniques has opened up an area of user experience which would have been very difficult to explore using a quantitative methodology, which in itself would have fundamentally changed the relationship between researcher and users. Grounded theory may not be able to live up to all the claims made by its supporters, but it remains the best tool for an investigation of this type.

On the whole, the split into four types of world, and the development and testing of models representing these types, seems to have been justified, even if possibly over-simplistic. Interviewees in general did not move between types, if it is allowed that a garden is organised (whereas a forest is not). The question of whether the town has semantic value would seem to depend on the design of the town, so perhaps it was a bad choice for "realistic but unorganised". More distinctive buildings would perhaps convey as much, or more, about their contents as classifications do to the average library user about the contents of the stock.

However, the division provided interviewees with a context of varying parameters, which allowed them to explore and reveal for later analysis via the grounded theory methodology, the factors other than design which influence their preferences. These factors can then be seen as influencing their choices as to an ideal design of a 3D world for information access.

Without the iterative approach, the development from ideas to testing and back to ideas could not have worked. Without the free and unstructured approach, it seems less likely that the richness of the input could have been preserved, and without the interactive element provided by using interviews, rather than, for example, diaries, the opportunity was provided to explore topics at an appropriate level of detail.

If another, similar, study were to be undertaken, it could be improved by:

- Storing interview data on a database, to facilitate later access
- Re-considering interview conditions – balancing interviewee convenience against background noise
- Scheduling transcriptions more closely to interviews
- Use of advanced features of the Nvivo software, which were not deployed in the current study
- Extending considerably the amount of time budgeted for immersion in the data

There are many threads to follow through such an amount of primary material, and many of these threads appear in unexpected places, so that two or three distinct interviews may turn out to have quite close and complex relationships, when viewed from one perspective, yet seem almost completely unrelated from another. In the current study, for example, the notion of “path” or “process” crosses the more structural or concrete versus abstract dimensions which are useful from another perspective. One of the rewards from this study has been an enhanced sensitivity to, and an increased respect for, the complex factors which might influence user-led design, and it is hoped that this may inform further research in the field.

Finally, the structure of this study has been quite complex, in that it consisted of rounds of interviews, literature review, discussion, and development of theory. These

rounds were repeated three times, preceded by a scene-setting literature review, and followed by an attempt to place the study in context of current developments and of the literature which inspired many of them. A simple linear presentation may not be the best way to present this, and it appears that a hypertext presentation, which would afford the reader the option of taking alternative routes through the material, might be preferable. It might also be appropriate for the material to be accessible via a virtual world, and it would be interesting to examine how this change of medium might affect the ability of users to access the information contained therein.

On the whole, however, the research approach appears to have been successful, and it would not be felt desirable to alter it radically, should another study of this type be undertaken.

9.3 Implications and applications

An implication for the information profession is that this is a very good time to get involved with the design and provision of 3D worlds for information access. This study provides evidence supporting activities which are already taking place in Second Life. People can relate to a 3D virtual environment, they are prepared to consider it as a stimulating and interesting setting for accessing information, and it would appear that they are prepared to consider customising such an environment to suit their particular requirements. Many will prefer a familiar model, based on the real-life examples of a library, a town, or a garden, probably because these models provide them with an interface with which they already know how to interact, or an environment which can be tailored to suit their particular needs.

9.3.1 Implications for further research

Some interviewees spoke about factors such as colour, and, more rarely, sound, generally only when these factors were important to their particular world design. The colourful nature of the test worlds was mentioned several times, in a positive sense. Previous experience of computer games was mentioned a few times, and it appeared that it was generally by those with significant such experience, good or bad. It might be possible to derive, from a much more structured interview, a better fit between people with particular preferences in any of these areas and particular elements of a

world, but such issues are not the focus here, where the interest was in the much simpler question, “what would the world be like?” Where the preferred world would be coloured, and that was mentioned, it has been described, but most of the issues raised concerned navigation, organisation, and ease of use. There were certainly references to “”detail” and “finish”, but in general, these finer points were ignored, in the spirit of the “proof of concept” models on display.

This is not a statistical exercise, but it would appear that there are no significant differences based on these criteria. More thorough studies would be required to determine this absolutely, but for the moment it appears more useful to draw a broad set of conclusions.

Other factors such as ethnic background, computer experience, educational history, cognitive style, spatial ability or navigational skills might also be relevant, but have not been considered. Some questions also emerged in memos, for example about the different selections which might be made by individuals who were “imaginative” or “concrete” thinkers. These were dropped as theory started to develop, but would possibly repay further examination.

In the series B1 interviews, the worlds were presented in the order: Forest, Library, Space, Town. There was a conscious decision not to start with the Space world, because it was thought desirable to give the interviewees some experience of moving around “on” a surface, before having them apparently floating in space. For a larger number of interviewees, it might be better to vary the order in which interviewees were shown the worlds, to determine if this had any effect on their preferences.

In a more controlled environment, it would be interesting to observe how users moved through the space, what they looked at, and in what order, how long it took them to explore or lose interest, and to test what they remembered about the layout.

In some cases, the interviewees were content to opt for a development of one of the demonstration worlds as their ideal. The library and town were most often chosen, in this case. The possibilities are either that one of these models particularly appealed to the interviewee, or that the interviewee was not sufficiently at ease with the idea to

venture to put forward a model of their own. It may simply be that some interviewees are more imaginative than others, or that some are better at "off-the-cuff" responses. This might make an interesting empirical study to run alongside the current one, if suitable research instruments could be devised.

The further development by some interviewees of the original idea, as discussed in chapter 6, was somewhat unexpected, but could be taken to show that there was a variety of degrees of "engagement" with the concept. It would be interesting to use "brainstorming" sessions to develop these and other ideas in an environment where participants feel sufficiently at their ease not to be embarrassed by making unconventional suggestions. Since the same world models recur, and few – scuba diving, patchwork and the airport – are models which have not occurred before, it may be reasonable to assume that these represent the "core" models derived by this methodology from this population. The previous sentence is so worded because a different methodology would probably have produced different results. However, since it is believed that this methodology is a valid one, it follows that this constitutes a valid, if not the only valid, set of results.

9.4 Summary of conclusions

This study has approached the question of designing virtual worlds from a user-centred perspective, which appears to have been missing from other treatments of the subject. It has found that it is possible to derive from interviews a set of properties which are distinct from, and complementary to, those considered in other publications. For example, it is widely acknowledged that "intelligibility" is a positive factor in the design of 3D worlds, but it does not appear to have been considered that "familiarity" of an environment might also play a significant part in the acceptance of the world as a "place" in which to work.

It was found that the properties of **familiarity, organisation or structure, mediation or assistance, and quality of presentation** were those deemed to be important by the participants in this study. It is felt probable that these properties, rather than the tendency to select a particular design, will be transferable across different groups of

users, and that these findings can help to determine the course of further research and design work in the area of 3D worlds for information retrieval.

It is thought that this research makes a contribution in the field of information behaviour, in that it has identified non-structural influences which can affect individuals' interaction with interfaces for accessing information. Although this type of research is time-consuming, it has led to insights which it would be less likely to achieve by other methodologies.

There is also a contribution in the field of information systems design, in that it appears that a "softer" approach, which is more sensitive to properties other than the simply structural, may have unforeseen benefits to the design process. The conclusion that users may not be as concerned with the actual model used for the 3D world, as they are with its familiarity, or the fact that they can recognise its organisation, or get dependable assistance, is the result of a different approach to those taken before, and merits further investigation.

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Appendix A

The introduction and interview for the first series of interviews, with group A interviewees, took roughly the following form:

> I'd like to explain the areas I'm interested in discussing here. In a rather general sense, you could say I'm looking at information space in an electronic environment, or cyberspace, as it has been called, and what perceptions people have of it. For example do you have any sort of image of information as having a concrete, 3D representation, when you're doing some kind of research? What might that look like?
>
> Have you read, or heard about, the books Neuromancer (and the other Gibsons) and Snow Crash?
>
> Have you played any computer games involving 3D movement (Quake, Doom, rallying, football, etc)? How did you find the experience?
>
> Moving back to the information space topic, if you could use a screen representation of a 3D environment when searching for information, what do you think would be a good model to have? What kind of space would come to mind? How would you see documents as being represented, for example, in an environment where you don't have the normal constraints of gravity, or speed of movement?
>
> Do you find the idea of 3D movement appealing, or not? Could you imagine a genuinely useful 3D interface? What might it look like?

Appendix B

Before the second round of interviews, prospective interviewees were given this introduction, as a group:

> Over the last few decades, many attempts, or rather several classes of attempts, have been made to solve the problem of representing large amounts of information on the relatively small area of a computer screen. For example, there are “lens” applications, which allow the user to focus on a smaller area of a larger display of information items. The Perspective Wall, developed at Xerox PARC, is one example of this class.
>
> {image of Perspective Wall]
>
> There are hierarchical arrangements of “nodes”, exemplified by the Cone Tree, in which conical segments of root and leaf nodes can be moved relative to each other, to obtain different views of structures and relationships.
>
> {image of Cone Tree]
>
> There is also a class of representations more akin to conventional graphing techniques, such as bar graphs and scatterplots, or “landscape” representations of bibliometrics such as term frequency and co-occurrence.
>
> {image of Information Landscape]
>
> Many of these techniques present the user with surrogates for documents – by navigating within the representation, for example, by ”moving” through a “space”, the user can selectSEBOK, A., NYSTAD, E., and HELGAR, S. 2004. Navigation in desktop virtual environments : an evaluation

and recommendations for supporting usability. *Virtual Reality* (2004) 8: pp. 26 – 40 an icon, or click on a shape, or otherwise activate a process which causes the document, or a citation of the document, to be displayed.

[image of city – height of buildings related to hits on websites]

These representations of information space may be more or less “realistic”.

[image of VR-VIBE]

The aspect of this which particularly interests me is the 3D representations of spaces. It is now possible, using Virtual Reality Modelling Language (VRML), to deliver across networks text files which can be interpreted by a normal browser program, such as Internet Explorer, using a small “plugin” application to display a “world” to the user.

The question I want to ask is, what would your information “world” look like? I don’t want to constrain your imagination by making you choose amongst a small number of alternatives, partly because that would be limiting your imagination to mine, and partly because just about any world you care to dream up can be represented as a VRML world.

It’s not just an exercise for the sake of it – we all know that we have to handle ever-increasing amounts of information, and that anything that can help us “get a handle” on it could be invaluable. Our visual capacity is very well developed, but is usually under-exploited in the world of information retrieval, perhaps confined to scanning lists of “hits” from a search engine. Add to this innate capacity to interpret colour and movement, the fact that we also have impressive geographical,

> spatial and wayfinding skills, and you may begin to see that here is under-utilised potential for information systems.
>
> The experience of using such a world is not unlike that of playing computer games of the role-playing genre, such as the first-person shooters (FPS) like Quake, or flight or driving simulators in amusement arcades. You could also say it's like the in-car camera view of Formula 1 racing, but with control over the steering. The computer screen is like a "window" on a world, through which you can navigate, in "walk" or "fly" modes, by using the mouse cursor. Worlds which are multi-user often have the facility of representing yourself in the world as an "avatar", which the other participants can see moving around in their view of the world.
>
> This is what is known as "non-immersive" VR, in that it does not use technology such as data gloves and head-mounted displays (although it could).
>
> The other obvious references, for those familiar with the works, are to Snow Crash and the Neuromancer books, which you might have read, or heard of.

Individual volunteers were introduced briefly to the topic again, then group B1 were given a short introduction to controlling the interface, and then were shown each world in turn, in the sequence: Forest, Library, Space, Town. They were then encouraged to say what they liked or disliked about each world, and asked which, if any, was their favourite.

As explained in Chapter 5, group B2 tried out an "amalgamated" world, but were encouraged to explore it in the same way as B1, and were asked the same questions.

Appendix C

The third round of interviews, with group C interviewees, was preceded by this email, which was sent to all prospective interviewees, in order a) to recruit volunteers, and b) to set out some of the "groundwork", so that it did not have to be explained to each interviewee individually.

> Hi, folks
> I'm asking for your help in my PhD research. If you're still reading, picture this scene:
> Perhaps you might be looking at results of a web search, or searching a digital library, or hunting through your Favourites or Bookmarks list, but instead of a list of text links, you see a "world" in which you can move around, maybe move things in the world around, find the item you want and select it for display.
> It appears that several projects have developed 3D models on computers, which people can then use like this, but no-one has really looked at what people might want the world to be like, just as no-one seems to have considered what people might want to be faced with when it comes to setting a VCR video recorder.
> So, you move the mouse, and your viewpoint moves in the world. What I want to know is, what would you want your world to look like?
>
> I've created a few small worlds to show you, which you can try out, if you like, but mainly I want to hear what you think.
>
> There's no questionnaire to fill in, just let me know when would suit you and you can spare a few minutes (say 15 or 20), and I'll come to you, with a laptop and my wee tape recorder.

> If you can help me out, please reply to this email. You don't even need to decide a time just now, just say OK, and I'll get back to you
>
> Regards,
>
> Alan

When the interviews were conducted, interviewees were reminded of the purpose of the interview, had the controls of the VRML plugin demonstrated to them, and were left to explore the worlds, which at this stage had been joined together, so that it was not necessary to "start" worlds from the beginning. Although they were not closely observed, interviewees were aware that the interviewer was at a short distance, so that they could be assisted if they had trouble with the interface, and could indicate when they had finished exploration.

Interviewees were encouraged to speak about their experiences with the worlds, and asked which ones(s) they preferred, but the main focus of the interview was, "if you could have a world designed which you could use to access information, what would it be like?"