Reading in Web-based hypertexts: cognitive processes strategies and reading goals

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READING IN WEB-BASED HYPERTEXTS: COGNITIVE PROCESSES STRATEGIES AND READING GOALS

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Dedication

In memory of my father Stauros Protopsaltis
Στη μνήμη του πατέρα μου Σταύρου Πρωτοψάλτη

Abstract

Hypertext is a multi-linear electronic, textual and interactive environment to present information. The objective of such an environment is that readers may browse through linked, cross-referenced, annotated texts in a multi-sequential manner, and thus, it is believed, to improve the learning. However, early and current research findings have revealed some mixed results concerning the alleged advantage of hypertext on learning over paper-based documents. Researchers have identified the lack of research about the cognitive processes and the strategies that readers use during reading as one of the main factors for such results. As a result, there is a need and scope for further research in modelling the cognitive processes involved in reading comprehension and the reading strategies in a hypertext environment.

This research addresses some of the gaps in the field by proposing a model that represents the sequence of events that take place during reading in a Web-based hypertext environment. Also, emphasis is placed on the strategies that readers use during hypertext reading and on the potential effect of different reading goals on reading comprehension. The evaluation of the model and the other hypotheses is conducted in two experiments using qualitative and quantitative methods. The first experiment employs the think aloud method. Forty two subjects participated. The results demonstrated that the proposed model precisely describes the sequence of events that take place during hypertext reading. They did not reveal any significant difference between different reading goals and understanding. They revealed four reading strategies: *serial*, *serial overview*, *mixed*, and *mixed overview*, and they identified three factors that influence the selection of hyperlinks: *coherence*, *link location*, and *personal interest*. The second experiment is an independent samples design experiment with ninety subjects. The results confirmed those found in the first experiment.

The current study makes a contribution in the field of hypertext reading by proposing and evaluating a procedural model and by making this model graphic. By doing so it addresses some of the voids in the field, expands our understanding of the reading processes and the reading strategies, and provides practical guideliness which are enhanced to promote design supporting effective learning processes.

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Introduction

The impact of information technology on the reading process is an issue worthy of examination. With the impetus provided by electronic media in general, and hypertext in particular, this issue has become the focus of much attention and speculation. Reading is an active process in which readers interact with text to reconstruct the message of the author. Nevertheless it is clearly a process which is only complete when comprehension is attained. The aim of reading remains similar in every document format or platform, either paper-based or electronic. Reading comprehension is a major area of investigation because the Web, hypertexts, and other electronic systems focus mainly on information and learning from text.

Electronic texts that incorporate hyperlinks introduce some complications in defining reading comprehension as they require skills and abilities beyond those required for comprehension of conventional, linear text books (RAND, 2002). Other differences between the electronic and paper media in reading have been demonstrated at the psychomotor, perceptual, and cognitive levels (Dillon, 1996b). At the cognitive level, which is the focus of this thesis, Wenger and Payne (1994; 1996) argue that, hypertext use depends on some additional types of processes that are not always important in linear text. Those processes are more involved in analytic

reasoning than in simple reading. They found that hypertext demands more relational processing than a linear document does. That means that readers need a further ability to relate and process text. What are the types of processes that are important in reading in a hypertext environment? What other abilities do readers need to successfully comprehend a hypertext document?

Hypertext challenges many well established assumptions and perspectives that have been developed from theory and research based on traditional paper-based documents. The main such frequently cited assumption by theorists is that of linearity (Landow, 1991, 1997; Nielsen, 1990, 1995). Most comprehensive theories of discourse comprehension assumed that human beings process information in a linear manner and scientists have based their research on linear paper text materials (Kintsch, 1994; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992; van Dijk & Kintsch, 1983). In contrast, some experts argue that hypertext revolutionises the way humans approach information.

The hypertext system has been considered by their advocates as a revolutionary medium that changes or even improves the way people read and learn information. However, early and current research findings on reading electronic text have revealed some mixed results concerning its believed superiority over traditional paper-based documents. The results have shown that paper-based documents were in most accounts better to hypertexts, and predominantly when subjects are not experts, while hypertext was found at times to be superior when subjects were experts. Electronic media and hypertext in particular have not revolutionised peoples reading and learning experiences. There are still issues and problems that need to be addressed. Despite the increasing popularity of hypertext systems, the Web, and the substantial literature on some of the problems related to hypertext, little is known about the cognitive processes that take place in electronic environments, and their relationship in hypertext reading/comprehension. Questions such as:

- What are the types of processes that are important in reading in a hypertext environment?
- What other abilities do readers need to successfully comprehend a hypertext document?
- What is the effect of strategies on hypertext reading/comprehension?

- What is the relation between navigational strategies and successful use of hypertext?

remain without definite answers.

Regardless of the problems with electronic information platforms in general, and hypertext in particular, technology is here to stay. As more and more individuals use new technologies to communicate information, these linguistic activities come to shape the ways in which we view and use language and literacy. Therefore, there is a need for further research in the area of cognitive processes during reading comprehension in a hypertext environment in order to improve our understanding about its use and how best to exploit its performance.

The present study is aiming to assist towards that direction. It focuses on the cognitive processes, on the strategies during reading a hypertext, and on the effect that different reading goals might have on comprehension, and on the factors that influence the hypelink selection. The next section states the aims and the objectives of the research in this thesis.

1. Aim and Objectives of the Thesis

The prime aim of the work reported in this thesis, is to study and model the cognitive processes involved during reading a hypertext document. This aim is separated into five major objectives that motivate the research. The objectives are:

- Challenging the notion of non-linearity in hypertext
- Modelling the cognitive process involved in hypertext reading
- Investigating the effect that reading goals have on hypertext comprehension
- Investigating the readers/users strategies during hypertext reading
- Investigating the effect that different goals may have in hypertext strategies

Initially, this study aims to challenge the most often cited characteristic for defining hypertexts, the concept of non-linearity. The objective is to argue that hypertext is not a non-linear medium as it has been portrayed, but a “multi-linear” medium for

presenting information. That means that the presented information contains an inner linearity based on the way that the different nodes are meaningfully connected to each other. As a consequence, the reader has to reveal or choose one or more of the multiple linear routes that hypertext offers in order to comprehend the presented information. From this perspective we argue that "linearity" is present and moreover, is closely related to the coherence of the text. Besides, perceiving hypertext as a multi-linear medium, we imply that it is not something entirely different compared to a traditional printed text, and does not change entirely the way we process information. Actually, both mediums share common attributes and common processes.

Following, the present study focuses on modelling hypertext reading comprehension. There is no comprehensive model so far that accounts for reading in hypertexts. The objective is to fill that gap by proposing a cognitive model to account for hypertext reading comprehension. The model is ambitious to describe the processes that take place during reading in a hypertext environment.

There is a lack of research on the effect reading goals might have on hypertext reading. Therefore, the aim of the present study is to explore the effect of reading goals in a hypertext environment, and on the use of strategies.

The final objective of this thesis is to investigate the strategies that take place during hypertext reading. There is a need to investigate the strategies because different strategies influence the way readers process the text and hence their comprehension. In addition, different goals imply different strategies. This study used a think aloud method that provided rich data concerning subjects' strategies.

The next sections provide first an overview of the contribution of this thesis, second, the research approach, and third the outline of the thesis.

2. Contribution

The contribution of this thesis can be divided in two levels. Theoretical and practical.

At a theoretical level, the proposed model helps to improve reading, text design and complex learning. It provides educators with a deeper understanding of the reading processes, where breakdowns in comprehension can occur, what factors influence hyperlink selection, and what strategies could improve the reading processes. The model helps us to visualise what components may fail to contribute to an effortless meaning making while reading.

At a practical level identifying the reading processes and the strategies readers use while reading a hypertext can help us to design and test aids that would help hypertext readers to browse hypertext documents effortless and quickly. Therefore, the practical contribution of the thesis takes the form of guidelines that serve the design of supporting effective learning platforms.

3. The Approach of the Research

A possible reason for the problems encountered with the use of hypertext as an effective information medium can be found in the research approach that scientists have primarily adopted. The research has so far focused on design, engineering, and information retrieval principles, and not on psychological aspects. As a result of that, hypertext and hypermedia applications do not incorporate findings from relevant research fields such as: cognitive psychology, cognitive science etc. However, psychological factors are often more responsible for the failure of an effective system use than technical problems (Dixon, Bortolussi, Twilley, & Leung, 1993).

Therefore, this thesis approaches hypertext from a cognitive science perspective. The aim is to explore the cognitive processes that take part in hypertext reading and gain an insight about what is actually happening, instead of hypothesizing. To do that, subjects were observed while they were reading. At the same time, the findings from studies based on paper-based documents were considered as a starting point. The reported research was influenced by findings in the areas of reading comprehension in traditional paper-based documents, and locating information in documents. This approach is consistent with suggestions that the present knowledge about reading comprehension and findings based on traditional print-base documents

should be the starting point towards a better understanding of reading comprehension in hypertext environments. In addition to that, findings from the area of locating information in a document were considered. Such findings are significant because they reveal the way readers locate information in documents and especially in large documents. In the same vein, such skills are very essential for successful reading in hypertext environment as well, because hypertext readers usually negotiate large amounts of information.

4. Thesis Outline

The thesis consists of six chapters. The next chapter, chapter one, reviews the literature on hypertext field and focuses on its cognitive aspects. Hypertext is considered as a multi-linear document differing to the popular notion of a non-linear document. The problems arising from hypertext are outlined in more detail. It emphasises the lack of rigorous studies in text understanding in hypertext environments and justifies the need to look into the existing research in conventional text books in order to advance our understanding about hypertext documents and the cognitive processes needed for its successful use. It recognises the poor understanding of many aspects in the field. It presents the existing models, and justifies the need for modelling the cognitive aspects of hypertext reading comprehension process in order to overcome first, the lack of accepted theoretical framework to located hypertext, and second, the lack of settled body of knowledge on either the nature of hypertext or its appropriate applications.

Next, chapter two describes the proposed cognitive model. The model is a procedural model, thus it describes a sequence of steps. The chapter offers a detailed description of each component and provides explanations on the sequence of events between the components during hypertext reading. The model was created in two phases. First, the initial phase is presented, and then the changes are introduced after the pilot study is explained and justified.

Chapter three portrays the method used to assess the model. The chapter gives a detailed account of the rigorous method for analysing rich qualitative data, called

think aloud method. The data derives from studying users interacting with a hypertext application while they think aloud at the same time. The advantages and disadvantages of the method are addressed and justification for its advantage over other methods and its appropriateness for the present study are provided.

Chapter four describes the pilot study of the experimental evaluation. The pilot study run to evaluate first, the design of the experiment as a whole, and second, the use of the think aloud protocol. The pilot study did not reveal any major discrepancies in the design. Furthermore, it served as a task analysis for the proposed model. It revealed some discrepancies in the model, which were considered in its revision. Finally, some preliminary results are described and discussed.

Chapter five describes the main experimental evaluation with the use of think aloud protocols. The data collected is analysed and the results are presented and discussed. The primarily aim of the experimentation was to test the proposed model. The data fully supports the proposed model. Moreover, the think aloud protocols revealed four strategies that readers in hypertext environments use, which are described and discussed. Another important aspect of hypertext reading presented in this chapter, are the factors that influence the selection of hypertext links. In addition to the qualitative data some quantitative data was also obtained and analysed. The data includes the time the subjects took to read the hypertext and their comprehension scores.

Chapter six presents the results of the second experiment using a different method for verification. The method used is purely quantitative. The aim of the second experiment was to replicate and then validate the results of the first study with a different method. The results validate the findings of the first experiment. All the results are presented and discussed.

Finally, the conclusion summarises the research and discusses its theoretical and practical implications. Furthermore, suggestions for future research are made.

The last part of the thesis consists of the reference list and the appentices. For the reference list and the citation the APA (American Psychology Association) style, which is based on the Harvard reference style, was followed. Furthermore, the APA

format for experimental reports was used to present the results of the experiments. The appendices consist of the pre-test questioner, the warm up exercises, the comprehension questions, and the java script cookie code.

Chapter 1

Hypertext and Cognition

Technology has always played a significant role in the manner in which people present, access and interact with information. Technology, also, increasingly changes the nature of literacy in an information age. Hypertext and hypermedia are emerging as evolutionary media for information presentation. Their impact on the reading process is an issue worthy of examination. With the impetus provided by electronic media in general, and hypertext in particular, this issue has become the focus of much attention and speculation. The current chapter reviews and discusses the literature in the field of hypertext reading and understanding. It identifies the problems and the weakness of the research and outlines the areas that require further investigation. Finally, it justifies the need for the current research.

1.1 Introduction

Reading is an active process in which readers interact with text to reconstruct the message of the author. Reading is clearly a process which is only complete when comprehension is attained. The critical element is that the reader reconstructs the message encoded in the written language (Dechant, 1991) no matter if the document is paper-based or hypertext. When the term "reading" is used in this thesis, it refers to reading comprehension and not to leisure reading, and more precisely, to reading comprehension in educational settings. That choice was based on the fact that reading a text for comprehension is a goal-oriented process of the human cognitive system, and a crucial factor in understanding text use (Schnotz & Bannert, 2003), since it is the control process. Comprehension can be modelled only if a specific goal is given (Kintsch & van Dijk, 1978) and that is usually the case in educational settings. As a consequence the focus of the study is on modelling the cognitive processes during hypertext reading. The scientific text seems the most appropriate, since understanding is essential and thus the reading goal is always present. Conversely, the reading goal is not always evident in leisure reading, thus its modelling is problematic. Additionally, empirical studies have manifested that readers of literary texts do read for personal meaning (Miall, 2000). Besides, scientific texts are considered to be objective repositories of knowledge and meaning in contrast to literary texts, where objective reading is, in a sense, undesirable and maybe even impossible (Mishra & Nguyen-Jahiel, 1998).

Reading comprehension is defined as "the process of simultaneously extracting and constructing meaning through interaction and involvement with written language" (RAND, 2002, p. xiii). However, electronic texts that incorporate hyperlinks and hypermedia introduce some complications in defining comprehension because they require skills and abilities beyond those required for comprehension of conventional, linear text books (RAND, 2002).

1.2 What is Hypertext?

A number of definitions have been attached to hypertext during the last decades. A hypertext system is one for displaying information that contains references (hyperlinks) to other information on the system, and for easily publishing, updating and searching for the information (wordIQ.com, 2004). Another definition defines hypertext as text which does not form a single sequence and which may be read in various orders; specially text and graphics which are interconnected in such a way that a reader of the material (as displayed at a computer terminal, etc.) can discontinue reading one document at certain points in order to consult other related matter (Simpson & Weiner, 1993).

There is some disagreement among scholars on what hypertext is. Some disagreements refer to the issue of scale. There are hypertext systems that link documents across networks anywhere in the world, while others may simply link segments of text within the same document. Other disagreements concern the text part of hypertext. The term hypertext implies that the nodes in the system contain only text (Nielsen, 1990, 1995). Nevertheless, many hypertext systems can link not only text together but graphics, sound, video, and programs (Traiger, 1993). The term multimedia has been introduced to describe such systems. The most popular hypertext system is the World Wide Web (WWW) which incorporates a wide range of textual genres, audio, video, and animation format of information.

No matter how one defines hypertext, it consists of two important components, the nodes and the links. Nodes are the smallest possible self contained units of information. The amount of information included in a particular node is defined as the smallest possible amount of information that can exist on its own and still be comprehensible. Links are defined as associations between two nodes. Links can be either directional or bidirectional. Conklin (1987) suggested two kinds of links between nodes, the structural links and the referential links. The structural links define the structure of the document and indicate the relationships between the nodes. The referential links define the associations between the information included in the nodes.

In hypertext environments, unlike traditional print based documents, users do not expect to view the nodes in any particular sequence but rather in their own ordering, depending on the selection order of the hypertext links. The current study approaches hypertext as a system containing only or primarily text. This approach is chosen because text still remains the most significant way to communicate information in this global information technology age.

1.3 History of Hypertext

The first description of the idea came in 1945, when Vannevar Bush wrote an article in The Atlantic Monthly called "As We May Think" about a futuristic device he called a *Memex* (Bush, 1945). He described the device as electronically linked to a library and able to display books and films from the library, and further able to automatically follow references from these to the work referenced. The Memex did more than offer linked information to a user though. It was a tool for establishing links as well as following them. The technology used would have been a combination of electromechanical controls and microfilm cameras and readers, all integrated in a large desk. Most of the microfilm library would have been contained within the desk itself, with the option of adding or removing microfilm reels at will. It could also be used without linking, to generate information on microfilm, by taking photos from paper or from a touch sensitive translucent screen. In a way then the Memex desk was more than a hypertext machine. It was a microfilm based precursor to the personal computer.

Computer scientist Ted Nelson coined the word *hypertext* in 1965. Nelson's work and many other early hypertext systems such as Douglas Engelbart's NLS and the popular HyperCard application bundled with the Apple Macintosh computer were quickly overshadowed by the success of Tim Berners-Lee's World Wide Web, even though the latter lacked many features of those earlier systems such as typed links, transclusion[1] and source tracking.

[1]In computer science, some hypertext systems have the capability for documents to include sections of other documents by reference, that function is called transclusion.

1.4 Hypertext and Linearity

The most common way to define hypertext is to contrast it with traditional text such as books. The definitions accorded to the text are also presumed to be the determinants of reading practices. Hypertext is conventionally described as a non-linear medium of information presentation. Nielsen (1990) defines hypertext as *nonsequential*; there is no single order that determines the sequence in which the text is to be read. Delaney and Landow (1990, p. 3) underline that: "Text was linear, bounded, and fixed. … Unlike the static form of the book, a hypertext can be composed, and read, non-sequentially; it is a variable structure, composed of blocks of text and the electronic links that join them". Moreover, Rouet and Levonen (1996, p. 9) defining hypertext, hypermedia, and multimedia systems pointed out that: "A common attribute of these systems is non-linearity. … The reader or learner is able to build his or her own paths, to select and organise the information relevant to his or her needs or objectives".

Researchers, who describe hypertext as a non-linear medium for presenting information, emphasise a characteristic that is missing from hypertext. Their definitions are based on storage differences of the medium compared to printed documents. In a paper format there is a physical linearity because of its physical limitations as a medium. In hypertext the information is stored in a computer's memory in a network format. The nature of the hypertext medium does not enforce a predefined order thus there is no single sequence, and there are no actual physical limitations. However, the term non-linearity does not fully describe hypertext. The problem with such definitions is that it is not clear what is meant by non-linearity. Moreover, the term can be misleading, because it can be understood as no sequence at all and, sometimes, no structure at all. This would be a major inaccuracy.

In traditional media, such as text-books, information is organised linearly. This is true for sentences in a paragraph, paragraphs in a chapter, and chapters in a book. Certainly reading a word, a sentence or a paragraph is largely a linear activity (Just & Carpenter, 1980). However, if that is true for paper documents it is true for hyper documents as well. Thus linearity is present in hypertexts as well. Hypertext nodes,

which consist of text, involve linear reading at the level of word, sentence, or paragraph. Hypertext is defined as a non-linear medium for presenting information when it clearly contains linear features. On the other hand, all traditional printed materials are characterised as linear, although they are not. For instance, when someone reads a book that contains several chapters with different subjects, it is not mandatory to read everything in the order they have been placed in. The reader can choose the information he/she is interested in and skip the rest. The same applies while reading a newspaper or looking through a dictionary. Furthermore, books contain contents and indexes that help readers to easily locate the information they are looking for. These facilities are not considered as linear tools.

It is clear that in traditional paper documents pieces of information are placed in a predefined sequence. However, that does not imply that the reading process would start from the first page and finish on the last. Thus, the term linearity could only characterise how pieces of information are stored in paper documents, and not how readers will process the information. That does not help us to clearly distinguish hypertext from traditional documents. Both media contain elements which can be characterised as non-linear.

In contrast, any individual path through hypertext is linear. The reader is still reading nodes in sequence, which is to say, one after the other, linearly. What makes hypertext different is not non-linearity but choice of alternative routes. Choice refers to the interaction of a reader with the information to determine which path of the several available paths, is the one chosen at a certain time. Different readers, of course, will select different paths through the information.

1.5 Hypertext and Multi-linearity

A document either printed or electronic is an information vehicle. The aim is to make the information widely available and understood to readers. The main characteristic of a text that makes it comprehensible to readers is its coherence (van Dijk & Kintsch, 1983). Coherence is defined by the presence of overlapping arguments, literally arguments semantically related (van Dijk & Kintsch, 1983). A printed

document follows the author's way of thinking and the information has been put in a predefined coherent sequence (linearly). The reader has to follow the author's sequence in order to fully comprehend the information.

In contrast, with hypertext, information is stored in a different way, in a non-linear way (Delaney & Landow, 1990; Nielsen, 1995; Rouet & Levonen, 1996). However, *non-linear* is a vague term, because it does not stress how the information is stored, only how it is not. If non-linearity means that there is no sequence between the information this ultimately implies two things. Firstly, that there is no meaningful relationship between them and so there is no coherence in the text. If that is the case, the reader would not be able to fully comprehend it and hypertext would have failed as a medium. However, Mayer (2001) argues that for successful understanding of a multimedia message the presented material should have a coherent structure. If not, then the learner's comprehension efforts will be inconclusive. Secondly, the text passages are meaningfully autonomic and actually there is no need for them to be connected in any sequence, no matter what the presentation medium. Bolter (1992, p. 25) for instance, points out that: "a hypertext has no canonical order. Every path defines an equally convincing and appropriate reading, and in that simple fact the reader's relationship to the text changes radically". Such definitions do not regard the information as an important part of hypertext and they only focus on the engineering aspects of the medium. If non-linearity means that there is no single predefined sequence among the information, it does not imply that there is no sequence at all.

The current study proposes and adopts a different approach. It claims that an inner multiple-linearity is always present in hypertext, based on the coherence of the presented information and on the sequence of the linguistic message. As a consequence the term *multi-linear* is a more appropriate term to define how pieces of information are connected to each other in hypertext environments. Multi-linearity as a term implies the existence of alternative linear pathways, which are not physically obvious and are not the same for all users. However, the pathways could be discovered by all users. Liestol (1994) has coined the term *multi-linear* but then he called the whole concept into question by noting a distinction between the stored positions of text, which may have non-linear organisation in space, and the act of reading, which is "chronological, conditioned by the durative ordering time" (Liestol,

1994). The present approach argues that one cannot really see how pieces of information are stored in hypertext but instead one can see how they are connected to each other (links). Thus, multi-linearity is the term which entirely describes how information has been placed together. Bolter (1998) pointing to the fluidity of hypertext agrees with the present approach and argues that hypertext is not non-linear but rather multi-linear. Nevertheless, readers always process one-piece of information after the other and one link after the other. Thus the element of linearity is always present in the way readers read and comprehend text. Essentially, what a reader does is to discover his/her individual sequence of the information. In hypertext there are several ways in which someone can read the stored information depending on which pathway he/she will follow. Different people might access the same information in different ways choosing to follow different sequences. Then again some people might access the same information differently, depending on how many times they will read it and what their aims are. The fact that there is no predefined sequence does not mean that there is not sequence at all. The sequence exists but it is not a single one, it is a multiple one. The difference is that in the conventional paper document the sequence is predefined by the author, and most of the times it is single, while in hypertext it is multiple and it rests with the reader to discover which sequence he/she will follow in order to meaningfully understand the text.

The distinction between the two terms is significant because definitions create expectations to both, readers and hypertext developers. Emphasising the non-linear feature of hypertext, in essence, one emphasises the technical aspects of the medium, sidelining its application as an information vehicle. Therefore much of the early research has focused on design, engineering, and information retrieval principles (Perfetti, 1996; Rouet & Levonen, 1996; Wenger & Payne, 1996) and not on psychological factors. These are more often responsible for the failure of effective system use than technical problems (Dixon et al., 1993). In contrary, the term multi-linear emphasises the linguistic features and perceives hypertext as an information vehicle where the communication of the information is fundamental and takes advantage of its technological characteristics. Additionally, this approach implies that reading in hypertexts is not such a different process compared to reading in traditional print environments.

1.6 Hypertext and Reading

Reading is an interactive and constructive process, and not merely the transferring of information from the text to the reader's mind. "It involves exact detailed, sequential perception and identification of letters, words, spelling patterns and larger language units" (Spache, 1964, p. 12). Readers approach texts with multiple perspectives, varying degrees of prior knowledge of the subject matter, varying degrees of interest and motivation, and diverse knowledge about the various types of texts and their structure and different expectations. These variations result in differences both in manner of process of reading, and also in the nature of comprehension (Afflerbach, 1990; Mishra & Nguyen-Jahiel, 1998).

In reading, the context of the text is very important and the reader brings his/her own meaning to the text and he/she is an active participant in the construction of the meaning (Goodman, 1967; Smith, 1982). Goodman (1967, p. 127) describes reading as "a psycholinguistic guessing game", where readers do not need to perceive and extract all the elements, but only the necessary cues to produce guesses which are right at the first time. According to the reader response theory (Fish, 1980) texts do not exist in isolation. Rather, the reader determines the meaning of the text, interacting with the text, and interpreting it his/her own way. Iser (1978) sees readers as "actualizing" texts by filling in their "gaps" (logical and sequential voids that we must fill in) or "indeterminacies" (uncertainties) of meaning. Fish (1980) gives the reader an even more active role as the text's true producer. These approaches recognise reading, not simply as eye movement, where readers' eyes move back and forth and wait for images and concepts to announce themselves. Readers exert great energy, making inferences, arranging details into pictures, venturing and revising predictions. Texts generate effects of meaning for the reader in a virtual space created between reader and text. Readers are active participants in the construction of the meaning, interacting with the text and creating their own individual understanding. Furthermore, the interactions that occur during reading are unpredictable and vary from one reader to the next (Fish, 1980; Iser, 1978).

Although hypertext may differ significantly from printed text in its structure, it shares many similarities for the reader. Hypertexts, regardless of their node and link structure, are still composed of units of text. Hypertext reading requires from the reader deliberate decisions about which path to follow. However, there are no reasons to believe or experimental findings to show that, at the sentence level and at the paragraph level at least, reading takes place in a different way compared to conventional printed texts. At a higher level of organisation, it is common for the reader to get asked frequently for alternative routes through the text. However, although the reader may be encouraged to make more active choices, this still results in a serial route through the text since only one node can be accessed at a time (McKnight, Dillon, & Richardson, 1991).

Hypertext challenges many well established assumptions and perspectives that have been developed from theory and research based on traditional paper-based documents. One such assumption is that of linearity. Most comprehensive theories of discourse comprehension assume that human beings process information in a linear fashion and scientists have based all their research on linear paper text materials (Goldman, 1996; Kintsch, 1988, 1998; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). Hypertext though, challenges the traditional models of sequential reading and the presumption of linearity (Bayne & Land, 2000; Landow, 1997). Hypertext systems according to Nielsen (1995), provide a non-sequential and entirely new method of accessing and presenting information, unlike traditional information systems, which are primarily sequential in nature. They provide flexible access to information by incorporating the notion of navigation, annotation, and customised presentation. Nevertheless, other researchers (e.g. Landow, 1991, 1997) went even further arguing that hypertext not just changes the way people read information but even improves it. However, comments like that were based on hypertext fiction novels. Examples of such hypertexts can be found in the field of hyperfiction with numerous hypertext novels. The seminal hyperfiction, published on disk by Eastgate Systems, is generally thought to be afternoon, a story by Michael Joyce (1987). In the nearly 20 years since the publication of afternoon, a small body of literature has appeared in this form; some is freely available on the Internet, for example, 253 or Tube Theatre by Geoff Ryman (1998) and some, such as Patchwork Girl (Jackson, 1995) is distributed on disk. For hypertext theorists such as Landow the textual

medium determines the nature of response. To understand hypertext fiction, says Landow (1992, p. 103), it "involves deducing its qualities from the defining characteristics of hypertext. Similarly, Stuart Moulthrop (1993) points to what he calls the *hypotext*, the underlying structures and specifications of a hypertext: this part, he says, is "arguably the most important" (p. 86). However, such assumptions are problematic because either they are not based on information processing theory, or are based on an uncritical acceptance of a host of quasi-psychological notions of reading and cognition (Dillon, 1996a).

Another point that is problematic in hypertext theory is the notion of linking and its proximity with the associative nature of thinking. As Dryden (1994, p. 285) puts it, “in its structure of branching; links and nodes, hypertext simulates the mind’s associative processes, thereby providing an electronic platform for constructing and recording reader’s literate thinking”. In the same vein Slatin (1990, p. 874) argues that reading in hypertext environment “ is understood as a discontinuous or non-linear process which, like thinking, is associative in nature, as opposed to the sequential process envisioned by conventional text”. However, the fact that part of human memory may be organised in associative networks does not mean that the best formats in which to read are also associative networks (Neuwirth, C. M. and Kaufer, D., 1989 cited in Charney, 1994). Furthermore, “because readers cannot import textual (or hypertextual) structures directly into long-term memory, the putative resemblance of hypertexts to long memory is irrelevant. It in no way entails that hypertexts are superior to linear text for facilitating reading or promoting learning” (Charney, 1994, p. 245). Nevertheless, “the author’s conception of the connection’s relevance is not the reader’s” (Dobrin, 1994, p. 310).

However, there are evidences to suggest that readers perceive reading in a hypertext environment different compared to print reading. For example, Sutherland-Smith (2002) argues that students perceive Web text reading different from print reading. Similarly, Mishra and Nguyen-Jahiel (1998) found that participants in their study perceived their experiences with the printed text fundamentally different than those with the hypertext.

It is evident that there is no theoretical framework in which to place hypertext reading and the need for one is essential. Leu et al. (2004) identify reading

comprehension as a major area of investigation because the Web, hypertexts, and other electronic systems focus so much on information and learning from text. That is exactly what the present study is ambitious to offer, a cognitive model to account for hypertext comprehension. However, given the powerful connection between reading comprehension ability and learning (Alexander & Jetton, 2000) it becomes evident that reading and comprehension are so closely related that one cannot talk about the one without mentioning the other. For that reason in the next section a review of the research on hypertext comprehension is presented and issues that need further research are discussed.

1.7 Research on Hypertext Comprehension

The major purpose of reading a document is comprehension and reading a hypertext is no exception. The critical element is that the reader reconstructs the message encoded in the written language (Dechant, 1991). As more and more individuals use new technologies to communicate information, these linguistic activities come to shape the ways in which we view and use language and literacy (Leu et al., 2004). Electronic documents and hypertext in particular provide new text formats, new reading purposes, and new ways to interact with information that can cause difficulties to readers taught to extract meaning from traditional paper-based documents (Coiro, 2003). Key differences between hypertext and print documents relate to textual boundaries, mobility, and navigation (Spires & Estes, 2002). In addition, readers seem to perceive electronic reading to be different from print reading (Mishra & Nguyen-Jahiel, 1998; Sutherland-Smith, 2002). Thus, what are the new literacies of the Internet and other electronic media? Any realistic analysis of what we know about new literacies from the traditional research literature must recognise that we actually know very little. Far too little research has been conducted in this area for far too long. This is, perhaps, the most worrying observation that results from any analysis of research in this area (Lankshear & Knobel, 2003; Leu, 2000).

There is a need to examine the various components of meaning construction to help us understand the extent to which comprehension processes are similar or different within the multimedia, hyperlinked contexts of the Internet and other ICTs (Information Communication Tools) (Coiro, 2003). Similarly, Zimmerman and Walls (2000) state that there is a need to develop a deeper understanding of how people use and navigate web-based documents so that guidelines can be developed to steer the development of better documents. However, the parameters of reading comprehension on the Internet are likely to expand to include problem identification, search strategies, analysis, synthesis, and the meaning construction required in e-mail messages and other communication technologies (RAND, 2002).

Comprehension is characterised as the construction of a mental model that represents the objects and schematic relations described in a text (van Dijk & Kintsch, 1983). Comprehension is a classic outcome measure of performance and perhaps the strongest test of a learning technology (Dillon & Gabbard, 1998). Thus, hypertext's success as an information vehicle and as a learning technology can be linked to its ability to assist comprehension. Early and current research on hypertext comprehension was focused on whether or not hypertext assists comprehension more than traditional paper-based documents (see: Chen & Rada, 1996; Dillon, 1996a; Dillon & Gabbard, 1998; Foltz, 1996; Macedo-Rouet, Rouet, Epstein, & Fayard, 2003; Macedo-Rouet, Rouet, Fayard, & Epstein, 2002; Miall & Dobson, 2001) and on differences between expert and novice users (Chen, Fan, & Macredie, 2004; Last, O'Donnell, & Kelly, 2001; Lazonder, Biemans, & Wopereis, 2000). However, the results during the last decade are mainly confusing and contradictory. Researchers on the field have failed to provide reliable data about the cognitive processes involved in hypertext text comprehension. For instance, empirical research in the field has shown little or no advantage of hypertext over traditional printed media (see: Chen & Rada, 1996; Dillon, 1996a; Dillon & Gabbard, 1998; Foltz, 1996; Macedo-Rouet, Rouet, Epstein et al., 2003; Macedo-Rouet et al., 2002; Miall & Dobson, 2001). Users, especially the novice ones, may experience disorientation and navigational problems while reading (Dillon, 1996b; Rouet & Levonen, 1996; Zellweger, Mangen, & Newman, 2002). Besides, they may have difficulties following the overall structure of information and relating it to their prior knowledge or cognitive schemata (Altun, 2000). The reality of electronic text usage is far from ideal. "Improvement might be

sought in the development of a framework for analysing reader-documentation interaction, in order to conceptualise human information usage that is needed to examine and evaluate designs for electronic documents" (van Oostendorp & de Mul, 1996b, p. 3). Today hypertext is widely used, but little systematic research has investigated how much better or worse information is learned from hypertext formats than from traditional text or how the design of hypertext enhances learning experiences (Lee & Tedder, 2003). On top of that, research in hypermedia in the past was too technologically oriented and not so well grounded in the knowledge of applied cognitive science (Tergan, 1997). Many more questions require investigation: What new aspects of comprehension are needed when reading information on the Web? Are inferential processes and strategies similar or different on the Web? How do other aspects of the comprehension process change? Reading comprehension strategies within this context are likely to be important in particular, and we need to know what these are (Leu et al., 2004).

It is unfeasible to answer all these questions and to tackle all these issues in a single study. Considering that, the present study primarily focuses on modelling the cognitive processes involved in hypertext reading comprehension. Many researchers (Coiro, 2003; Leu et al., 2004; Miall, 2000; Salmerón, Cañas, Kintsch, & Fajardo, 2005; Spires & Estes, 2002) have emphasised the need for further research to model the cognitive processes involved in reading comprehension in a hypertext environment. Despite the increasing popularity of hypertext systems and the Web, little is known about the cognitive processes that take place in electronic environments. For instance, a survey of the literature reveals that there is little research into the meaning making process of non-expert hypertext readers (Mishra & Nguyen-Jahiel, 1998).

Hypertext challenges the assumptions and practices that have dominated theories of text comprehension and learning. The major aspect among these is the assumption that readers process information in a linear fashion at least most of the time (Dillon, 1996a; Goldman, 1996). Traditionally, reading comprehension has often been defined by the construction of meaning from a fixed body of text. On the Internet, reading comprehension takes on a very different and broader definition. New skills and strategies are required in this context to successfully comprehend information

such as how to search for appropriate information; how to comprehend search engine results; how to make correct inferences about information that will be found behind any hyperlink; how to coordinate and synthesise vast amounts of information, presented in multiple media formats, and how to know which informational elements require attention and which ones may be ignored (Coiro, 2003). Readers with an identical goal, will construct meaning differently, not only because they bring different background knowledge to the task but also because they will use very different search strategies, follow very different informational paths, read very different sets of information, and attend to very different informational elements. Reading comprehension has a very different meaning on the Internet (Coiro, 2003).

Given the powerful connection between reading comprehension ability and learning (Alexander & Jetton, 2000) it is clear that the development of a hypertext comprehension model is essential in this global information technology age, where the World Wide Web (WWW) and other continuously emerging Information and Communication Technologies (ICTs) will dominate the literacy practices. If electronic texts are worth using, they must offer value above their paper-based counterparts (Gillingham, 1996). However, the use of the new medium does not only depend on its superiority over traditional paper documents. The new medium offers alternatives such as storing, flexibility, freedom, adaptability etc. that the paper-based documents do not. Thus the focus of the research should be on how either to improve the medium or how to take full advantage of its potential, and not if it is better compared to paper books. There is an increasing recognition that this technology is here to stay; it will continue to appear in schools even before research outcomes are known (Leu et al., 2004).

A New Literacies Perspective suggests that an extensive research must be introduced immediately for a better understanding of the new skills, strategies, and dispositions that are required to use the Internet, WWW, and other ICTs effectively (Leu et al., 2004). New terms and definitions have appeared in the research literature to describe in a better way what literacy means in this new information technology era. Terms such as “multiple literacies” (Street, 1984), and “multi-literacies” (Group, 1996), attempt to incorporate the skills that people need to develop in order to be considered as literal. Kress and van Leeuwen (Krees & van Leeuwen, 1990) for example, argue

that reading and writing practices of literacy are only part of what people are going to learn in order to be literate. Literacy in nowadays involves, at all levels, the ability to use and communicate in a diverse range of technologies. Besides, a growing body of researchers emphasize the need to investigate the relation of New Literacies with social, cultural and ethnographic factors (Street, 2000).

1.8 Effects of Reading Goals on Hypertext Comprehension

Perfetti et al. (1999) states that the task or the goal has a strong influence on how readers read. When reading paper-based print texts, readers spend more time on goal related information (Dee-Lucas & Huston, 1999). Text comprehension is a goal-oriented process of the human cognitive system, in which individuals actively select and process information to construct mental representations that correspond to present or anticipated demands (Schnotz & Bannert, 2003). Because goals influence learning for linear texts it is important to consider how they affect reading and learning in hypertext environments as well (Last et al., 2001).

There is no extensive research on the effect that different reading goals might have on comprehension in hypertexts. The findings from those studies are inconclusive and often contradictory. For instance, Foltz (1996) found out that there was no difference in reading comprehension between general and specific reading goals on three different text formats, including two types of hypertexts. Similarly, Curry et al. (1999) discovered that reading goals did not influence participants comprehension but he identified observable differences in how participants represented the given information under general and specific conditions. In a slightly different study, Rouet (2003) investigated if general questions would result in longer search patterns compared to specific questions using two different hypertexts. He found out that search time was significantly longer for general questions than for specific ones. Additionally, Schoeller (2005) found out that different reading goals have an effect on learning from hypertext but only for those participants who were

allocated to the heading condition. She found no significant effect for the participants who were allocated into the no heading condition.

It is evident from the findings discussed that there are no conclusive results on the effect of reading goals on hypertext reading comprehension. The current study will investigate the effect that general and specific reading goals might have in reading and learning in hypertext environments.

1.9 Hypertext Comprehension Models

Hypertext challenges the assumptions and practices that have dominated theories of text comprehension and learning. The main aspect among these is the assumption that readers process information in a linear fashion at least most of the time (Dillon, 1996a; Goldman, 1996). However, most of the research on hypertext comprehension has been based on Kintsch's and van Dijk's (1978; van Dijk & Kintsch, 1983) model and on its expansion, the construction integration model (Kintsch, 1988, 1998) of text comprehension (Salmerón et al., 2005). This model distinguishes between two forms of representation, the text-base and the situational model. According to the model, many factors influence text comprehension. However, background knowledge and coherence remain the main factors. These models have influenced the current research as well. The following section describes the Kintsch and van Dijk comprehension model.

1.9.1 Kintsch's and van Dijk's reading comprehension model

"Comprehension occurs when and if the elements that enter into the process achieve a stable state in which the majority of elements are meaningfully related to one another and other elements that do not fit the pattern of the majority are suppressed" (Kintsch, 1998, p. 4). There have been several attempts by educational psychologists to explore reading comprehension over the past decades. One of the most widely acceptable attempts was made by Kintsch and van Dijk (1978; van Dijk & Kintsch,

1983). Their model (Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983) assumes that there are multiple processes during comprehension, occurring sometimes in parallel, sometimes sequentially (Kintsch & van Dijk, 1978).

In their first attempt (Kintsch & van Dijk, 1978) they characterised the semantic structure of a discourse at two levels, at the level of *microstructure* and at the level of *macrostructure*. The microstructure is "the local level of the discourse, that is, the structure of the individual propositions and their relation" (Kintsch & van Dijk, 1978, p. 365). That means that the microstructure consists of the meaning of local arguments, hence arguments that are included in sentences or phrases or even in paragraphs. "The macrostructure is of a more global nature, characterising the discourse as a whole" (Kintsch & van Dijk, 1978, p. 365). Namely, the macrostructure is the creation of a more general, completed meaning of the read passage including the use of the reader's knowledge of the world.

In a development of the model (van Dijk & Kintsch, 1983) they identified another level of cognitive representation that are constructed during comprehension totalling three levels. The first level is the surface code, and is a record of the exact wording and syntax of the sentences. The surface code is preserved in memory for only a few seconds when a technical text is read. The second level is the text-base. The text-base contains explicit propositions in the text in a stripped-down form that captures the semantic meaning, but loses details of the surface code. The text-base is preserved in memory for several minutes or longer. The last level is the situation model, which is the referential mental world of what the text is about. Kintsch and van Dijk (1978; van Dijk & Kintsch, 1983) assume that the surface of a discourse is interpreted as a set of propositions. Propositions are the smallest units of meaning such as clause or phrase. Various semantic relations among them order the set of propositions. Some of these relations are explicitly expressed in the surface structure of the discourse; while others are inferred during the process of interpretation with the help of various kinds of context-specific or general knowledge.

Kintsch's and van Dijk's (1978; van Dijk & Kintsch, 1983) model has largely been adopted by research on reading comprehension processes in hypertext environments. Nonetheless, many researchers (Coiro, 2003; Leu et al., 2004; Miall, 2000; Salmerón, Cañas, Kintsch, & Fajardo, 2004; Spires & Estes, 2002) have

emphasised the need for further research to model the cognitive processes involved in reading comprehension in hypertext environments. However, to date four models provide some explanation on understanding, and comprehension in electronic environments (Lemercier & Tricot, 2004). First, the cognitive load theory (Sweller, 2003). Second, the cognitive theory of multimedia learning (Mayer, 2001; Moreno & Mayer, 1999). Third, the model for multidocument representation (Perfetti et al., 1999), and finally, the comprehension model for text and graphics (Schnotz, 1993; Schnotz & Bannert, 2003).

1.9.2 Cognitive load theory

The cognitive load theory has been introduced by Sweller (1988) and it is referring to instructional material and solving problems activities relevant to learning. The theory suggests that learning takes place best under conditions that are aligned with human cognitive architecture and it refers to traditional printed material. However, Sweller (1999), based on his earlier theory, proposed a framework to account for the effect of multimedia on learning and comprehension. The cognitive load theory refers to the amount of activity imposed on working memory during a task (Sweller, 2003). It focuses on the role of working memory in the learning process. The major factor that contributes to cognitive load is the number of elements which require attention (Cooper, 1998). The theory rests upon the limited capacity of working memory. When comprehension takes place, working memory has to be actively engaged in order to encode the information successfully and retain then in the long term memory. If the resources of working memory are exceeded then learning will be ineffective (Cooper, 1998). Reducing the cost imposed by the accomplishment of the task, both by modifying the task or by modifying the material, discharges cognitive resources, and thus permits learning to take place. Other essential elements of the theory are *schemas*. Schemas allow elements of information and skills to be categorised and stored in long-term memory. When brought into working memory, a schema, no matter what its size, is treated as a single element. Thus, working memory is able to process large amount of already known information.

Sweller (1988; 2003) distinguishes between two different types of cognitive load, the intrinsic cognitive load and the extraneous cognitive load. The intrinsic cognitive load refers to the intrinsic nature of the presented information, while the extraneous cognitive load is due to the instructional materials used to present the information.

The cognitive load theory is best applied in the area of instructional design of cognitively complex or technically challenging material. Thus, learning mediums such as hypertexts, if they are to be effective, have to keep cognitive load at a minimum during learning. To do so, they have to apply the cognitive load theory to hypertext design.

While in the past the theory has been primarily applied to technical areas, it is now being applied to more language-based areas (Soloman, 2000). However, this theory focuses primarily on the cognitive component of working memory and not on the complete reading process. Furthermore, it does not tackle the importance of the reading strategies during hypertext reading.

1.9.3 Cognitive theory of multimedia learning

Mayer (2001) proposed a cognitive model of multimedia learning intended to present the human information processing system, based on three well established ideas in cognitive science. The ideas are the dual-channel or dual-coding approach, the limited capacity of working memory, and the active processing assumption. The model represents the memory stores, including sensory memory, working memory, and long-term memory. The model addresses both visual (words, images) and auditory (sounds) inputs, by incorporating a visual sensory memory and auditory sensory memory. However, as Mayer (2001) notes the central work of multimedia learning takes place in working memory, where information is temporarily held and manipulated in active consciousness. The format of the information is either pictorial or verbal and there is an interaction between the two modes of representation, as learners are able to convert the pictorial information to auditory and vice versa. Moreno and Mayer (1999) have shown that mixed-modality presentations are

superior to the most integrated text and visual presentations in multimedia learning. Furthermore, the information held in working memory is integrated with knowledge brought into working memory from the long-term memory. Due to the limited capacity of working memory only a few images or sounds can be held and processed at one time.

While Mayer's model represents the information processing system, by illustrating the different systems that take part in multimedia learning, the proposed model focuses on the processes that take part during hypertext reading and not on the systems involved.

1.9.4 Model for multidocument representation

The main ideas of this "framework for a theory is that the intelligent use of texts entails mental representations of specific texts, situations described in texts, and relations among texts" (Perfetti et al., 1999, p. 99). Reading multiple texts produces representations that include connections between the texts. They proposed a representational model and they accept propositions as a practical starting point, adopting van Dijk's and Kintsch's (1983) concept. The general model has two components: the Intertext Model and the Situation Model. "The Intertext Model represents the relationships among documents, and among a document and elements of the situation; the Situations Model represents situations very broadly constructed-both real situations and hypothetical ones; and, importantly, multiple interrelated situations" (Perfetti et al., 1999, pp. 102-103). When both components are interconnected, they generate the full Documents Model.

According to this model a reader creates a model about the documents called Documents Model when he/she reads some documents about a subject. That includes a mental representation of each text, each situation described in a text, relations among texts, and also relations between texts and situations (Perfetti et al., 1999). However, the creation of Documents Models is encouraged by tasks that support attention to documents as opposed to situations, while situation models come rather easily, even when there is some emphasis on documents.

When dealing with comprehension of a simple document which comes from a single source, it is accepted that the reader's representation is coherent (Lemercier & Tricot, 2004). However, according to Perfetti's et al.(1999) model, the reader's representation about some of the information is not necessarily coherent or, alternatively, some knowledge establishes relations between contents which are not coherent with one another.

Perfetti at al. (1999) model is a representational model. Hence, it focuses on the mental representations during reading and not on processes that take place during reading. Furthermore, it addresses the issue of multiple documents reading as opposed to a single document and it is based on traditional printed texts. However, reading in an electronic environment requires some processes that are not essential in traditional document reading. On the contrary, the cognitive model presented in this thesis is a procedural model. A procedural model describes a sequence of steps. It also refers to hypertext documents instead of traditional printed documents.

1.9.5 Comprehension model for text and graphics

Schnotz (1993; 2003) introduced a theory about learning from verbal and pictorial representations. He emphasised an integrative comprehension of text and graphics and the model initially was based on printed material. However, Schnotz and Bannert (2003) introduced the theory to account for electronic representations of information, because they provide flexible combinations of different forms of information. The theory emphasises the hypothesis that a benefit can be gained from the dual coding of information. This notion was first introduced by Paivio (1986) in his dual-coding theory of comprehension of documents which includes both text and graphics.

Schnotz and Bannert (2003) based their model on two distinctive forms of representations, the descriptive and depictive representations. Descriptive representations consist of symbols describing an object and the signs for their relations (Schnotz & Bannert, 2003). For instance, spoken or written texts belong to descriptive representations. On the other hand, pictures belong to depictive

representations. However, although they allow us to extract relational information, they do not contain symbols for these relations (Schnotz & Bannert, 2003).

According to the model (Schnotz & Bannert, 2003), the reader of a text constructs first a mental representation of the surface code, then generates a propositional representation of the content, and finally constructs a mental model of the subject matter presented in the text. These representations are based on an interaction of bottom-up and top-down activation of cognitive schemata, which act as a central executive. In picture comprehension, the reader first creates a visual mental representation of the picture and then constructs a mental model as well as a propositional representation of the information shown in the picture (Schnotz & Bannert, 2003). The task-relevant information is selected through top-down activation of a cognitive schema.

Schnotz's and Bannert's (2003) model is focused on the representation of the information and not on the procedural aspects of reading comprehension. It mainly adapts the text representations suggested by van Dijk and Kintsch (Kintsch, 1988; 1998; van Dijk & Kintsch, 1983). Additionally, it excludes the strategies that readers might use during reading in an electronic environment.

All the models presented above are trying to explain the cognitive processes that take place during reading in hypertext. However, most of the models focus on representational issues and the cognitive components but not on the procedural process. Furthermore, none of these models incorporates locating information and thus the use of strategies.

1.10 Guthrie's Reading for Locating Information Model

Despite the importance of locating information in workplaces and schools, limited research is available to explicate the processes involved in locating information (Kirsch & Guthrie, 1984). Perhaps one reason for this neglect is the tendency to assume that reading research applies to tasks concerning locating information (Dreher & Guthrie, 1990).

"Locating information in text is defined as the set of cognitive operations that is necessary for a person to identify specific information, such as propositions, phrases, or numbers, within a large amount of writing, such as passage of prose, a table, or a combination of both" (Guthrie & Kirsch, 1987, p. 220). Guthrie (1988), based on a previously proposed model by Guthrie and Mosenthal (1987) has outlined a significant new approach to understand readers information seeking skills. His model (Guthrie, 1988) consists of five components: *goal formation, category selection, extraction of information, integration, recycling.*

Formation of a goal refers to the case in which either the learner understands a question presented to him/her, or a specific information need arising during the course of a broader learning activity such as writing a term paper. However, the learner may be required to construct sub goals, especially if the broader goal is vague and the information set is large and complex. The learner may also be required to reformulate the goal, within certain limits, if the information is not available to satisfy the original statement completely (Guthrie, 1988; Guthrie & Mosenthal, 1987).

The second component of the framework is category selection. Sets of information such as tables or textbooks chapters are usually structured although the quality of structuring is not always optimal. There are sections or segments of the information set that are interrelated but may be partitioned for inspection or analysis. The segments of a table are its rows and columns; segments of a chapter are its sections, units, and its graphically unique portions (Guthrie & Mosenthal, 1987). So the reader must search these categories and its segments and attempt to locate a specific unit of information within one or more of them. "Not all categories will be relevant to task performance, so attention must be selectively directed to a pertinent one" (Guthrie, 1988, p. 182).

The next component of the model (Guthrie, 1988) is the extraction of details from a category. In a text, a specific unit of detail that will satisfy the reader's goal is usually located in a certain place. So it is important for the reader to distinguish the important from less important detail in order to succeed his goal.

Integration of the extracted information is the next step of the model. The reader at this stage integrates the extracted information with either previously obtained information or with his/her goal or sub goals (Guthrie, 1988).

The last constituent of the framework refers to recycling through the prior components until the reader obtains a satisfactory solution for his/her goal. That means that if the necessary information does not exist within a category or categories that already have been searched by the reader, then he/she would have to select a different category or refine his/her goal or sub goals until the goal has been successfully succeed.

However, Guthrie's (1988) model has primarily been assessed on documents such as manuals, schematics, and periodicals and not textbooks (e.g. Guthrie, 1988; Guthrie & Kirsch, 1987). Dreher and Guthrie (1990) expanded this model in text documents with focus on category selection. They used as reading material a textbook chapter because locating information in a textbook chapter involves finding a specific subset of information relevant to a particular goal. They conclude that: "Good category selection involves selecting information categories that match the features of the goal and keeping to a minimum the number of categories that are examined" (Dreher & Guthrie, 1990, p. 327).

1.11 Reading Strategies

Reading is a very complex process and it does not only imply the identification of the meaning of the words, sentences and other elements of the text. Moreover, it involves the use of different strategies. Readers can use various strategies for reading a document either in a linear or in a hypertext format. Reading strategies require a goal that they intentionally invoked. Furthermore, they require effort, and they work differently on different tasks (Gillingham, 1996). Different reading sequences of the same text influence text comprehension in a linear text (Kintsch & Yarbrough, 1982; Schnotz, 1982; 1984 cited in: Salmerón et al., 2005).

Salmerón et al. (2005) call for further research on hypertext strategies in order to fully understand their effects on hypertext comprehension. The current study investigates the strategies that hypertext readers use in connection with the use of the think aloud method. In addition, the study will try to reveal some of the factors that might affect their use. A good starting point is the present knowledge about strategic reading in paper-based documents (Schmar-Dobler, 2003). Further, qualitative studies on hypertext strategies might give us an insight about the reasons that lead readers to use a particular strategy. The following sections primarily present research findings about the reading strategies in traditional print documents and in electronic environments.

1.11.1 Reading strategies in traditional texts

What underlines the need for further research on reading comprehension in hypertext environments is the insufficient attention that has been paid to the strategies readers employ in traditional printed documents and hypertexts (Britt, Rouet, & Perfetti, 1996; Wright, 1993; Yang, 1997). Wright (1993) for example, referring to paper-based text models, argues convincingly that any model intending to account for the reading process needs to incorporate the reading strategies. However, none of the existing models (Kintsch, 1994, 1998; McKoon & Ratcliff, 1992; Meyer, 1985; van Dijk & Kintsch, 1983) has incorporated the various strategies which are used by readers. They rather examine them as a separate element.

Regardless of the fact that there is no extensive research on reading strategies some studies have taken place and have shown that readers are using more than one strategy during reading a traditional document. Dillon et al. (1989) have identified two types of reading strategies. Only one of them could be described as linear. This strategy is *a serial detailed read* from start to finish. The other strategy is *to scan-read* the article in a non-sequential fashion to rapidly extract relevant information.

Similarly, Goldman and Saul (1990) identified a number of strategies used by subjects when they read text passages. Subjects read individual sentences and could go backward and forward through the sentences. At the global level they identified

three approaches; the *through* approach, in which subjects read straight through a text; the *review*, in which subjects went to the passage end and then reviewed sentences; and the *regress* approach, in which they went back to previous sentences throughout the text. They also found that subjects almost always used more than one approach in reading a passage.

Mayer (1997) argues that it is important to be cautious about generalising finding from traditional texts to different forms of hypermedia because each technology contains different contexts and resources for constructing meaning and requires somewhat different strategies in its applications.

1.11.2 Reading strategies in hypertext

Strategies are a very essential element of reading and comprehension. Different strategies influence the way readers process the text and hence their comprehension (Salmerón et al., 2005). Strategies might play an even more essential role in hypertext than in traditional paper-based documents, because of readers' necessity to strategically navigate through the different nodes in hypertext documents. "Reading strategies in hypertext can be considered as the decision rule that a reader follows to navigate through the different nodes of a hypertext" (Salmerón et al., 2005, p. 174). Thus, in essence reading strategies become navigation strategies in hypertext environments. Coiro (2003), stressing the importance of strategies in hypertext, argues that readers with an identical goal for example, will construct meaning differently, not only because they bring different background knowledge to the task but also because they will use very different search strategies, follow very different informational paths, read very different sets of information, and attend to very different informational elements. Hypertext technologies, with unlimited freedoms of multiple navigational pathways, present opportunities that may seduce some readers away from important content unless they have developed strategies to deal with these seductions (Lawless & Kulikowich, 1996; Lawless, Mills, & Brown, 2002). Thus, it is evident that reading models that do not take reading or navigation strategies into consideration, they ignore a very fundamental aspect of the reading process, in both traditional print and electronic environments.

Reading strategies can affect both the amount of information obtained and its reading order, which can consequently influence comprehension. More explicitly, Salmerón et al. (2005) argue that the amount of information read by a hypertext reader affects the text-base, while the reading sequence influences the situation model. Additionally, the navigation strategies used by readers of hypermedia systems are different to the navigation strategies used when reading conventional text (Levental, Teasley, Instone, Schertler Rohlman, & Farhat, 1993). Nevertheless, despite a substantial literature on problems related to hypertext navigation, we know remarkably little about the relationship between navigational strategies and the successful use of hypertext (McEneaney, 2000). The present research on the proposed reading model in hypertext environments places the navigation strategies at the centre of its focus.

Other differences between the electronic and paper media in reading have been demonstrated at the psychomotor, perceptual, and cognitive levels (Dillon, 1996b). At the cognitive level, which is the focus of this work, Wenger and Payne (1994; 1996) argue that, hypertext use depends on some additional types of processes that are not always important in linear text. Those processes are more similar to those involved in analytic reasoning than those involved in simple reading. They found that hypertext demands more relational processing than does a linear document. That means that readers need a further ability to relate and process text. Similarly, the authors of the RAND report (2002) argue that electronic texts require skills and abilities beyond those required for the comprehension of traditional print documents. What are the types of processes that are important in reading in a hypertext environment? What other abilities do readers need to successfully comprehend a hypertext document?

Regarding the question of how people read on the Web (WWW), Nielsen responds that they do not (Nielsen, 1997). He claims that people rarely read on the WWW. Instead they scan the page, picking out individual words and sentences. Slatin (1990) identified three different types of hypertext readers: *the browser*, *the user*, and *the co-author*. The browser reads for no particular purpose, browsing around in order to find something interesting with which to engage. The user is looking for specific information and tries to locate it, and the co-author collaborates

deliberately with the hypertext, contributing information or incorporating existing nodes into new hypertexts. However, these strategies are more about readers approach towards hypertext rather than readers reading strategies while reading. Additionally, Slatin (1990) approaches hypertext as authoring/reading environment rather than as a presentation medium. In another study, Anderson-Inman et al. (1994) identified three types of hypertext readers in their research on the Electro Text Project. The first one was called "*book lover*, a person who typically reads everything in linear form, and uses the available resources carefully. The second type of hypertext reader was called s*tudier*, a reader who navigates through pages in a linear form, backtracks for reviewing and checking information, and more frequent use of comprehension monitoring questions. The last type of hypertext reader was coded as a *resource junkie*. A reader of this type spends most of his/her time looking for and using resources. It is, in fact, their navigation patterns and strategies that are the most varied and complex.

Foltz (1992) found out that subjects during reading of hypertext tend to read the text in a very coherent manner, seldom jumping into a different content. Subjects with a general reading goal used a *depth-first* method throughout the whole hierarchy, and some others used a combination of *depth-first* with *cross-hierarchical* method. However, subjects with specific reading goals used a much more selective method. All subjects used these strategies to find coherence among the paths.

Lawless and Kulikowich (1996; 1998) have identified three types of navigation: *knowledge seekers*, *feature explorers* and *apathetic hypertext users*. The first type, knowledge seekers, spends most of the time reading on content related documents. The feature explorers spend most of their time on special features such as images, videos, and maps. Finally, the apathetic users spend short time on content related documents, and seem to follow a random reading order.

In another study Navarro-Prieto et al. (1999) have identified three strategies in Web searching. The first is a *top-down* strategy. The users employing this strategy search first, in a general area and then narrow down their search. The second strategy is a *bottom-up* strategy. The bottom-up strategy implies that users look directly for the specific information. Experienced participants most often used this strategy. The

last strategy is a *mixed* strategy: readers used both strategies in parallel, in multiple windows, and they were only used by the experienced participants.

As it has been shown above, when people read they make many choices. They choose what to read and what to skim; they choose when to read some information and when to ignore them. They might choose to read in a very detailed or in a very fast fashion. This kind of reading implies the use of reading strategies. However, there is no agreement in the literature regarding the strategies that hypertext readers use when they read for comprehension (Unz & Hesse, 1999). Furthermore, there are no theories, either of reading or of learning, that tell us what strategies people need during reading (Britt et al., 1996; Wright, 1989, 1993). The need for such theories is substantial, if we really want to explore discourse comprehension and improve reading, learning, and text design. This need becomes more extensive with the widespread use of hypertext as an information vehicle, because readers have now more choices than ever before on how to access information. Nevertheless, further research is needed to investigate the strategies that readers use while reading and any model that aims to describe discourse comprehension needs to take them into consideration.

Hypertext readers need to use even more sophisticated strategies because the challenge is increasing. They have to build their own pathway through information and that requires an ability to locate information, distinguish between relevant and irrelevant information, choose hypertext links, infer the contents that lie beneath a hypertext link, monitor their reading but at the same time monitor their position in the hypertext environment. Thus the current study investigates the reading strategies readers use during hypertext reading and examines some of the factors that might influence the hypertext link selection.

To conclude, despite the increasing popularity of hypertext systems and the Web, little is known about the cognitive processes that take place in electronic environments. It is evident that there is a need for further research to model the cognitive processes involved in reading comprehension in a hypertext environment in order to understand the processes better, and to take full advantage of the medium's potential. The present study does exactly that by focusing on the modelling of the cognitive processes that take place during reading in a hypertext

environment. It proposes a cognitive model that describes the steps that a reader undertakes and it considers the use of readers' strategies. The study also investigates the effect of reading goals on reading comprehension in hypertexts, and studies the strategies that readers use while reading. Finally, it offers an insight in the factors that influence these reading strategies.

The next chapter describes and explains the proposed model for hypertext reading comprehension and the theoretical background that has influenced it.

Chapter 2

Hypertext Reading Comprehension Model

The type of information considered in this thesis is Web based hypertext, consisting of multi-linear text. The thesis focuses on text and not on any other form of information presented in a hypermedia environment, such as sound, graphics, or video. This focus is chosen because text remains the main method to communicate information in this global information technology age. Leu et al. (2004) for instance, identify reading comprehension as a major area of investigation because the Web, hypertexts, and other electronic systems focus so much on information and learning from text. Hypertext documents challenge the assumptions of paper-based text comprehension theories and learning theories from text (van Oostendorp & de Mul, 1996b). One of their main assumptions is that learners' process verbal information in a linear order.

A model to account for hypertext reading comprehension is presented in this chapter. The theories that influenced the construction of the model are also considered. The model is concerned with the processes involved in the act of comprehension. Comprehension occurs when and if the information entered in the process achieve a stable state in which the majority of the information are meaningfully related to one another (Kintsch, 1998).

2.1 Introduction

"Electronic texts that incorporate hyperlinks and hypermedia introduce some complications in defining comprehension because they require skills and abilities beyond those required for the comprehension of conventional, linear print" (RAND, 2002, p. 14). Spires and Estes (2002, p. 123) call for "rich theoretical description of the comprehension processes during Web-based reading". Understanding the nature of hypertext reading is vital in order to improve hypertext design, reading strategies, and eventually users' performance (Protopsaltis & Bouki, 2004a). It is also important in order to understand and illustrate its full potential as presentational or educational medium. In spite of the increasing attention towards this area, there are still many questions unanswered.

Hypertext systems allow users to navigate between nodes that connect multiple units of information and select the ones they are interested in. A hypertext document is a multilinear document (Protopsaltis, Bouki, & Sharp, 2000). This multilinearity challenges the way people read information and even "improves" it according to some scholars (Bayne & Land, 2000; Landow, 1991, 1997). However, empirical research in the field has shown little or no advantage of hypertext over traditional printed media (see: Dillon, 1996a; Dillon & Gabbard, 1998; Macedo-Rouet, Rouet, Epstein et al., 2003; Macedo-Rouet et al., 2002; Miall & Dobson, 2001). Users, especially the novice ones, may experience disorientation and navigational problems while reading (Dillon, 1996b; Rouet & Levonen, 1996; Zellweger et al., 2002). Besides, they may have difficulties following the overall structure of information and relating it to their prior knowledge or cognitive schemata (Altun, 2000).

One way to overcome these difficulties is to understand the cognitive processes that take place during hypertext reading. However, neither a general theory of hypertext nor a model of the cognitive process involved in reading exists (Altun, 2000; Rouet & Levonen, 1996). Additionally, little research has been done by reading researchers and educators to assess hypertext's potential impact on and implications for reading and literacy education (Altun, 2003).

Despite a substantial literature on problems related to hypertext navigation, we know remarkably little about the relationship between navigational strategies and successful use of hypertext (McEneaney, 2000). This study attempts to contribute towards this direction by proposing a cognitive model for hypertext reading comprehension, considering the strategies hypertext readers/users apply. Cognitive processes have proved to be crucial in activities such as reading and searching information in an electronic medium (van Oostendorp & de Mul, 1996b).

Research has demonstrated differences between the electronic and paper media in reading at the psychomotor, perceptual, and cognitive levels (Dillon, 1996b). At the cognitive level, which is the focus of this work, Wenger and Payne (1994; 1996) argue that, hypertext use depends on some additional types of processes that are not always important in linear text. They found that hypertext demands more relational processing than does a linear document. That means that readers need a further ability to relate and process text. It is rational to assume that these processes have not been taken into consideration by the models that account for paper-based comprehension, because they had either no influence or very limited influence over comprehension in such documents. This assumption implies that these models are insufficient to account for hypertext comprehension, and underlines the need for new reading comprehension models to exclusively account for hypertext documents. Furthermore, researchers (Spires & Estes, 2002) have emphasised the need to further research and model the cognitive processes involved in reading in a hypertext environment. The new models have to consider these additional types of processes that play a role in hypertext understanding. Therefore, there is a need to investigate these cognitive processes in order to understand the nature of hypertext reading (Espéret, 1996).

Former research on traditional paper-based documents can be a valuable starting point towards the production of a comprehension model to account for hypertext documents. Espéret (1990) for instance, argues that the results from traditional textual psycholinguistics have to be taken into account to explain the strategies observed in hypertext users. Nevertheless, Schmar-Dobler (2003) proposes as a good starting point the present knowledge about strategic reading in paper-based documents. This is the starting point in the present study.

In the reminder of this chapter the comprehension model and the locating information model (Guthrie, 1988; Guthrie & Mosenthal, 1987; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983) that have influenced this work will be briefly discussed again, and then the proposed model for hypertext comprehension will follow.

2.2 Why Kintsch's and van Dijk's Models and Guthrie's Model?

The Kintsch and van Dijk (1978; van Dijk & Kintsch, 1983) framework is very well suited for the present research, because it focuses on the extraction of meaning, which is part of the focus of the proposed model. Their theory is the most common cited theory on text comprehension field, and has been previously used on hypertext comprehension research. Eysenk and Keane (1997) characterised their theory as one of the most successful in the field. It is a very comprehensive attempt towards the understanding of text comprehension. Their notion of text-base (microstructure) and situation model (macrostructure) has been acknowledged and adopted by most reading models that have been created since (e.g. Kintsch, 1998; McKoon & Ratcliff, 1992; Meyer, 1984). For instance, Meyer (1984) in his model accepts propositions as the smallest units of meaning proposed by Kintsch and van Dijk (Kintsch, 1998; 1978; van Dijk & Kintsch, 1983) and identifies two different levels of representation, the micropropositional and macropropositional which are central in Kintsch and van Dijk (Kintsch, 1998; 1978; van Dijk & Kintsch, 1983) work. Nevertheless, Kintsch and van Dijk (Kintsch, 1998; 1978; van Dijk & Kintsch, 1983), found solid

experimental results to support their distinction of three representational levels (surface structure, text-base and situation model) during comprehension.

Additionally, in the hypertext comprehension field, Schnotz and Bannert (2003) introduced a theory to account for electronic representations based on the dual coding of information first introduced by Paivio (1986). According to their model (Schnotz & Bannert, 2003), the reader of a text constructs first a mental representation of the surface code, then generates a propositional representation of the content, and finally constructs a mental model of the subject matter presented in the text. The distinction between the three different levels of representation is identical with the representation proposed by van Dijk and Kintsch (1983). Similarly, Perfetti et al. (1999) in their theory of multisource documents, accept as essential components of comprehension, the text-base and the situation model, notions which are fundamental in van Dijk's and Kintsch's (1983) model. Furthermore, Foltz (1992; 1996) has used Kintsch's and van Dijk's (1978) model as a basis to predict hypertext comprehension.

The research presented above demonstrates the importance and strengths of the Kintsch and van Dijk (Kintsch, 1998; 1978; van Dijk & Kintsch, 1983) model and justifies its adoption as a starting point for the present study. Furthermore, the current study focuses on hypertext comprehension as a whole rather than on word or sentence understanding in a hypertext environment. Therefore their (Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983) model is very appropriate for this aim, because its focus was on story understanding as a whole. Besides, it is reasonable to assume that low level processes such as letter or word or sentence identification remain the same in hypertext as in conventional paper documents.

On the other hand, reading comprehension in a hypertext environment takes on a very different and broader definition. New skills and strategies are required in this context to successfully comprehend information such as how to search and locate appropriate information; how to coordinate and synthesise large amounts of information, and how to know which informational elements require attention and which ones may be ignored (Coiro, 2003). Hypertext gives greater freedom and flexibility to the reader, to locate and read the presented information. Hypertext readers have to create their own reading path by choosing the various hyperlinks to

follow. Reading strategies in hypertext can be considered as the decision rule that readers perform in order to choose the link to follow in a hypertext environment. These new skills emphasise readers' ability to locate information and state that locating information in a hypertext environment becomes even more important in this information technology age. Besides, Wenger and Payne (1994) claim that successful comprehension and use of complex information is highly dependent on readers ability to locate and then integrate the information from different locations within a hypertext. For that reason Guthrie's (1988) model seems appropriate to assist us towards the building of a hypertext reading model that integrates readers strategies. Besides, Guthrie's (1988) work is the only known work to discuss location of information in paper-based documents. Such work though, provides an important research base from which to analyse literacy practices in the hypertext environment of the Internet.

2.3 Reading Comprehension and Hypertext Format: A conceptual framework

The method used to experimentally validate the hypertext comprehension model is the think aloud method. The purpose of the collection and analysis of think aloud protocols is the study of cognitive processes. Descriptions of cognitive processes can take the form of models. The main forms are: dimensional models[2], categorical models[3], and procedural models[4] (van Someren et al., 1994). The present model is a procedural model because it aims at the cognitive processes during hypertext reading. A procedural model describes a sequence of steps that can be interpreted as descriptions of components of the human mind. The steps can be either described in abstract terms or elaborated in more detail. The amount of details needed depends on the need for a computational model and on the amount of detail that is relevant to the research questions (van Someren et al., 1994).

[2] A dimensional model means that a protocol is rated on one or more dimensions (van Someren, Barnard, & Sandberg, 1994).
[3] A categorical model assigns categories of cognitive processes to a protocol (van Someren et al., 1994).
[4] A procedural model describes a sequence of steps (van Someren et al., 1994).

The structure of the model is based on task analysis, the Kintsch and van Dijk's (1978; van Dijk & Kintsch, 1983) text comprehension model, and Guthrie's (1988) locating information model. The principle that underlines the analysis of the model is that the contents of the protocols can be predicted from the structure of the task, the psychological knowledge about the domain and the knowledge about the verbalisation process (van Someren et al., 1994). Task analysis in this context means constructing a first approximation of the model from information about the task, where the required and sufficient cognitive operations are described (van Someren et al., 1994). In addition, existing models for similar tasks are useful sources towards the construction of a model (van Someren et al., 1994).

2.3.1 A Cognitive model for hypertext reading comprehension

The model is intended to be an approximate representation of the human cognitive processes central to the interaction between the reader and the hypertext. It describes abstractly the main cognitive processes that take place during hypertext reading. The aim of the model is not to describe the complete reading process from letter identification, and word extraction but rather to focus on comprehension and strategies. It does not focus on representation but rather on process level. It attempts to predict the contents of the think aloud protocols. According to Dillon (1994), a good model must fulfil certain parameters. First, it must be accurate; hence what it offers must be correct in the sense that it describes real factors or aspects that influence the reading processes. Second, it must be relatively non-complex, so it can be suitable for non-specialists. Finally, it should be modifiable; therefore it should be capable of being adjusted in the light of feedback. The proposed model is ambitious to fulfil all these parameters. The next section outlines the model in detail.

2.3.2 Moving towards a hypertext reading comprehension model

The initial model contains eight components, some of them interconnected to reflect the primary cognitive process of hypertext reading. Stated briefly, the components

are: 1) *Formation of a goal or a task*, 2) *Scan and choose the appropriate categories*, 3) *Read the categories*, 4) *Follow the appropriate path*, 5) *Repeat steps 2, 3, and 4, as many times as necessary*, 6) *Recycle if you fail*, 7) *Build the macrostructure*, and 8) *Goal succeeded*. Figure 2.1 shows a schematic description of the components of the model.

The first component of the model is the definition of the reader's goal or task. Then, the model predicts that readers have to scan through the document and choose the appropriate categories of information that match their goals. Next, they proceed to the reading of the chosen categories. When the reading is finished readers will have to select a link that will lead them to another piece of information that will help them to fulfil their goals. However, in hypertexts information are presented in many nodes lying underneath hypertext links. Therefore, readers have to scan, select, and read categories of information many times before they build a complete meaning about the document's subject matter and fulfil their goals. For that reason the component *Repeat steps 2, 3 and 4 as many times as necessary* has been included in the model. Besides, if the reading process or the selection of a link is not the appropriate one, readers can recycle the information and reread or select another link. Then, the reader integrates the newly acquired information with previously existed in order to create the situation model of the presented information. The final step of the model is the completion of the given or constructed goal so the reader can proceed to another task to apply the information he/she has just read. The sequence of the processes predicted by the present model is primarily sequential as Figure 2.1 demonstrates.

However, the pilot study (Protopsaltis & Bouki, 2004a) revealed some deficiencies in the way readers approach hypertext documents compared to the proposed model. The pilot study had a dual purpose. First, to illustrate any problematic areas of the experimental design and second, to serve as task analysis by outlining the different steps of the reading process. Hence the model has been improved and its complete description is presented next.

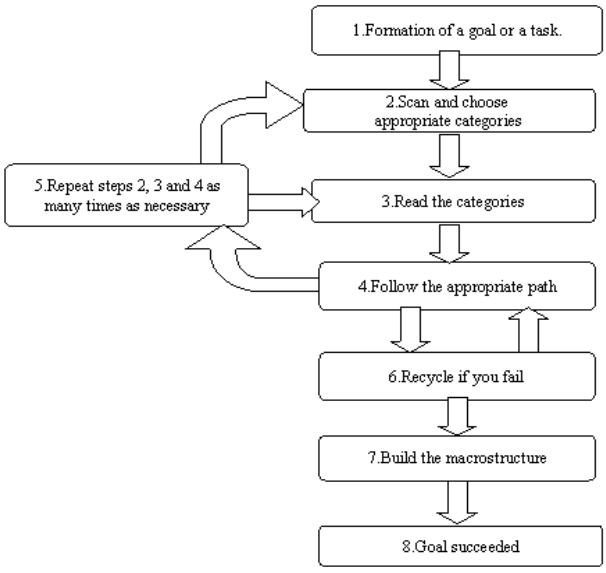


Figure 2.1: Initial model for hypertext comprehension

2.3.3 The hypertext reading comprehension model

The cognitive model to account for hypertext reading comprehension is presented and described in the following sections. The model contains twelve components (see Figure 2.2). First, all the different components will be described and then the relation between them will be explained. The components are:

Formation of a goal or task

The reading goal is a crucial factor in understanding text use (Dillon, 1996b). It is common for the goal or the task to be given, particularly in educational settings. Text comprehension is a goal-oriented process of the human cognitive system, in which individuals actively select and process information to construct mental representations that correspond to present or anticipate demands (Schnotz & Bannert,

2003). Furthermore, as Guthrie (1988) points out, locating and integrating information starts with readers forming a goal. Comprehension can be modelled only if a specific goal is given (Kintsch & van Dijk, 1978). Hence the control processes involved in comprehension must be known. The goal or task is either formed or given, depending on the aim of reading. The reader's goals in reading, control the application of the schema that determines which information are relevant and which irrelevant (Kintsch & van Dijk, 1978). If the main goal is complex, the reader could formulate sub-goals. The goal or sub-goals can be influenced by the reading process and the scanning of the categories. The accomplishment of the sub-goals will gradually lead to the accomplishment of the final goal.

Scan the categories of information

The step *scan the categories of information* offers the reader the chance to scan through the hypertext for selecting the appropriate categories of information in order to precede reading. Not all categories are relevant to the task performance, thus the reader must identify the most relevant ones. Task or goal relevant information is selected through a top-down process. Hypertext documents, with unlimited possibilities of multiple navigational pathways, present opportunities that may seduce some readers away from important content (Lawless et al., 2002). This is one of the reasons that make the scanning process a valuable tool in hypertext documents reading. Although *the scan of the categories* component belongs to the reading strategies, it requires a particular attention, because of its importance in hypertext reading. As Nielsen (1997) points out, readers on the Web usually do not read but they rather scan the presented information. Furthermore, the pilot study of the present study has shown that half of the subjects used the scanning process to locate the appropriate categories of information before they started reading the hypertext. These reasons justify its use as a separate component in the present study. Another reason is that readers have to make choices because of the short-term memory limitations and select from the presented information those items that are the most relevant for their goals (Lemercier & Tricot, 2004).

Read the categories of information

The component *read the categories of information* refers to reading the presented information by the reader. It is assumed that the text is processed sequentially from left to right. Besides, because of the working's memory limited capacity, only a few segments of the presented information may be attended at a time. Readers at this stage establish the surface structure of the presented information. That includes the specific words, sentences, and the layout of the text (Goldman, 2004).

Build the text-base

The component *build the text-base* is a subcomponent of the read component and refers to the representation of the information. The model adapts the concept of text-base and accepts propositions as the smallest units of meaning by van Dijk and Kintsch (1983). The text-base (or what was called microstructure in their previous work: Kintsch & van Dijk, 1978) contains explicit propositions in the text in a stripped-down form that captures the semantic meaning, but loses details of the surface code. Text-base is defined as the restricted meaning of the text, and is narrowed down to the level of individual sentences and paragraphs (van Dijk & Kintsch, 1983). The text-base represents what is said in the text. It captures the referential and intra-sentential and inter- sentential relations among the words in the text (Goldman, 2004). It is beyond the scope of this study to investigate in detail how readers construct meaningful text representations in hypertext. Nevertheless, it is reasonable to assume that this process is similar to the one that takes place during paper-based reading.

Build the situation model

In the next stage of the model the reader builds the *situation model* (or macrostructure) of the text, a network of main ideas (see: Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). The situation model is formed during reading. This is why the three processes (read the categories, build the text-base and build the

situation model) overlap in the schematic representation of the model. All three processes are very closely related, as shown in Figure 2.2, and the one interacts and influences the other. The situation model refers to reader's understanding of the situation and ideas described in the text. However, this understanding does not contain references to the surface code of the text (Kintsch, 1994; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983), and that is why the situation model component is represented with dotted lines. It is the referential mental world of what the text is about. The reader is integrating the newly extracted information with previously extracted information, background information and information about the world. This integration leads to a comprehensive understanding of the presented information, the situation model or macrostructure. The knowledge representation takes the form of networks of propositions. As Kintsch (1998, p. 37) specifies, "for the purpose of text representation, a proposition is simply a predicate-argument schema". "The macrostructure is a hierarchically ordered set of propositions representing the global structure of the text that is derived from the microstructure" (Kintsch, 1998, p. 50). The situation model is retained in memory much longer than the text-base and the surface code, assuming that the reader has adequate world knowledge to build a situation model.

A condition for successful comprehension and thus complete situation model is the coherence among the information. A complete situation model is also a coherent one. Furthermore, coherence is achieved both within and between the levels of representation when comprehension is successful. This should be the case if there is no serious coherence gap within a particular level and if there is harmony between the levels of representation. However, according to Perfetti et al. (1999) some knowledge can be represented in the long term memory (LTM) in a non-coherent way or, alternatively, some knowledge establishes relations between contents which are not coherent with one another.

Use appropriate strategy

The component called *use appropriate strategy* refers to the use of strategies during reading. When people read, they make many choices. They choose what to read,

what to skip or what to skim; they choose when to read some information and when to ignore them. They might choose to read in a very detailed or in very fast way. This kind of reading implies the use of reading strategies. As it is indicated in Figure 2.2, strategies influence the complete reading process and the selection of the links. Reading strategies were always part of the reading comprehension. However, they are more important in hypertext environment than in traditional documents, because hypertext documents, with unlimited freedoms of multiple navigational pathways, present opportunities that may seduce some readers away from important content (Lawless et al., 2002). Therefore, hypertext readers need to use even more sophisticated strategies because the challenge ahead is even greater. Different strategies influence the way readers process the text and hence their comprehension. Reading strategies can affect both, the amount of information obtained and the reading order. Salmerón et al. (2005) argue that the amount of information read by a hypertext reader affects the text-base, while the reading sequence influences the situation model. The reading strategies are not described here because they are not known. They will be revealed by the readers themselves through their think aloud protocols and they will be presented in the next chapter.

Monitoring

The model also contains a step called *monitoring*. Monitoring is the ability of a reader to be aware, while reading, whether a text is making sense or not (Wilhelm, 2001). Researchers have always emphasised its importance in reading. Readers' ability to monitor their comprehension is a significant skill that distinguishes skilful readers from unskilful ones. In the hypertext environment monitoring involves the assessment of subjects understanding the information they have just read and/or the assessment about the selection of a hypertext link. There is an interaction between the monitoring component and all the other components of the model throughout the reading process. However, monitoring might not always be present or might not always play a role during reading comprehension. That is the reason of having the monitoring component represented in dotted lines in the graphical representation in Figure 2.2.

Follow the appropriate path

The component *follow the appropriate path* expresses the reader's capacity to choose a hypertext link in order to continue with the rest of the information. Information in hypertext environments are presented under hypertext links. Readers have to make correct inferences about information that will be found at any hyperlink. This is where the strategies are coming in to play. As has been previously said, readers who will follow very different informational paths, read very different sets of information, and attend to very different informational elements; they will construct different meaning about the presented information even if their goals are identical (Coiro, 2003). The chosen path will most likely match the readers' goal or sub-goals, and coheres with the previously read information. Coherence has been proven to play an essential role in the way readers proceed through information (Foltz, 1996; Seufert & Brünken, 2004).

Repeat as many times as necessary

Another element of the model is called *repeat as many times as necessary*. However, this does not refer to a distinct cognitive process but rather explains that all the processes mentioned so far might take place more than once, depending on the length of the hypertext. That suggests that readers can repeat the necessary steps as many times as necessary until they reach their goal or fulfil their task. These steps are: *scan the categories*, *follow the appropriate link*, *read the categories*, and *use the relevant strategies*. As information in hypertext environments are presented in multiple segments, connected via hypertext links, readers have to follow these same processes many times until they successfully build the situation model of the subject matter.

Goal accomplished

The model also contains the *accomplishment of readers' goal* element. After reading all the required information the readers have to check if they have fulfilled their goal or sub goals. The step refers to both, comprehension of the information and to the action of reading alone, without much comprehension. Thus, the readers who achieved comprehension might have built either a comprehensive text-base of the presented information or a situation model to fulfil their goal. Other readers though might decided to stop reading thinking that they have done enough to fulfil their goals or the task's demands, without really comprehending the information. In both cases, they are ready to proceed to any additional tasks that may be required, such as answering questions or writing an essay or even applying their knowledge on a practical task. However, if the comprehension of the presented information has not

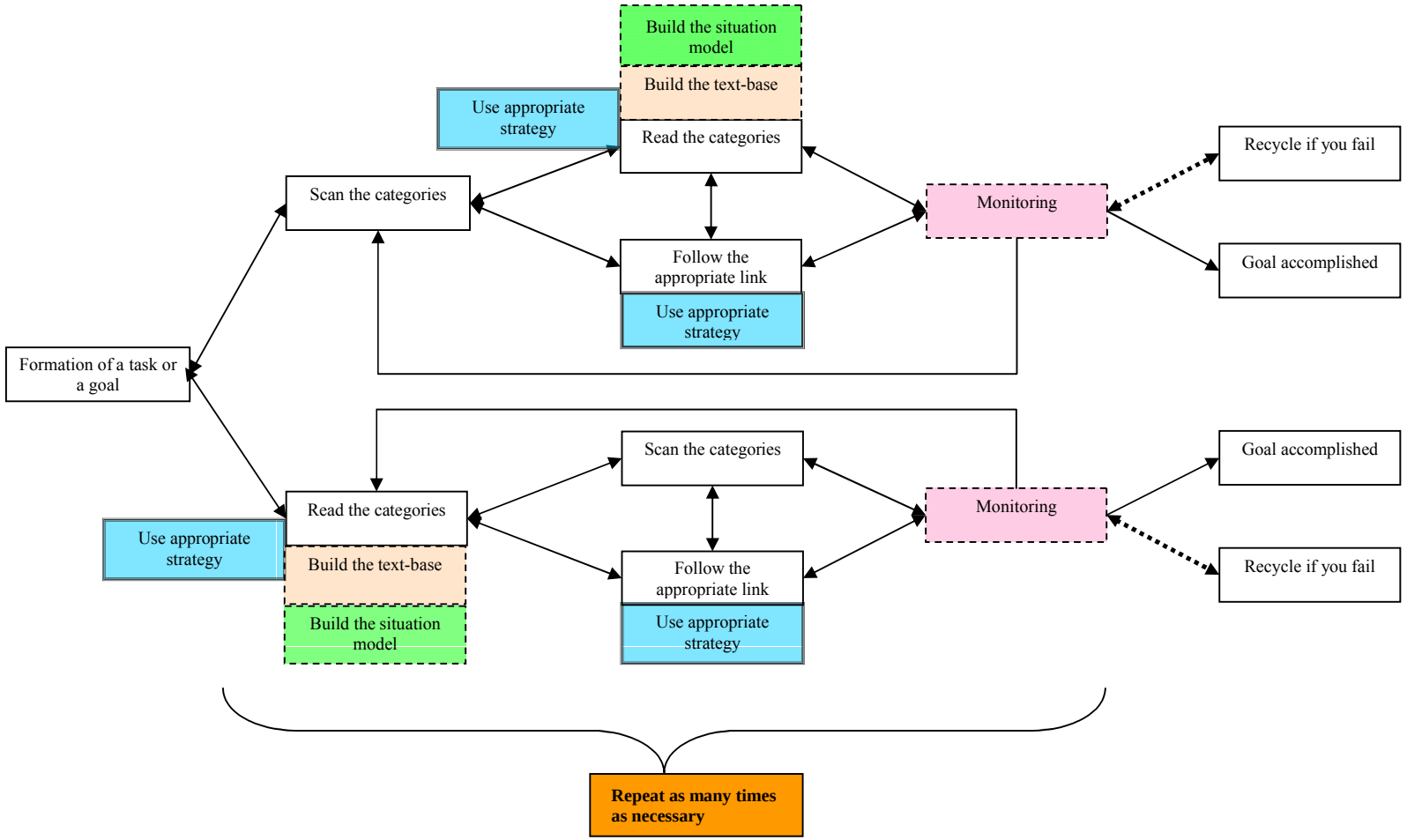


Figure 2.2: Hypertext reading comprehension model

been accomplished and the readers are willing to pursuit that goal, they have to move on to the next step, which is the *recycle if you fail*.

Recycle if you fail

The *recycle* element of the model suggests that readers can start again the reading process by either altering their initial goal and proceed with any of the necessary steps in order to successfully comprehend the hypertext, or through other paths or segments of the text, if the followed ones are not the right ones to accomplish their goal. If they have failed to capture the meaning of certain fragments of information or if their understanding is not complete, they can go back and revisit/reread them.

Sequence of events among the components

For the purpose of describing the sequence of events among the components, the model can be divided into two levels, the top and bottom level, depending on what the readers' second step will be. The reader after the *formation of the goal* can choose between *scan the categories* or *read the categories.* Both levels contain the same steps but their sequence is different. First, the sequence of events at the top level will be described.

The starting point is the *formation of the goal*. Then, the user *scans the categories* and after that he/she will precede either into *read the categories* or *follow the appropriate link* component. The *use appropriate strategy* component is attached to both steps implying that it influences both processes. Looking first at the *read the categories* step the reader has a number of alternatives, which are: to move back to the *scan the categories* component, or to *follow the appropriate link*, or to *monitoring*. There is a two way communication between the components, thus at any time the user can move back to the step he/she came from. Describing now the *follow the appropriate link*, the user/reader has again a number of alternatives. He/she can move back to the *scan the categories* component, or to *read the categories*, or to *monitoring*. From the *monitoring* component the user can move to either *read the*

categories, or *follow the appropriate link*, or to *recycle if you fail* or *goal accomplished* or to *scan the categories*. If the *monitoring* step does not influence the *read the categories* or the *scans the categories* steps, users might move on to *recycle if you fail* or *goal accomplished* without using the intermediate step.

Moving on to the bottom level the starting point is again the *formation of the goal*. Then, the user *reads the categories* and after that he/she will precede either into *scan the categories* or *follow the appropriate link* component. Yet again, the *use appropriate strategy* component is influencing both processes (*reads the categories* and *scan the categories*). Looking first at the *scan the categories* step the reader has a number of alternatives, which are: to move back to the *read the categories* component, or to *follow the appropriate link*, or to *monitoring*. There is a two way communication between the components, thus at any time the user can move back to the step he/she came from. Describing now the events from the *follow the appropriate link* component, the user/reader has again a number of alternatives. He/she can move back to the *scan the categories* component, or to *read the categories*, or to *monitoring*. From the *monitoring* component the user can move to either *scan the categories*, or *follow the appropriate link*, or to *recycle if you fail* or *goal accomplished*. Similar to the top level, if the *monitoring* step does not influence the *read the categories* or the *scans the categories* steps, users might move on to *recycle if you fail* or *goal accomplished* without using the intermediate step.

In concluding, the model proposes that the communication of the components can either be sequential or circular. As it is evident from the schematic representation of the model in Figure 2.2, subjects can apply their process in a serial manner with back and forth communication between the components. Additionally, subjects can follow the proposed components in a circular manner, since they are not restricted in to one to one communication between the components, but they can move from *Read the categories* or *Scan the categories* to the rest of the components in a clockwise or anticlockwise direction. The circular manner of communication largely agrees with van Dijk's and Kintsch's (1983) suggestion that cognitive processes during reading take place in cycles.

2.4 Conclusion

A procedural cognitive model to account for hypertext reading comprehension has been presented and the sequence of steps have been described and explained. In addition to that the initial effort towards the development of the model was stated and all the changes were justified. In order to validate the elements making up the hypertext comprehension model, a series of think aloud protocols have been performed. The readers' protocols will be tested against the model to see if the elements of the model did emerge in their protocols. The experimental evaluation of the model will be presented after the next chapter, which describes the method.

Chapter 3

Method

This chapter debates the qualitative think aloud method. It outlines the advantages and disadvantages of this method and the conditions under which it can be effectively used. A think aloud protocol is produced when a reader verbalises his or her thoughts while completing a given task.

3.1 Qualitative Research

A starting point in trying to understand the collection of information for research purposes is that there are broadly two approaches: quantitative research and qualitative research. Quantitative research refers to observations and measurements that can be made objectively and repeated by other researchers. These kinds of measurements mainly refer to natural sciences and refer to well establish statistical methods and procedures. However, researchers are interested in studying human

behaviour and the social world inhabited by human beings. It is very difficult to explain human behaviour in simply measuring terms. Therefore, qualitative methods were developed. Qualitative research is not concerned with findings arrived at by statistical procedures or other means of quantification. It is concerned with findings of direct encounters with individuals, for example through one to one interviews, or group interviews, or observations. It focuses on the answers to questions which begin with: Why? How? In what way? However, some of the data maybe quantified but the mass of the analysis is interpretative (Strauss & Corbin, 1998).

Both methodologies have strengths and weaknesses. One common criticism aimed at qualitative research is that the results of a study may not be generalised to a larger population due to the fact of a small sample and of subjects frequently not randomly chosen. Nevertheless, the answer to this criticism may come from the aim of the study itself. For instance, maybe the research question is looking at a specific subgroup of a population and not at the general population. Also, the small sample perhaps is necessary because very few subjects have the condition the research focuses on.

Some of the major types of qualitative research are phenomenology, ethnology, case study, and grounded theory. Phenomenology means the study of phenomena. Phenomena can be events, situations, experiences or concepts. Ethnography is the study of cultures and people that have some attributes in common. Case study in qualitative research is concerned with the in-depth analysis of a single or small number of units in contrast to large samples that quantitative methods use. Grounded theory is concerned with the development of new theories through the collection and analysis of data about a phenomenon or actions. The theory derives from data, systematically gathered and analysed through the research process. It is beyond the scope of this study to go into any further detail of any of these types. Instead the remainder of this chapter will focus on the qualitative method of think aloud protocols, which is closer related to ground theory. However, the think aloud method is a different method compared to ground theory, and has its roots in introspection.

There are many reasons for qualitative research. The main one is the nature of the research problem. Qualitative methods can be used to explore phenomena such as feelings, emotions, and cognitive processes that are difficult to explore through other

research methods (Strauss & Corbin, 1998). The main method that will be used in this thesis is qualitative, and more precise, the think aloud method. Some of the data will also be quantified. Furthermore, in order to verify even further the proposed theory a quantitative method (experimentation) will be used in the second experimental study. However, this method will be described in chapter seven together with the results of the second experiment.

3.2 History of the Think Aloud Method

The think aloud method has its roots in psychological research and more precise in introspection. At the beginning of the 19th century introspection was based on the idea that one can observe events that take place in consciousness and verbalise them. Introspection had led to some successful research but there were also some fundamental problems attached to it. These problems had mainly to do with the claim that introspection could access the contents of consciousness and was asking subjects to interpret their actions. In addition, the produced data was accessible only to a single observer. This made it almost impossible to replicate empirical studies and thereby to settle scientific discussions about cognitive processes. The think aloud method overcomes these limitations by only assuming a very simple verbalisation without any interpretation. It is the work of the specialist to interpret the results and not the subjects. Also, the think aloud method treats the protocols as hard data, accessible to anyone. Finally, think aloud protocols are given on-line (concurrent verbal reports) while retrospective reports are not. In the remainder of this work when referring to think aloud protocols we refer to concurrent verbal protocols.

With the dominance of behaviourism until the late 60's and its focus on observable responses to stimuli, the use of verbal reports as data declined. By the end of the 60's the interest in cognitive processes increased dramatically as the field of cognitive psychology expanded, and so the interest about the methods that can provide data for these processes. A major boost towards this direction was the seminal work of Newell and Simon (1972) who used think aloud protocols to investigate the cognitive processes while solving problems based on the information processing theory. This work had a major influence, because it showed that very

detailed verbal data can be obtained (van Someren et al., 1994). Although many scientists were sceptical, the method gained increasingly wide acceptance over the last decades as researchers (Afflerbach, 2000; Afflerbach & Johnston, 1984; Ericsson, 1988; Ericsson & Simon, 1993; Pressley & Afflerbach, 1995) argued convincingly about the validity of the method by extensively reviewing the think aloud literature. Kucan and Beck (1997) for instance, argue, that the think aloud method is one of the tools that allowed psychologists to explore previously inaccessible domains of cognitive processing. Another factor that supported the widespread of the think aloud method is computer simulations of cognitive processes. It is the most widely used method today in usability testing in a degree that Nielsen (1993, p. 195) argues that "thinking aloud may be the single most valuable usability engineering method" even though its application does not always follow closely the Ericsson and Simon's guidelines, and usability researchers often apply theoretically inconsistent procedures according to Boren and Ramey (2000). Researchers (Afflerbach, 2000; Pressley & Afflerbach, 1995) though emphasise their confidence in the method and the results produced by it when used to measure comprehension processes.

3.3 The Think Aloud Method

The method used in the present study to evaluate the hypertext comprehension model is the think aloud method. Ericsson and Simon (1993) perceive thinking as a temporal sequence of events or states. Based on that assumption, they argue that with the think aloud method it is possible for subjects to verbalise their thoughts during a task in a manner that does not alter the sequence of their thinking. In fact, all major theoretical frameworks concerned with thinking have advocated the use of verbally reported sequence of thoughts (Ericsson, 2002). As Ericsson and Simon (1980, p. 220) point out "a direct trace is obtained of the heeded information, and hence, an indirect one of the internal stages of the cognitive process". Subjects are instructed to verbalise their thoughts while performing the given task without explaining what they are doing. If subjects were asked to explain or describe what they are doing, additional information and processes have to be accessed to produce these

explanations or descriptions. As a result, the sequence of thoughts is changed, because the subjects must attend to information not normally needed to perform the task (Ericsson & Simon, 1993). Subjects do not need a lot of practice before being able to produce think aloud reports. In the light of this fact one can infer that these protocols are consistent with the structure of their normal cognitive processes and their skills for verbalising information. Although, "spontaneous thinking aloud is rare in every day life of normal adults, adults normally engaged in many other forms of verbalization relevant to thinking" (Ericsson & Simon, 1993, p. xiv).

3.3.1 Levels of verbalisation

Ericsson and Simon (1993) distinguish among three types of verbalisations, Level 1, Level 2, and Level 3 verbalisation. A Level 1 verbalisation is simply the vocalisation of heeded articulatory or oral encoding, as required by the given task. At this level there are no intermediate processes, and subjects need no special effort to communicate their thoughts. This is the most reliable sort of verbalisation. Level 2 verbalisation involves description, or rather explication of the thought contents. Ericsson and Simon (1993) suggest that this kind of verbalisation does not affect the occurrence of the thinking process, rather explicate or label the heeded information. This is also considered as reliable data. Level 3 verbalisation is the verbalisation that requires from subjects to explain their thought processes or thoughts. This type of verbalisation is not a recording of the information already present in STM (Short Term Memory), but requires linking this information to earlier thoughts and previously attended information. This additional process changes the original sequences, the cognitive process and thus does not correspond to accurate representation of the heeded information (Ericsson & Simon, 1993). This is not considered as reliable data and it should not be used by researchers.

In sum, with the verbalisations of Level 1 and Level 2 the sequence of information keeps its original structure and no other information is heeded. Level 1 and Level 2 verbalisations are considered as valid data. While, with Level 3 verbalisation subjects are required to pay attention to additional information and

hence change the sequence of the heeded information. Level 3 verbalisations are not considered as valid data.

3.3.2 Think aloud procedure

3.3.2i Settings

The think aloud method usually requires subjects to be tested individually. It is important for participants to feel at ease. Even though, this is important for all kinds of research, it is particularly important for the think aloud method because the experimental session is going to take some time. It is equally important to provide subjects with some water because the process is tiring for the voice and the throat of the subjects.

3.3.2ii Instructions

The instructions about the task ahead are simple and are kept to the minimum. Their essence is to make subjects to perform the task and say out loud everything that comes through their mind. An example of an instruction can be: "Please solve the following problems and while you doing so, try to say everything that goes through your mind" (van Someren et al., 1994, p. 43). It is better to avoid phrases that may cause people to express personal opinions, as that may lead to Level 3 verbalisation, which is not valid data.

3.3.2iii Warming up

There is a short warm up time period, usually a few minutes to a quarter of an hour. A common practice exercise is mental calculations. Most subjects will talk quite automatically after that time (van Someren et al., 1994). When after a quarter of an hour a subject still finds it hard to verbalise his/her thoughts, it is better to stop

because it is unlikely that this subject will produce valuable protocols (van Someren et al., 1994).

3.3.2iv Experimenter's behaviour

When the practice period is concluded then the experimental session can begin. Ideally, during the session the task flow should not be interrupted. When the subject is working on the task, the role of the experimenter is a restrained one. The only interference should occur when the subject stops talking. The recommended prompt to the subjects is "keep talking" (Ericsson & Simon, 1993). However, if a need for some short of communication between the experimenter and the subject occurs, that communication should be kept to the minimum, so the task flow is not interrupted and the subject does not feel frustrated.

3.3.2v Transcription of the protocols

The session is usually recorded on audio or video-tape. After the session has been recorded, it has to be transcribed. Transcribing a protocol usually means typing it out as verbatim as possible. There are some practical guidelines that have been developed to assist the transcription of verbatim protocols. In general, anything that has been recorded including any utterances, any mumblings, any long pauses, and any interruptions that may have taken place during the session has to appear in the transcribed protocol. Recognisable pauses for example, and unusual silence between words are noted down by special marks, typically by dots (…) (van Someren et al., 1994). In instances when the person who transcribes the protocols can not understand something it is recommended to mark it down in the typed protocol, and not to try to infer what the subject might meant (van Someren et al., 1994). Another point to consider during transcription is punctuation. Because most sentences in the think aloud protocols are not well formed, it is wise not to use punctuation at all. Instead it is recommended to start a new line for each new sentence, or when one thinks that a new sentence starts (van Someren et al., 1994). The aim is to produce a transcribed protocol either identical or as close as possible to the recorded one.

3.3.2vi Segmentation of the protocols

After the transcription the segmentation of the protocols takes place. In the segmentation process, it is usual to break the data up (or segment them) into a series of single ideas or statements, perhaps clauses, phrases or sentences, which will later be coded (Gilhooly & Green, 1996). Research shows that in speech the boundaries of a phrase is usually marked by a pause (Ericsson & Simon, 1993). The combination of the pauses and the linguistic structure provides a natural and reliable method to segment the think aloud protocols (van Someren et al., 1994). Segments can be combined into episodes. An episode is a sequence of segments that correspond to a single element in the model.

3.3.2vii Coding of the protocols

The purpose of the collection and the analysis of think aloud protocols is the study of cognitive processes. This means that one want to construct or test a process model. "A procedural psychological model describes which cognitive processes will occur and also in which order they will occur" (van Someren et al., 1994, p. 118). The last step of the think aloud protocols analysis consists of the coding of the segmented protocols. The coding process entails the identification of a set of coding categories. The categories represent the kinds of concepts and operations that are likely to be useful in the task area (Gilhooly & Green, 1996). These coding categories form the coding scheme. The coding scheme specifies how the elements of the model can be identified in the obtained data (van Someren et al., 1994). A coding scheme is based on the proposed psychological model and on the verbalisation theory. The process usually is quite straight forward. One has to take every process or sub process stated in the model and outline how this process is expected to emerge in the protocols. For every process the experimenter defines the type of statements referring to that process (van Someren et al., 1994). These statements can be either general or specific.

In the think aloud protocols it is possible to come across verbalisations that do not derive from the model, so they have not been included into the coding scheme developed from it. To overcome this problem the experimenter can either ignore these cases as irrelevant, because they do not bear upon performance or create special coding categories in order to assess any influence upon the task or the cognitive load of the subjects (van Someren et al., 1994). Examples of these verbalisations and possible coding categories are given below:

(a) Talking about not related issues ("Oh, I must not forget to call my friend")

(b) Evaluation of the task or task related issues at a meta-level ("It is tiring to talk so much", "I hate these kinds of problems")

(c) Comments on oneself ("I am thirsty", "I am not comfortable")

(d) Silent periods. At times people will briefly stop verbalising. After some time they may continue or they may prompted to continue. It may be relevant to assign a code to relatively long pauses (van Someren et al., 1994, p. 120).

The main requirement of a coding scheme is that it allows objective coding of the obtained protocols. To achieve that a coding scheme must be complete, justified by the model, unambiguous and context independent (van Someren et al., 1994). It is usual for the initial sample protocols to be segmented and encoded by at least two coders and the intercoder reliability computed, so as to determine the validity of the segmentation and coding schemes. The coding reliability is achieved by an independent coder. The intercoder reliability should be at least 85% for the scheme to be considered reliable (Gilhooly & Green, 1996). There are various items of software now available for the computer-assisted analysis of the text that allow both the segmentation and the coding of text on-line, including Ethnograph, Atlas.ti, Qualpro, Textbase Alpha, and Hyperqual. Such systems can decrease bias and increase reliability.

3.4 Why Think Aloud Protocols?

For studies focus in getting a rich source of data, the think aloud method is an excellent choice (Branch, 2000). It has been argued that there is a need for a variety of methods to understand how comprehension is accomplished (Whitney & Budd, 1996), either in traditional printed media or in new hyperdocuments. Think aloud protocols have been used to investigate the reading processes and meaning construction in traditional printed media (see for review: Afflerbach, 2000; Pressley & Afflerbach, 1995). Similarly, verbal protocols have been effectively used by researchers to gain information on reading strategies (Levine & Reves, 1998; Olshavsky, 1976). The suitability of the method to different areas of inquiry within the discipline of reading has provided rich accounts of reading (Afflerbach, 2000; Pressley & Afflerbach, 1995). However, their use in hypertext is not widespread (Gray, 1990; Macedo-Rouet et al., 2002). This is where the think aloud method is emerging as a very useful tool. The success of hypertext as a medium for presenting information depends on the online reading and exploration of the presented information. That in turn requires knowledge about users/readers, online behaviours, cognitive processes and strategic processing. The think aloud method is an excellent tool to extract such information because, it exposes conscious, strategic processing (Trabasso & Magliano, 1996). Additionally, Spires and Estes (2002) are arguing for the need to investigate comprehension processes on the WWW, indicating the think aloud method as a potential avenue for exploring these issues.

Although the think aloud method has been increasingly used in the study of text comprehension, some researchers remain sceptical about its value. For instance, Wilson (1994) questions the importance of non conscious thoughts or those that are difficult to verbalise, in learning. These are processes that think aloud protocols can not tap. In contrast though, think aloud methods have been successfully used to reveal inferences and mental operations during comprehension (Trabasso & Magliano, 1996; Trabasso & Suh, 1993; Trabasso, Suh, Payton, & Jain, 1995; Zwaan & Brown, 1996). In addition, the method has been also successfully used in the study of hypertext comprehension and the use of navigation strategies (Gray, 1990; Tremayne & Dunwoody, 2001).

Ericsson and Simon (1993) argued convincingly that some research questions do not stimulate accurate verbal reports. In particular people are not really able to answer "why" they act or behave in a certain way. It is more likely that subjects will generate an answer in response to that question rather than report their actual thoughts at the time of their actions. The experimenter should be very vigilant not to request such responses from the subjects, since they are not regarded as reliable data.

To conclude, the think aloud method is a potential avenue for answering research questions about reading activities and processes in electronic environments (Spires & Estes, 2002). The method is one of the tools that allowed psychologists to explore previously inaccessible domains of cognitive processing, such as inferences and mental operations during comprehension among others. Questions about the validity of the method have been convincingly answered by extensive reviews of literature. Therefore, the think aloud method appears as the best method to study the cognitive process during hypertext comprehension.

3.5 Think Aloud Protocols in Text Comprehension

Think aloud protocols have been used in many research studies as a method of understanding the cognitive processes that language users use (Afflerbach, 2000; Afflerbach & Johnston, 1984; Anderson, Bachman, Perkins, & Cohen, 1991; Cohen, 1987; Ericsson & Simon, 1993). Direct access to the cognitive processes is impossible since it is a mental operation which is unobservable (Gordon, 1987 cited in Anderson et al., 1991). Using think aloud protocols is a way of getting access to the unobservable behaviour of reading comprehension and of previously inaccessible domains of cognitive processing (Anderson et al., 1991; Kucan & Beck, 1997). Not all subjects are able to produce verbal reports. In a review, Ericsson (1988) found that subjects that were asked to think aloud during reading easy, or well-written texts, produce essentially no additional verbalisations. With easy texts the reading process is fully automated and thus not available for verbalisation. Kintsch (1998) and Ericsson and Simon (1993) argue that conscious processing is not necessary during the understanding of easy texts. Other studies of well formed texts showed that

reading proceeds rapidly and smoothly, with few pauses and re-readings (Just & Carpenter, 1980).

In contrast, difficult texts caused slow reading and substantial verbalisation of information not present in the original text. Active and strategic efforts at meaning construction only occur with challenging texts (Pressley & Afflerbach, 1995). Similarly, Kintsch (1988) argued that with ill-formed or difficult texts, active efforts to derive meaning based on problem solving processes are expected. The meaning of those texts would go through intermediate reportable states, and so these states are expected to be present in subjects' verbalisation. Easy and well written texts are difficult to paraphrase rapidly, so when subjects verbally report the meaning of a phrase or a sentence during think aloud, they are more likely to reproduce the text itself than their own perception of the text. On the other hand, texts which are difficult for subjects require considerable cognitive processing and associated verbalisation prior to attaining an integrated representation (Ericsson & Simon, 1993). Verbal reports on text comprehension are likely to be more informative when reading involves texts that are ill organised or subjects lack background knowledge (Ericsson, 1988).

Research has shown that the utility of the method comes from its ability to reveal the contents of working memory (Trabasso & Magliano, 1996; Trabasso & Suh, 1993). This, according to Whitney and Budd (1996), makes the think aloud method especially valuable because the most adequate models of comprehension propose that working memory plays a central role in reading comprehension (e.g. Just & Carpenter, 1992; Kintsch, 1994). However, the strength of the method is that it is the closest possible way to get to the cognitive processes of readers.

Although it has been proposed that there is much to learn about the relation between think aloud data and memory operations, it does seem clear that think aloud protocols allow to evaluate readers' processing strategies in various reading situations (Whitney & Budd, 1996). That assumption makes think aloud protocols very appropriate for the investigation of the comprehension processes and the browsing strategies during reading in hypertext. Even critics of the method, such as Wilson (1994), accept its capability to tap the contents of consciousness.

3.6 Hypertext Comprehension and Think Aloud

Researchers interested in information-seeking behaviour have used think aloud protocols. Yang (1997) used think aloud protocols to study the behaviour of university students while accessing information in the "Perseus" hypertext system. Hughes et al. (1998) also used think aloud protocols to examine the reading in a hypertext environment. Xie and Cool (1998) used this technique to study end-user online searching. They found, through the use of this method that, "much insight is gained into the problems encountered by searchers and the adaptive strategies they employ in such situations" (Xie & Cool, 1998, p. 329). Dunwoody (2001) used the think aloud method to investigate how people react to the information they see in the "Why Files", which is a science Web site. Tremayne and Dunwoody (2001) used the method to investigate the relationship between interactivity, cognitive elaboration, and learning. The think aloud method makes it possible to study processes and phenomena of hypertext comprehension, which have been difficult, if not impossible, to investigate by traditional research methods.

Hypertext systems allow users to navigate between the nodes, which connect multiple units of information. However, this freedom of choice is not always a result to an effortless navigation and information extraction. Research suggests that hypertext users, especially the novice ones, may experience disorientation and navigation problems while reading in hypertext (Macedo-Rouet, Rouet, Espein, & Fayard, 2003; Rouet & Levonen, 1996). Users may have difficulties following the overall structure of information in a hypertext and relating it to their prior knowledge or schemata (Altun, 2000). Cho (1995) reported that lack of experience in hypertext may have confused and disoriented users in his study during reading. A large volume of current research (Chen et al., 2004; Cho, 1995; Folzt, 1996; Gray, 1990; Lazonder et al., 2000) has focused on navigation patterns between novice and expert hypertext users. In addition, prior experience in hypertexts is considered as a major factor on navigation (Last et al., 2001; Lazonder et al., 2000; Wenz, 2000).

3.7 Experimentation

The think aloud method is the main method used in this study. However, for validation purposes another experiment will be conducted with a quantitative method. Quantitative research differs from qualitative research in the following ways: first, the data is usually gathered using more structured research instruments, second, the results provide less detain on behaviour, attitudes, and motivation, third, the results are based on larger sample sizes that are representative of the population, fourth, the research can usually replicated, and finally, the analysis of the results is more objective. The most common quantitative research techniques include: observation, experimentation, and survey technique. The technique followed in the second experiment is experimentation. Experimental methods let scientists identify the cause or reason for behaviour by providing solid scientific data. An experiment is usually carried out in a laboratory where highly accurate recording of human cognitive functions are best achieved. Participants are allocated in the different conditions randomly, while all variables are controlled by the experimenter apart from the independent variable. The independent variable then can only be responsible for changes in the dependent variables. However, this method will be described in more detail in chapter five where the second experiment will be presented.

3.8 Conclusion

This chapter has highlighted the method used for the experimental evaluation of the proposed theory. The method is called think aloud protocols. Verbal reports and protocol analysis enrich our understanding of reading. Its history was presented along with its complete procedure. Using think aloud protocols is a way of getting access to the unobservable behaviour of reading comprehension and of previously inaccessible domains of cognitive processing. That makes the think aloud method the most appropriate method for the recent study. The following chapters portray the experimental evaluation of the proposed model with the use of think aloud protocols. First, the pilot study is presented followed by the main (first) experiment.

Chapter 4

Experimental Evaluation: Pilot Study

To validate the elements that the hypertext comprehension model consists of, a pilot study with the use of think aloud protocols has been performed. The pilot study serves as a task analysis and validates the experimental design. The readers' protocols have been tested against the initial model to see if the elements of the model did emerge in their protocols. In addition, the protocols assisted towards the refinement of the proposed model. The pilot study will be described next and the results will be presented and discussed.

4.1 Method

This experimental study was undertaken using the think-aloud method. The method offers the opportunity to gather detailed understandings of reading and reading-

related phenomena (Afflerbach, 2000). Protocol analysis may contribute to the initial building of theories that represent progress in the understanding of reading (Afflerbach, 2000; Ericsson & Simon, 1980). Also, it has been proven not to influence the reading process and to provide data that is difficult to obtain with any other method (Ericsson & Simon, 1993; van Someren et al., 1994). In addition, the think aloud method has proven to reveal the contents of working memory during reading, which is a very rich source of data (Whitney & Budd, 1996).

4.1.1 Subjects

Eight students participated. All subjects were volunteers. Subjects were screened to ensure that they had not taken any courses in economics, and had no reading disabilities (see appendix I). All subjects were native English speakers. All subjects were familiar with online (www) documents since they were using the Web as a source of information for their course works and the majority of them were computer science students as well. None of the subjects had participated in a think aloud study before.

4.1.2 Material: Practice material

Three mental calculation exercises for warming up were used (see appendix II). The calculations included the multiplying of two, two digit numbers (22 times 36), the multiplying of two, one two digit and one tree digit numbers (17 times 342), and the following mathematical problem:

A bottle of white wine costs £5.50 and a bottle of red wine costs £5.20. The bottle of white wine costs £4.50 less than the wine and the bottle of red wine costs £4.40 less than the wine. How much does each bottle cost, and how much one has to pay for both bottles of wine?

The subjects had to complete first the two, two digit number calculation and the mathematical problem, and then if they needed more practice they were given the

second multiplying problem (17 times 342). Most of the subjects did not need to perform the third warm up exercise.

4.1.3 Material: Hypertext

The experimental text converted to hypertext had to fulfil some parameters in order to produce rich think aloud protocols. The chosen text had to be not easily understood because that makes comprehension process fully automated and provides minimum verbalisation. Well written texts are difficult to paraphrase rapidly. This suggests that in orally reporting the heeded meaning of a phrase or sentence, people would be more likely to report that phrase or sentence (Ericsson, 1988). Verbal reports on text comprehension are likely to be much more informative when reading involves difficult texts or texts that are not well organised or poorly matched with readers' background knowledge (Ericsson, 1988). To comprehend difficult texts subjects need to actively retrieve and integrate their own knowledge of the world and the presented information. Ericsson (1988) found that subjects that were asked to think aloud during reading easy, or well-written texts, produce essentially no additional verbalisations. With easy texts the reading process is fully automated and thus not available for verbalisation. Kintsch (1998) and Ericsson and Simon (1993) view is that conscious processing is not necessary during the understanding of easy texts. However, difficult texts that require many operations will result in uncompleted meaning representation. High demands on resources should yield either high reading times or low scores on comprehension tests (Kintsch & van Dijk, 1978).

A 5,075-word economic paper by (Howitt, 1999) appeared to fill these requirements because subjects had no background knowledge in economics, the paper had difficult vocabulary, and it was relatively above their level as it was written for an academic conference and not for 1st and 2nd year students. The paper was converted to a hypertext format. The conversion of the paper into hypertext format was done manually at the early stage and then with macromedia dreamweaver 4. First, the topics and sub-topics of the nodes' text were identified, for example one of the topics was under the heading "Management". The text was then decomposed to chunks and the original headers were used as hypertext links. Any text references

or notes were converted to hypertext links. Research findings on usable electronic texts and educational hypertexts were taken into consideration for its development (Dillon, 1994; Martin, 1990). The aim was to maintain the document format that is widely used in the WWW.

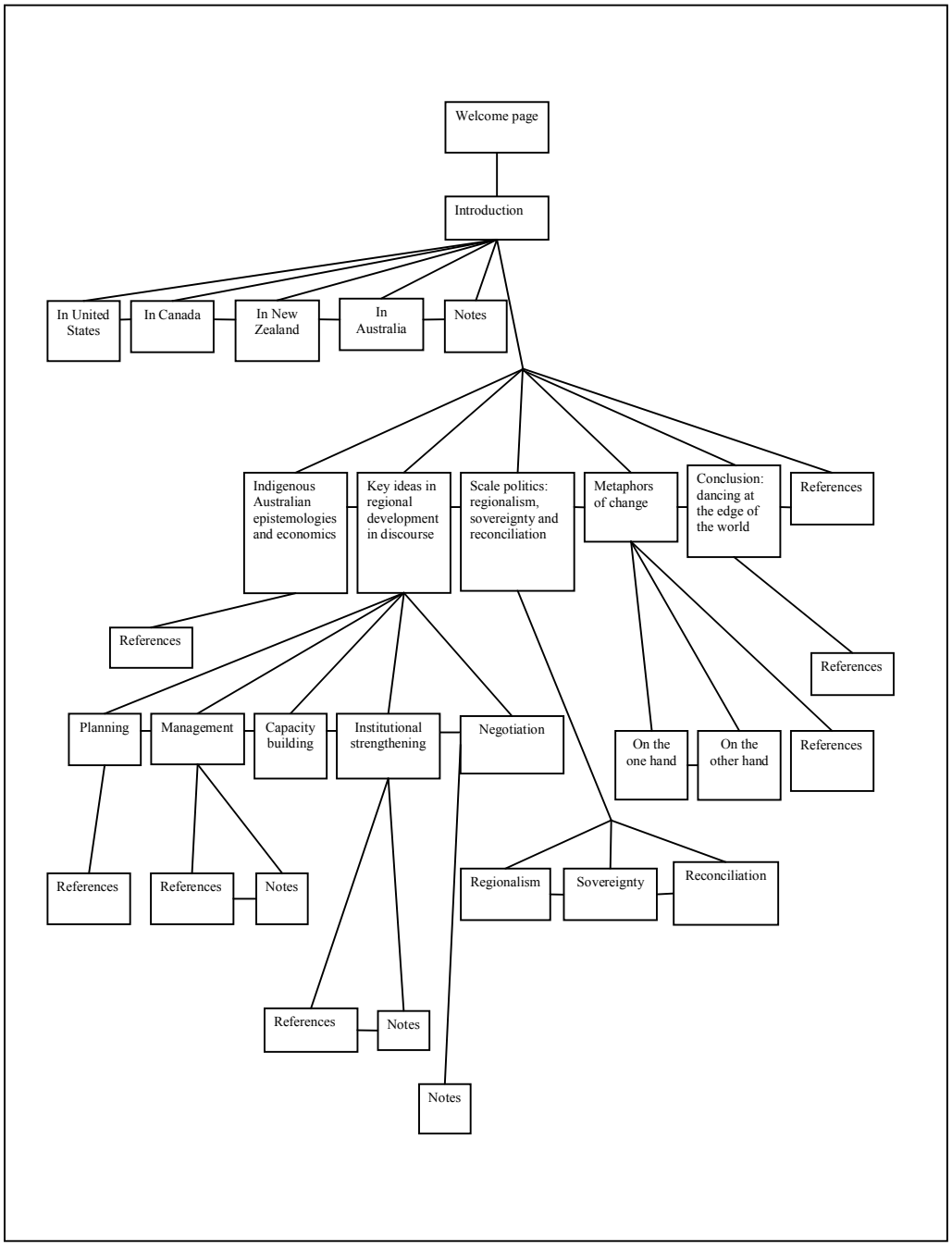
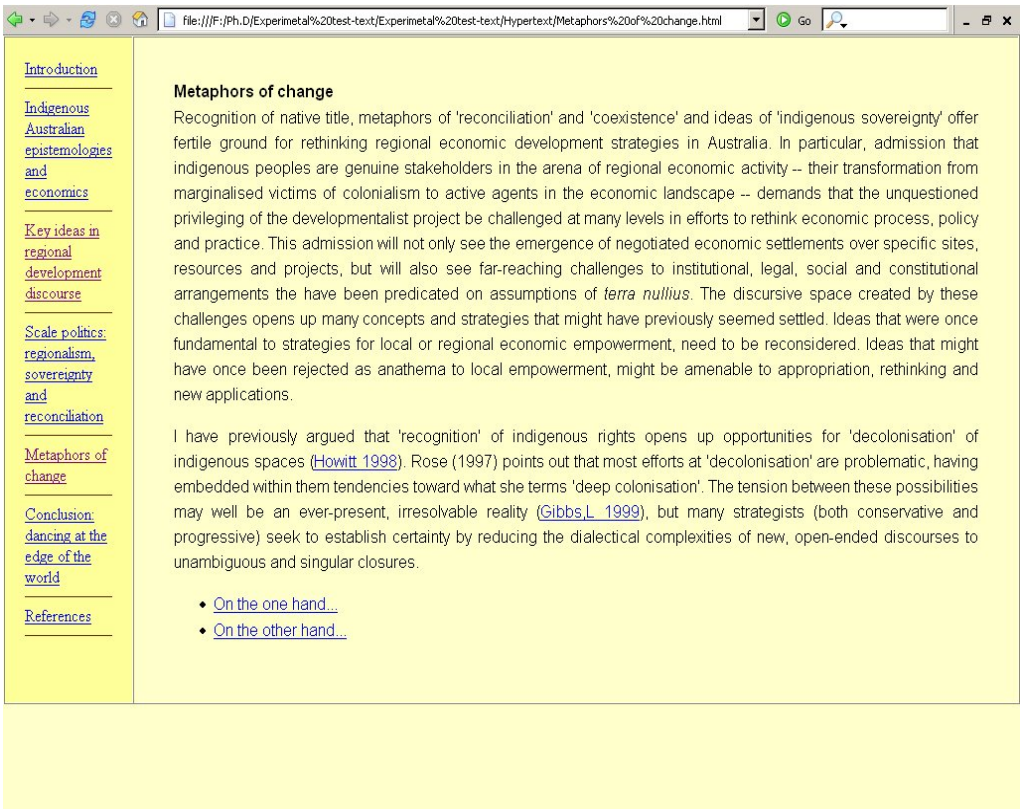


Figure 4.1: Hierarchical structure of the hypertext



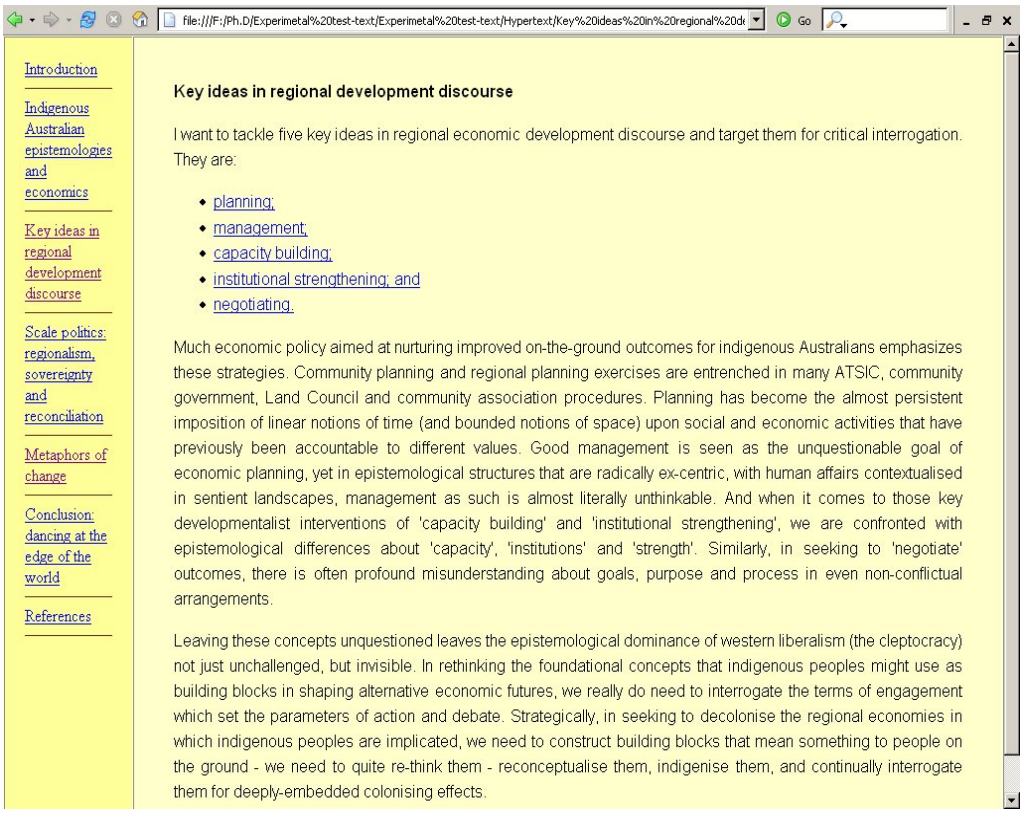


Figure 4.2: Examples of the hypertext nodes

The structure of the hypertext was based on the semantic structure provided by the author and it was converted to a hierarchical tree as shown in Figure 4.1. Another reason for using the hierarchical structure was the fact that while Web developers can organize Web sites in a variety of ways, the basic structures include linear, hierarchical, and Web or cross-linked structures (Zimmerman & Walls, 2000). Each section of the original document was converted to an individual node. A total of 23 nodes were created. There was a welcome page before the main document. A menu for navigational purposes was available at the left hand side of the document. Users had a choice of global and local navigational links. An example of the hypertexts' nodes can be seen in Figure 4.2, illustrating the different global and local navigational links offered to readers.

4.1.4 Material: Comprehension material

Subjects were given two types of tasks, multiple choice questions and short essay questions. The multiple choice questions and the short essay questions corresponded to reading to understand a document and reading to answer questions. These aims of reading are central in several accounts of reading task (Hornbæk & Frokjær, 2003).

There were 15 items in the test, consisting of tree types of questions: a) multiple-choice questions, b) open-ended questions and c) essay question. There were twelve multiple-choice items, two open-ended questions and one essay question (see appendix VI). The first two question types had the same weight as being 1 point for each correct answer while the essay question had a weight of 4 points. Students were not penalized for errors of grammar, spelling, or punctuation. In other words, scoring open-ended and essay questions was done entirely based on the content of the answer. When students gave a correct answer, they received 1 point; a partial correct response received half a point for the multiple and open-ended questions. Two of the multiple choice questions asked for two answers. The essay question had 4 main arguments; each one was awarded with one (1) point. The highest possible score on the test was twenty (20). The test was given on paper and the reading text was available on the computer for the students during the test.

4.1.5 Apparatus

A computer was used to display the hypertext. A Pentium IV 1.8 GHz Hi-Grade computer with 512MB memory was used. The monitor was a CTX 17 inches CRT colour monitor, with 16 inches viewable area. The monitor resolution was 1024x768 pixels. To record the think aloud protocols a tape recorder was used. The recorder was a SONY M-560V micro cassette recorder.

4.1.6 Design

The pilot study was a 3 by 1 (one independent variable with three conditions) between subjects design, manipulating the reading goals (Protopsaltis & Bouki, 2004a, 2004b). The reading goals were manipulated by providing different instructions about what subjects should read in the text (see appendices III, IV, V). Simply instructing subjects to read a text for normal comprehension does not even assure the comprehension has taken place. Therefore researchers attempt to assess subjects' comprehension of a given text by asking them to summarise or to recall, or to answer questions about it, or even all of it together (Ericsson, 1988).

4.1.7 Procedure

Subjects were settled comfortably in a quiet room and a glass of water was provided. They were randomly assigned to one of the three experimental conditions, reading for answering specific questions, reading for answering general questions, and reading with no instructions. A tape recorder was used along with a computer for the recording of the think aloud protocols. They were briefly told the aim of the study (see appendix III, IV, V for the full instructions). They read the text until they felt satisfied that they were able to answer questions on the subject matter. Warm up exercises were given for practicing the think aloud method until they felt confident with it. After the reading task, subjects received the booklet with the recognition

material. All subjects answered the same set of questions without consulting the learning material. The experiment was conducted in individual sessions. Each session took approximately one hour to be completed.

4.1.8 Coding scheme

The goal of the protocol analysis is to construct a mapping between the proposed model and how the cognitive processes will appear in the protocols. This mapping will have the form of a coding scheme that is based on the model and the verbalisation theory. Using the coding scheme, the protocol can be compared with the model (van Someren et al., 1994). The coding scheme specifies how elements of the model can be identified in the data (van Someren et al., 1994). For every process described in the model, the types of statements referring to that process are described in the coding scheme. The model used in th pilot study was the preliminary model. Nine coding categories were created in total. Six categories were derived from the model and three were "special" (van Someren et al., 1994). The six categories derived from the model are:

- goal or task
- scan and choose
- read/microstructure
- action
- recycle
- macrostructure

Statements allocated to the *read* category were literal reproductions of the information. Statements such as *I'll scan the menu to see where to go to*, which indicate brief inspection of the information and choice of a path, were allocated to the *scan and choose* category. For the *action* category the expected utterances were: *I'll click on…* or *I'm going to move to…*. The verbalisations that were considered as a match to the *macrostructure* category are reproductions of the information presented to the subjects, which do not represent a literal copy of the original text. Another indication of the macrostructure was when subjects produce relevant world

knowledge in working memory and express it (Trabasso & Magliano, 1996). All the codes were assigned in a similar way and all the appropriate types of the expected statements were described. An example of a coded protocol can be seen in Figure 4.3. Segments that cannot be coded but do appear in the protocols reflect deviations of the model (van Someren et al., 1994).

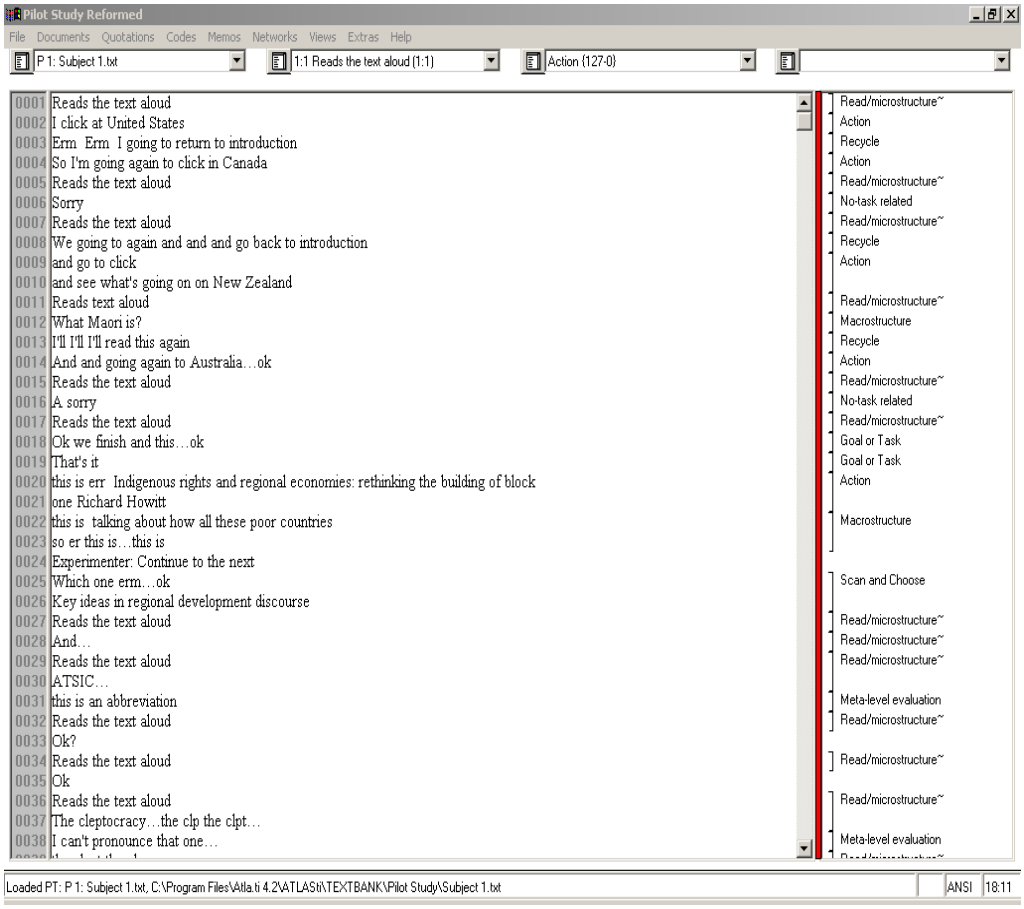


Figure 4.3: Example of a coded protocol from the pilot study

Three special coding categories were created for verbalisations that are not covered from the model but may still be anticipated in the protocols. These categories are:

- no-task related

- meta-level evaluation
- comments on oneself

Statements such as, *I'm trying to concentrate on the first paragraph* or *I don't have a clue* were allocated to the *meta-level evaluation* category. They indicate evaluation of the task or task situation at a meta-level by expressing the understanding or the lack, of a particular phrase or word (Zwaan & Brown, 1996). To the *no-task related* category the allocated statements were *Oh, must not forget to call….* Again, all the codes were assigned in a similar way and all the appropriate types of the expected statements were described.

4.1.8 Coding scheme evaluation

Essentially, coding entails assigning labels to think aloud protocols following the coding scheme. Making the coding scheme reliable an evaluation is necessary. The intercoder reliability should be at least 85% for the scheme to be considered reliable (Gilhooly & Green, 1996). Two coders evaluated the coding scheme and the correspondence between their coding was 95.6%. After discussion, the two coders reached an agreement about the segments that there was no correspondence.

4.2 Results

The primary data collected were the think aloud protocols. The cognitive model was validated by the think aloud protocols. Reading times and answer scores were also obtained. It is valid to analyse the qualitative data obtained in the pilot study, because the sample is adequate for qualitative studies, despite its small size. On contrary, one cannot read too much into quantitative analysis, because of the sample's size. To examine those results a one way analysis of variance (ANOVA) was conducted.

4.2.1 Analysis of the cognitive model

To examine the cognitive components of the hypertext understanding model an analysis on the relation of the coded protocols to the proposed model was performed. All the segments were assigned to a coding category. A total of 668 codes were produced, spread between the nine coding categories. Subjects produced Level 1 and Level 2 verbalisations, which are considered as reliable data. The number of codes produced by each subject varied from 46 to 134. The mean number of codes per protocol was 82.6. The three special coding categories were allocated with 24% of the codes that count for not task related statements. These verbalisations often occur during the think aloud process. It is common to ignore cases like that, because they do not influence task performance (van Someren et al., 1994). Therefore, the analysis of the results was based on the 76% of the codes that refer to task related issues. Table 4.1 presents the codes assigned in each coding category.

Codes Assigned

	Goal or Task		Scan and Choose		Read/ Microstructure		Action		Recycle		Macrostructure	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
	16	2.4%	24	3.6%	256	38.3%	127	19.0%	38	5.7%	43	6.4%
Total	668	100%	668	100%	668	100%	668	100%	668	100%	668	100%

Table 4.1: Codes assigned in the coding categories

Overall 76% of the produced codes conform to the cognitive model. The majority of the codes, 38.3%, were classified as *read/microstructure*, while the *action* category had the second highest percentage of 19%. The *goal or task* category was assigned with 2.4% of the codes and the *scan and choose* with 3.6%. The *recycle* category counted 5.6% of the codes and finally, 6.4% of the codes were classified as *macrostructure*. There were no statements in the protocols that could not be coded in any of the coding categories. The results confirmed that the proposed model

successfully describes the cognitive processes that take place during reading a hypertext.

However, there were differences in the way subjects chose to read the hypertext in the initial stage. Half of the subjects, 50%, started reading the hypertext without scanning the document before, and they selected the first link that came across. The remaining 50% of subjects scanned the available links before choosing one to follow.

4.2.2 Analysis of hypertext reading times

The total time of reading the hypertext was recorded. The mean time for reading was 26.6 minutes with a standard deviation of 5.3. There was no significant difference between the reading times based on the different reading goals (F (2, 5) =.883, p=.469).

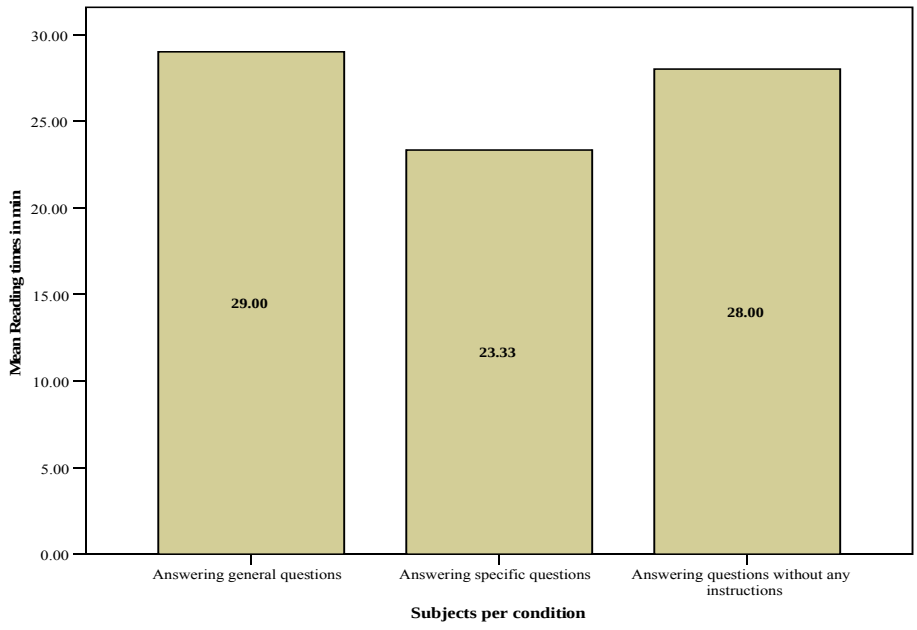


Figure 4.4: Hypertext reading times

4.2.3 Analysis of the hypertext comprehension

The comprehension was estimated through grading the multiple choice and short essay questions. One score for each subject was calculated. The maximum achievable score was 20. There was no significant difference in comprehension based on different reading goals ($F(2, 5) = .485$, $p = .642$).

4.2.4 Analysis of the amount of text read

A page was clearly identified as "read" from the think aloud protocols when subjects produced literal copies of the information. The results showed no significant difference between the amount of text subjects read on different goals ($F(2, 5) = 2.239$, $p = .202$).

4.2.5 Analysis of navigation

The purpose of the analysis of the subjects' navigational patterns is to investigate the strategies readers use while reading in hypertext. Furthermore, it permits examining whether the goal manipulation caused differences in the strategies used by the subjects. The analysis of the think aloud protocols revealed three strategies. First, a *serial* or *linear* strategy, where subjects read the hypertext in a linear manner following the "predefined" order. In other words, subjects followed the first link they came across without scanning the document to see what other links were available. Figure 4.2 shows an example of hypertext nodes and the available links. For instance, subject number 5 produced the following verbalisation:

I'm gonna go for United States first
Ok
Reads the text aloud
All right I'm gonna read that again
Reads the text aloud
Press Canada

Reads the text aloud
(pause)
New Zealand just click on New Zealand

The subject selected the first link presented and as soon as he/she had to select another one, the subject again selected the first link presented. This pattern was applied throughout the document.

The second strategy that readers used was a *mixed* strategy. Readers chose some links in a linear fashion while others in a random fashion. An example of subject's verbalisation using this strategy is given below:

I click on the other hand
I don't think is working (the link)
(muttering…unidentified reading) (goes to metaphor of change)
Reads the text aloud
In particular, admission that indigenous peoples are genuine stakeholders in the arena of regional economic activity -- their transformation…
I don't gonna read any other than that
Conclusion dancing at the edge of the world…
I look that next
It doesn't work (the link) aah
Conclusion dancing at the edge of the world
it sounds interesting
see what is at the bottom of the page, nothing
it's got links to some (short pause) writers (pause)
I see what they've write about I click on Le Guin
Ah just references to books

While this subject had started reading the text in a linear fashion, after a while started jumping to different hypertext nodes without following any presented sequence, trying to find the information he/she was looking for.

The third strategy is rather more sophisticated, the *mixed overview* strategy. Overview because subjects first scanned the document to see what links are available

and then chose one to proceed with. Mixed because they chose to follow links sometimes in a linear and others in a random fashion. An example of verbalisation that indicates this strategy is:

Sorry I'm just curious about Australia
because that's were I'm from
Reads the text aloud
Ok I'm just gonna compare it to New Zealand
Reads the text aloud
Just to see Canada
Reads the text aloud"
While in another phase of the reading produced:
"I'm actually quite taken by these Metaphors of change
"Scale politics, regionalism, sovereignty..."
so I feel already sort of got some ideas of what the politics is
so I'm just gonna have a look of Metaphors of change
Reads the text aloud

The first example shows the subject's selected links in a non sequential manner, while the second verbalisation presents a change to a sequential manner, because the links in the second example are presented in a sequence.

Strategies were not affected by the different reading goals. Subjects with different reading goals used different strategies.

4.2.6 Factors influencing navigation strategies

One of the most common arguments in favour of hypertext compared to traditional printed documents is the freedom and flexibility that offers users to construct their own sequence of information. However, there is no extensive study on the factors that influence this choice. Foltz (1996) has shown that one factor that influences readers choice of hypertext links is coherence. He also found that readers made 80%-90% of their transitions in a coherent manner. Carter (2000) points out that "in hypertext,

coherence must be felt no matter in what sequence the text is encounter" (p. 90). The notion of coherence is very close to what Landow (1987) and Zellweger (1998) refer to when they insist on the necessity to help readers to discover the relation between the source and the destination of a link. Tosca (1999) calls it the bridge metaphor.

The results show that another factor that influences readers' choices is personal interest. For instance, one of the subjects gave the following verbalisation when choosing a link about New Zealand: *I click on New Zealand; I am from New Zealand that's why I pick New Zealand*. Another subject gave a very similar explanation for choosing another link relevant to Australia: *Sorry I'm just curious about Australia, because that's where I'm from*. In both cases the reason for choosing a particular link was related to social factors. Similarly, a third subject mentioned: *Rick Coledge grab my interest…*, and said in the same vein: *reading each title in terms if anything grabs my interest*. There is no justification why the subject's interest was grabbed on that information or what she/he was looking for in the text. However, it is clear that interests are having a significant effect on the reading processes. Scholars suggest that there is a need for a more systematic focus on interest and motivational factors - in reading in general and in hypertext environments in particular (Leu & Reinking, 1996).

However, for the majority of the readers the sequence of the links based on their location in the text, seems to be the determinant factor for choosing a hyperlink. Users tend to select the first available link. A possible explanation for this can be the lack of relevant schema referring to hypertext reading and navigation. Similarly, Dillon (1996b) argues that the lack of standards in electronic documents development means that readers can not acquire skills from one document that could be valuable during the use of another. In addition, Nielsen (1997) argues readers do not read online, instead they scan the document picking up individual words and sentences, and printing it out. Nevertheless, this tactic does not allow them to develop the necessary cognitive schema for hypertext reading and may affect the strategies they employ during reading. Moreover, in order to overcome this deficiency readers tend to apply strategies borrowed from reading in traditional paper documents. Troffer (2000) argues, for example, that readers feel comfortable with hierarchical structures because many print texts are organised this way. Researchers have argued that in order to

improve hypertext performance and reduce readers dissatisfaction and disorientation, structures should be borrowed from traditional paper texts (Gillingham, 1996).

4.3 Discussion

The pilot study ran efficiently and did not reveal any problems concerning the experimental design. However, at the beginning of the pilot study and while subjects were instructed to read the text silently, it became apparent that the subjects' reading could not be observed, and in particular, it would be impossible to distinguish between genuine and fake reading. As a result, participants had to read the text aloud.

Nevertheless, differences were found between the model and the way subjects chose to read the hypertext in the initial stage. Half of the subjects, 50%, started reading the hypertext without scanning the document before, and they selected the first link that came across, something that the model did not anticipate. Therefore, the necessary modifications were made, and the new model was presented in chapter two.

To sum up, the pilot study demonstrated that there was no significant flaw in the design or in the implementation of the experiment, and any minor problems were addressed before the main experiment.

4.4 Conclusion

The pilot study was presented and some initial results were discussed. However, the main focus of the pilot study was the evaluation of the experimental design and not the extraction of results. The study demonstrated that there was no significant flaw in the design or in the implementation of the experiment, and any minor problems were addressed before the main experiment. The next section will discuss the main experiment with the use of think aloud method. The results will be presented and explained in detail.

Chapter 5

Experimental Evaluation: 1st experiment

To validate the elements and constituant parts of the hypertext comprehension model, a series of think aloud protocols have been performed. The readers' protocols have been tested against the model, to see if the elements of the model did emerge in their protocols. The experimental study will be described next and the results will be presented and discussed.

5.1 Method

This experimental study was undertaken using the think aloud method. The method offers the opportunity to gather detailed understandings of reading and reading-related phenomena (Afflerbach, 2000), and it is the same as the method used in the pilot study.

5.1.1 Subjects

Forty two undergraduate students from the computer science and media department participated. All subjects were volunteers. Subjects were screened to ensure that they had not taken any courses in economics, and had no reading disabilities (see appendix I). All subjects were native English speakers apart from one. All subjects were familiar with online (www) documents since they were using the Web as a source of information for their course works and the majority of them were computer science students as well. None of the subjects had participated in a think aloud study before.

5.1.2 Material

All practice material, hypertext, and comprehension material were the same as in the pilot study, described in chapter four.

5.1.3 Apparatus

All equipment and the specifications were the same as in the pilot study described in the previous chapter.

5.1.4 Design

The experiment was a 3 by 1 (one independent variable with three conditions) between subjects design, manipulating the reading goals. The reading goals were manipulated by providing different instructions about what the subjects should read in the text. By simply instructing subjects to read a text for normal comprehension does not even assure the comprehension has taken place. Therefore researchers attempt to assess subjects' comprehension of a given text by asking them to summarise or to recall, or to answer questions about it, or even all of that together

(Ericsson, 1988). The specific instructions group was instructed to read the hypertext in order to answer question on given sub-topic of the hypertext. The general instructions group was instructed to read the hypertext in order to give answers to questions related to the topic described by the documents title. Finally, the no instructions group was the control group and was given no instruction concerning the kind of questions they will ask to answer after reading.

The focus of the investigation is on the cognitive process that take place during hypertext reading. The main hypothesis is about the model, and it is assume that if the model is precise, then the verbalisations of the subjects in the protocols should fit in the model. If the model however, is imprecise, then the subjects' verbalisations should not match with the models components.

In addition, as far as the different experimental conditions the focus is on the influence of reading goals on the reading process. It is expected that the different reading condition will influence comprehension scores, reading times, and the use of strategies. More precise the hypotheses are as follows:

- Subjects in the general condition will have better comprehension scores compared to subjects in the specific condition because the comprehension test will cover questions about every aspect of the information.

- Subjects in the no guidance condition should score better in the comprehension test than subjects in the specific condition. That is because the post test will cover every aspect of the subject matter.

- Subjects in the general condition would need more time to read the material than the subjects allocated in the specific condition.

- Subjects with no guidance would need more time to read the material than the subjects allocated in to the other conditions.

- Subjects who have been assigned for the general condition would visit more links than the subjects assigned for the specific condition.

- Subjects with no guidance would visit more links than the other two conditions.

- The hypothesis about the reading strategies is that reading goals affect the reading strategies; therefore, subjects with different goals will use different reading strategies.

Furthermore, the think aloud protocols will reveal the strategies hypertext readers use during reading, and it will improve our understanding about the factors that influence their decisions of which nodes to follow.

5.1.6 Procedure

The procedure for this study was the same as the one used in the pilot study described in the previous chapter, chapter four.

5.2 Coding Scheme

The coding scheme for the first experiment is based on the coding scheme used in the pilot study. However, the changes that were made on the proposed model after the pilot study, have affected the categories of the coding scheme that derive from the model. As has been stated before, the goal of the protocol analysis is to construct a mapping of the proposed model and how the cognitive processes will appear in the protocols. This mapping will take the form of a coding scheme that is based on the model, the verbalisation theory and the task analysis. The think aloud method requires this for every process described in a model, the type of statements referring to that process is described in the coding scheme (van Someren et al., 1994). Subsequently, fourteen coding categories were created in total. Ten categories were derived from the model. Every single element of the model was converted into a coding category. For instance, from the *formation of a goal or a task* model category, the *goal/task* coding category was created. All model's components were converted into coding categories in the same way. Four other coding categories were formed

and categorised as "special" according to van Someren et al. (1994) guidelines. These coding categories included verbalisations which did not directly derive from the model but may still be anticipated in the protocols, and they will be described after the main ones. However, they may not have any influence in the processes described by the model. The ten categories derived from the model are:

- goal/task
- scan
- read
- text-base
- situation model
- action
- strategy
- monitoring
- recycle
- goal accomplished

The first coding category is called *goal/task*. This category is exactly the same as the one used in the pilot study. As has been explained in chapter four, it is common for the goal or the task to be given to the readers; particularly in educational settings. That is the case in the present study. Therefore the expected verbalisations are the same or similar to the experimental conditions and they could be as followed: *I'm looking for the key ideas in regional development discourse*, which is a heading in the hypertext and reveals specific reading aim. Other verbalisations could be like: *I need to find out about the indigenous rights and regional economies* or *I need to understand more about…*. These verbalisations illustrate the reading task. However, there are not many verbalisations expected about the readers' goals, because they do not have to generate them themselves.

A category, called *scan*, was created and contains statements such as *I'll scan the menu to see where to go to*, *I'll have a look first and then…* or *I am scanning to…* which indicate brief inspections of the information. This category is different from the *scan and choose* category used in the pilot study. The difference lies onto the fact that the *scan and choose* category has been separated into two. One is the *scan* category, which was explained above. The other which deals with the selection of a

link was allocated to the *action* category, and will be described in more detail later on. The *scan* category may sometimes be similar to the *read* category, because subjects may read quickly the available categories of information. However, when subjects' verbalisations refer to hypertext links or fractions of the text read in a rapid manner and the reading stopped suddenly, then those verbalisations will be allocated into the *scan* category, because they demonstrate an inspection of categories and not actual reading.

Statements allocated to the *read* category were literal reproductions of the information or the phrase *Reads the text aloud*. The *Reads the text aloud* phrase was used to replace long portions of text in the transcription of the protocols.

The next category is directly related to the previous one. The category is called *text-base*. Statements allocated to this category were information derived from the text but articulated with a different vocabulary to the one on the text. For instance, substitution of synonyms (e.g. trip for journey), simplification of the language (Goldman, 2004). Nevertheless, those statements are narrowed down to the level of individual sentences and paragraphs and no to the meaning of the text as a whole (van Dijk & Kintsch, 1983). It is difficult to propose expected verbalisations for this category because subjects may use various expressions; however, the use of synonyms or the paraphrase of sentences that were just read is a good indication.

Another category that is closely related to the *read* and the *text-base* is the *situation model* category. This category is the same as the *macrostructure* category in the pilot study. The verbalisations that were allocated in this one are those that reveal textual information combined with background knowledge or knowledge of the world. Hence, when subjects produce relevant world knowledge in working memory and express it (Trabasso & Magliano, 1996). Furthermore, verbalisations that indicate the subject's effort to capture the meaning of the information as a whole were allocated to this category. Similarly to the *text-base* category, it is difficult to suggest verbalisation for this category as well. Though, any expressions that expand on previously read information, that contain no information previously read, that integrate newly extracted information with previously extracted information (Kintsch, 1994) are solid indications of the subject's effort to build a situation model and therefore were allocated to the *situation model* category. Furthermore, Goldman

(2004) points towards some other indications such us: specialised vocabulary, facts about the objects in the text, an association that is irrelevant to the interpretation of a certain passage, and explanatory casual inference that is based on two ideas in the text plus existing knowledge.

For the *action* category the expected utterances were: *I'll click on…* or *I'm going to move to…*, *I'm scrolling…* and so on. Also, as an action was considered subjects verbalisations that contain names of the links, since subjects may just read the link and click on it without making it explicit. In such cases observation and note taking that was taken during the experimental session will be used to clarify the action and distinguished from any other category it may fit in. Such verbalisation can include: *management*, *capacity building*, *negotiating* and all the names of the links. However, if subjects have visited the links before, those statements were allocated in the recycle category explained below. In general, any utterance that indicates some short of action within the hypertext environment was allocated into *action* category.

Another category in the coding scheme is called *strategy*. This is a new category and it has been derived from the new step *use appropriate strategy*, introduced in the model after the pilot study. The expected verbalisations for this category are: *I'll skip that piece…*, *I'll jump forward to…* or *I'm skimming…* or any other utterances that reveal use of strategy.

Monitoring comprehension is the ability of a reader to be aware, while reading, whether the text is making sense or not (Wilhelm, 2001). Utterances that signify monitoring are those that express awareness or lack of awareness of what the content means. For instance, *that doesn't make any sense* or *ok*, *that's fine*, *all right* and so on (Wilhelm, 2001). Monitoring also includes verbalisations that verify an action, for example just after a link selection (e.g. ok) or just after finishing reading a passage (e.g. ok, fine, all right, right), indicating that the reading has been completed. However, some of the verbalisation mentioned above (e.g. ok, fine, all right, right) can be allocated in the *filler* category. A way to distinguish between them is when these utterances come immediately after reading a passage or an action. Then, those verbalisations refer to the meaning of the text or the action and so reveal monitoring of the comprehension process or the actions taken by the readers. Moreover, some other expected utterances that reveal monitoring might be: *I've done that…*, or *I've*

seen that… Monitoring can refer to both, either reading comprehension or even reading without any comprehension.

For the *goal accomplished* category the expected statements were: *I've finished*, *I've done it*, *that's it*, *I think I can answer the questions now, I'll stop now,* or even *I had enough…* and any other statements that point either towards the achievement of the goal or the task, particularly when they occur at the end of the protocol, or the termination of the task.

Recycle is the last of the categories that were originated from the proposed model. It incorporates both, rereading of a passage or a link selection that leads the readers back to the section they came from. Examples of expected verbalisations are: *I'll go back…*, *I'll return to …*, *I'll have to reread that…*, *let's go back…* or *let's read that again*.

There are four special coding categories. Three of those coding categories were used in the coding scheme of the pilot study for verbalisations that are not covered by the model but may still anticipated in the protocols. These categories are:

- no-task related
- meta-level evaluation
- comments on oneself

The expected verbalisations for these coding categories are the same as those described in the pilot study. Statements such as, *I'm trying to concentrate on the first paragraph* or *I don't have a clue* were allocated to the *meta-level evaluation* category. They indicate evaluation of the task or task situation at a meta-level by expressing the understanding or the lack, of a particular phrase or word (Zwaan & Brown, 1996). In addition, questions to the experimenter that concern the given task are characterised as meta-level evaluations. To the *no-task related* category the allocated statements were: *Oh, must not forget to call…* or any other statement referring to situations unrelated to the experimental session. The category, *comments on oneself* includes utterances like: *I'm thirsty* or *I'm not comfortable* or any other statement referring directly to the subjects self. All three special categories adapted here have been proposed by van Someren et al. (1994). Again, all the codes were

assigned in a similar way, by mapping them to the appropriate types of the subjects' statements.

Nevertheless, a new category has been introduced here to include verbalisations that were produced by subjects to fill in time or transition between sentences. The category is called:

- filler

The expected verbalisations for this category are: *Err*, *wow*, *hm*, *ok*, *right*, *blah blah*, and any other utterances that may be used by the subjects for that purpose. Verbalisations like *ok* or *right* can be distinguished from the ones allocated to the monitoring category, because they occur before any action has been undertaken by the subjects or before the reading of a passage has taken place. For instance, verbalisations like: *ok, let's start…* or *right, let's see…* indicate filling out time rather monitoring of any action or the reading process.

5.2.1 An example of a protocol analysis

An example of how the protocols were coded is given and explained below. Examples of coded protocols can be seen in Figures 5.1 and 5.2. In Figure 5.1, line 1 *right so I click on enter* has been coded into the *action* category because the subject uses the word *click*, which point toward a selection of a link. Additionally, the word enter represents a hypertext link. Next line in the protocol is line 3: *ok I think the text is quite eerr in depth....* This verbalisation was coded as *meta-level evaluation* because the subject comments on the text at a meta-level by expressing an opinion about the text's intensity. Similarly, the subject makes a comment about the quality of the language (*written in quite high level of English erm*) in next line (4). That verbalisation was coded as *meta-level evaluation* as well. In the next two lines (5, 6) subject 5 voices the following verbalisation: *seems to be…on economic systems erm*. That expression was allocated to the *text-base* coding category because the subject paraphrases what he/she has just read in the text without any background knowledge and only focusing on the local meaning of the text.

The next two lines, 7, and 8, (*early economic systems rrm*, and *conquests the distribution of land probably*) were coded as *situation model*, because he/she makes an inference about the topic of the text by suggesting that it is about land distribution as well. Nevertheless, the land distribution term was not mentioned in the segment of the text. In addition, the subject referred to the meaning of the passage at a more general level than at the level of the sentences he/she have just read. The lines 9, 10, and 11 (*eerr also a bit sees how the early settlers industrialise their nation and develop…and their economies*) were again coded as *text-base* because the subject paraphrased the information read in the document. Next is the *first In the United States* expression in line 13. This expression was coded as *action* because the *In the United States* expression is a hypertext link. In line 14 the subject says: *and this is to be about Native American Indians….* That verbalisation was coded as *situation model* because the subject made and inference about the passage's meaning using at the same time his/her knowledge about the world by stating that the America natives are called Indians.

The following lines from 15 to 19 (*and how their rights are actually hold on through the American constitution…and then also explains around the right they have and…and the economic interest in…in the actual world mineral surface water and reserve the recourses that they have*) were allocated to the *text-base* category because they focus on the local meaning of the text, paraphrasing its meaning. The expressions were coded as three *text-base* categories because their meaning can stand independently. Next line in the protocol is line 21 (*and second one is being Canada*). This expression was coded as *action* because is a hypertext link and the subject while selecting the link verbalises his/her action. Line 22 holds the expression: *and then to that one*. This expression was coded as *meta-level evaluation* because subject 5 just stating on what is going to come next as far as the meaning concerns without referring to the meaning at all. The reference to the meaning is taking place in the next line (23) where subject 5 says: *this is about eer the governmental efforts…errm to bring indigenous people in the line with what they want*. Again, this phrase was coded as *text-base* because the subject paraphrases the information presented in the text without using any additional knowledge.

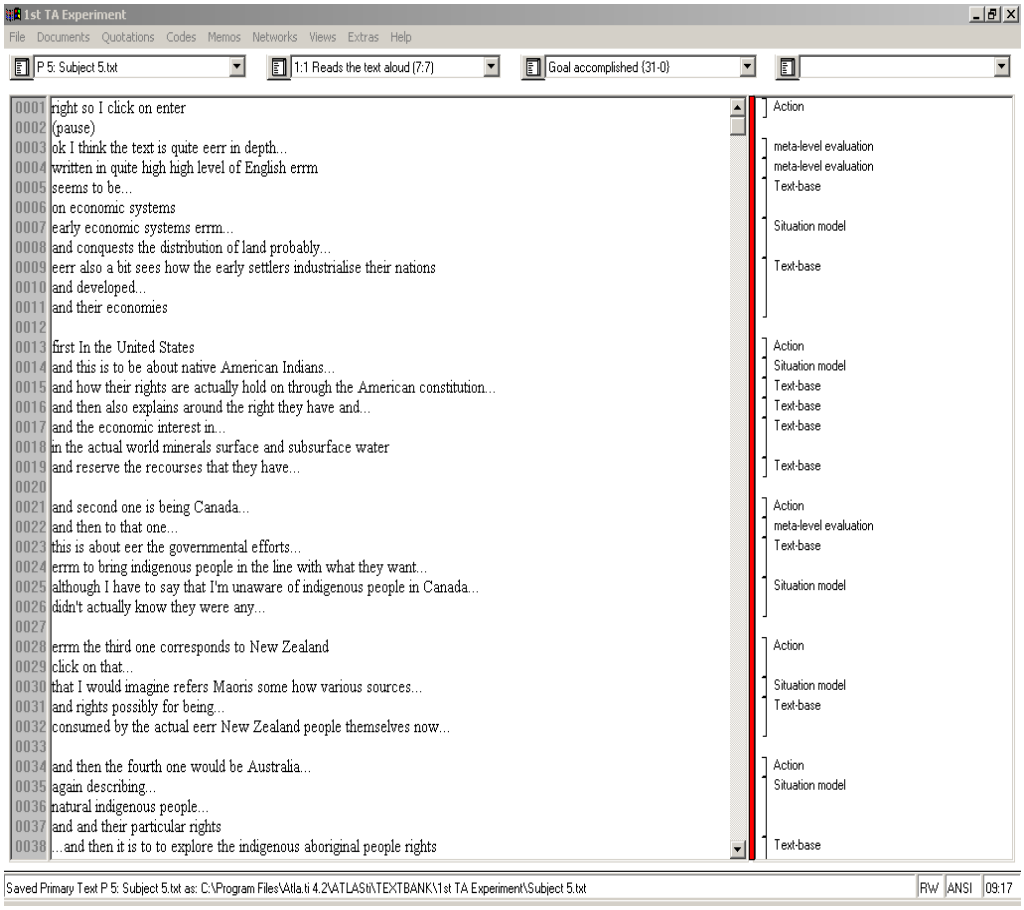


Figure 5.1: Example of a coded protocol

The next two lines (25: *although I have to say that I'm unaware of indigenous people in Canada*, and 26: *didn't actually know they were any…*) which are the last in the example presented in Figure 5.1 were coded into *situation model* category. The subject here uses his/her background knowledge along with the information from the text to state that he/she did not know about Canadian native people. In line 28 and 29 the subject produces the following phrase: *errm the third one corresponds to New Zealand click on that....* That phrase was coded as *action* because the name of *New Zealand* corresponds to a hypertext link and in addition to that the subject uses the word *click*. The next line (30: *that I would imagine refers Maoris some how various sources..*) was coded as *situation model* because the subject makes an inference based on his background knowledge or knowledge about the world by referring to native people of New Zealand as *Maori*. The term Maori was not used in the text. The next two lines (31, 32: *and rights possibly for being...consumed by the actual*

eerr New Zealand people themselves now...) were coded as *text-base* because the subject paraphrases the information he/she just read. The last sentence is in line 34 and contains the following: *and then the fourth one would be Australia....* That sentence was coded as *action* because *Australia* is a hypertext link.

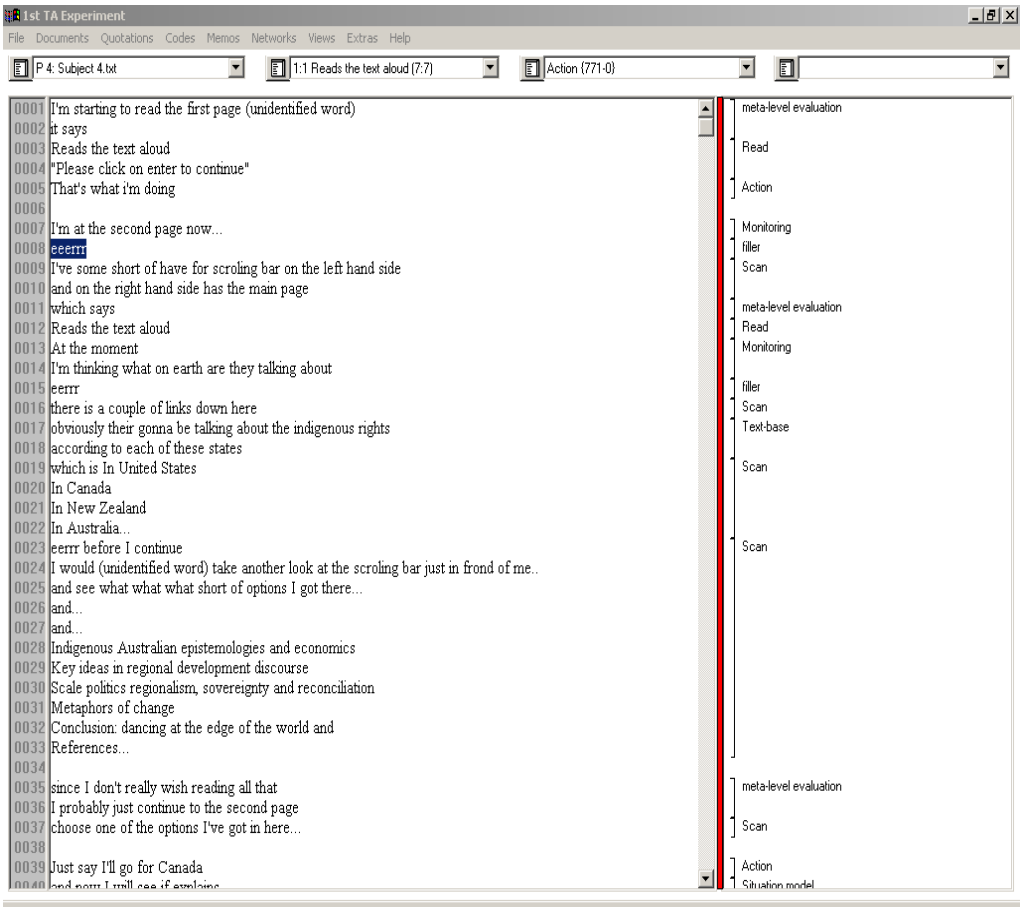


Figure 5.2: Examples of coded protocols

Some other examples of coded verbalisations that have not been covered from the previous are presented in Figure 5.2. Therefore, in line 7 the subject voices: *I'm at the second page now....* That verbalisation was coded as *monitoring* because the subject expresses his/her awareness of his/her position in the hypertext. The next line (7: *eeerrr*) was coded as *filer* since there was no meaning in that verbalisation and it is clear that the subject is using it to fill in the transition from one sentence to

another. In lines 9 and 10 there is an example of the *scan* code. The subject said: *I've some short of have for scrolling bar on the left hand side and on the right hand side has the main page*.

The subject here looks through the page quickly (scans) to see what information are available, before taking any action and that reveal a scanning process. In the next line (11) subject 4 says: *which says*, referring to what the text says. That statement was coded as *meta-level evaluation* because it does not refer to the text's meaning but it rather makes a statement about the text on a different level. Line 12 was transcribed as *Reads the text aloud*. That phrase has replaced the literal reproduction of the text and was coded into *read* category. All the codes were assigned in a similar way in all the protocols based on the produced coding scheme. The coding scheme however, was evaluated for its reliability. That process is explained in the next section.

Segments that cannot be coded but do appear in the protocols reflect deviations of the model (van Someren et al., 1994).

5.2.2 Coding scheme evaluation

The evaluation of the coding scheme was determined in two stages. The technique for quantifying correspondence between codes assigned by different coders is that all use one set of data that is coded by two coders (van Someren et al., 1994). The intercoder reliability should be at least 85% for the scheme to be considered reliable (Gilhooly & Green, 1996). Two coders evaluated the coding scheme at both stages. One of the coders was the author of this thesis, and the second coder was an independent one. The first evaluation took place during the pilot study and the intercoder reliability was 95.6%. However, because some of the coding categories have changed because of the development of the model, a new evaluation of the coding scheme was undertaken. Therefore, a representative sample (17%) of the total set of protocols was used. The correspondence between their coding was 90.7 %. The correspondence between the first and the second evaluation was 93.15% hence, the coding can be considered reliable. The main variations were on the differences

between the monitoring and meta-level evaluation categories. After discussion, the two coders reached an agreement about the categories and the segments with no correspondence.

5.3 Results

The primary data collected was from the think aloud protocols. The cognitive model and the reading strategies were validated by the think aloud protocols. The think aloud protocols were enhanced by observation and note-taking during the experimental sections. Subjects produced Level 1 and Level 2 verbalisations according to Ericsson and Simon (1993) classification, which are considered as reliable data. A Level 1 verbalisation is simply the vocalisation of heeded articulatory or oral encoding, as required by the given task. An example of such verbalisation (subject 1) is give bellow:

Key ideas in regional development discourse
Reads the text aloud
They are:
planning;
management;
capacity building;
institutional strengthening; and
negotiating

That verbalisation is simply the articulation of heeded information derived directly from the text. At this level there are no intermediate processes, and subjects need no special effort to communicate their thoughts.

Level 2 verbalisation involves description, or rather explication of the thought contents. An example of such verbalisations (subject 4) is:

go for the one in Australia...
Reads the text aloud
again doesn't really tell you anything about the differences in between

...natives and settlers
that doesn't give you that much
that much of an idea...

Reading times and answer scores were also obtained. To examine those results a one-way analysis of variance (ANOVA) was conducted.

5.3.1 Hypertext reading comprehension model

To examine the cognitive components of the model, an analysis of the relation of the coded protocols to the proposed model was performed. All the segments were assigned to a coding category. A total of 4,924 codes were produced, spread across the 14 coding categories. The number of codes produced by each subject varied from 26 to 468 as Figure 5.3 illustrates. The mean number of codes per protocol was 117.2. The four special coding categories were allocated to 16.8% of the codes that count for no-task associated statements. These verbalisations often occur during the think aloud process. It is common to ignore cases like those, as they do not influence task performance (van Someren et al., 1994).

Therefore, the analysis of the results was based on the 83.2% of the codes that refer to task related issues. Overall 100% of the task related codes are conforming to the cognitive model. The majority of the codes, 30.6%, were classified as *read*, while the *action* category had the second highest percentage of 15.6%. Followed by the *monitoring* category with 15.3% of the codes. The *goal/task* category was assigned to 0.9% of the codes and the *scan* to 1.5%. The *recycle* category counted for 5.8% of the codes. The *text-base* and the *situation model* categories were allocated to the 4.8% and 3.9% of the produced codes respectively. Also, 3.9% of the codes were classified as *strategy* and the remaining 0.6% of the codes was assigned to *goal accomplished* category. There were no statements in the protocols that could not be coded in any of the coding categories.

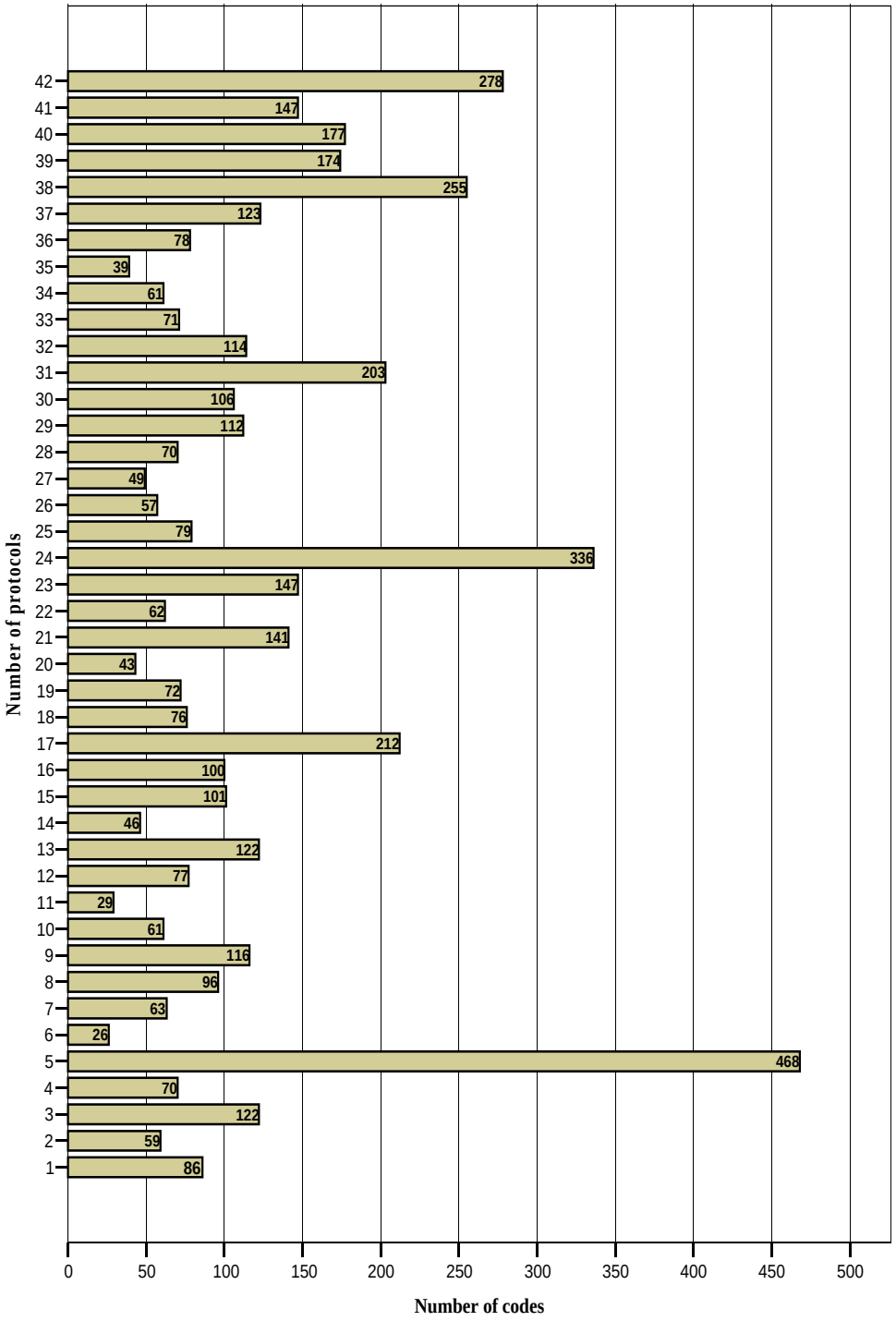


Figure 5.3: Number of codes produced by each subject

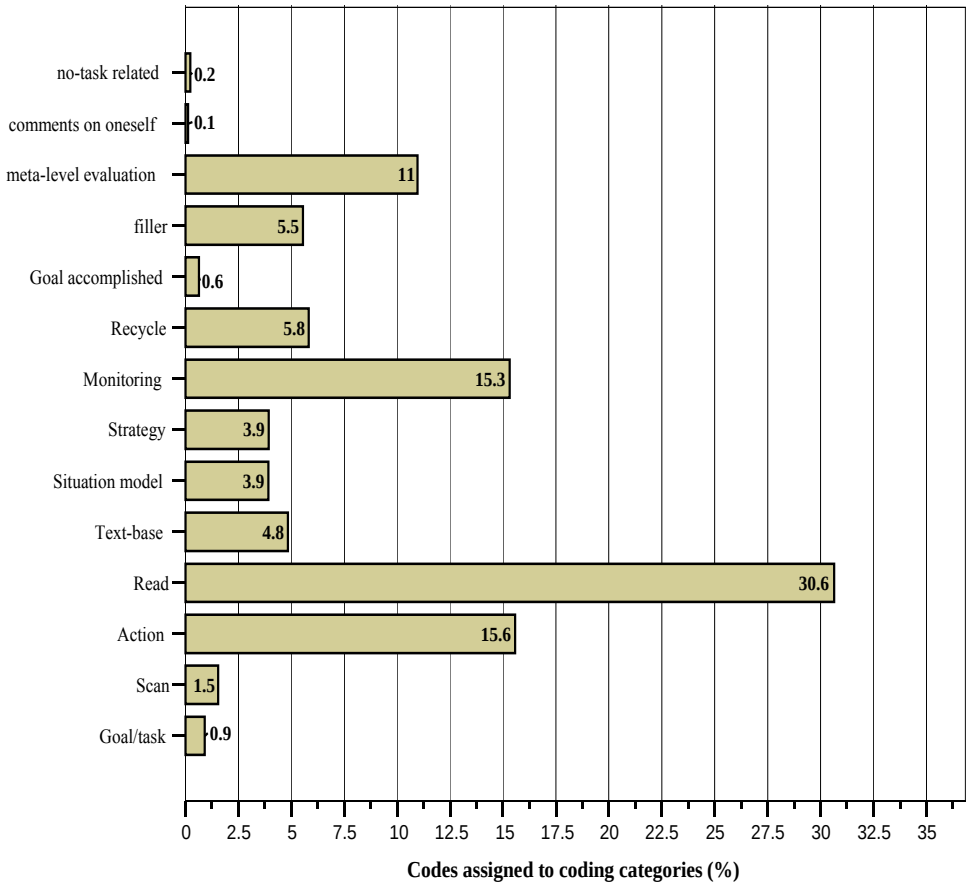


Figure 5.4: Codes allocated to each coding category

The model also predicts the sequence of steps that a hypertext reader undertakes, and it offers flexibility. It predicts a dual processing, either of a sequential or a circular nature, depending on the subjects needs. After the formation of the goal the subjects have two choices, they can either choose to read the categories or to scan the categories of information. All subjects have chosen one of these two steps falling well into the models prediction. The vast majority of the subjects 71.4% choose to read the hypertext without scanning the available categories at the beginning of their reading. The remaining 28.6% of the subjects use the *scan the categories* component. After these two steps because of the models flexibility to predict either sequential or circular sequence of events, the model predicted all the alternative sequences of steps that the subjects undertook. There were neither unpredicted processes verbalised by

the subjects nor any sequence of events unpredicted by the model. The model does not predict how many times each component will occur during the reading process but it suggests that it can occur as many times as necessary.

The results confirm that the proposed model successfully describes the cognitive processes that take place during reading a hypertext. The fact that the *read* category was the one with the highest percentage shows that communicating information is the major purpose of a hypertext document. Furthermore, *monitoring* is playing a vital role in hypertext reading understanding by checking the reading process and understanding throughout. However, a reader is required to undertake a series of actions in order to proceed with reading the hypertext. Those actions distinguish hypertext documents from paper-based documents.

5.3.2 Reading times

Means and standard deviations of the time difference tasks performance between the three groups are shown in Table 5.1.

Reading Times

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
General Instructions	14	34.1429	15.4863	4.1389	25.2014	43.0844	8.00	59.00
Specific Instructions	14	31.9286	6.4981	1.7367	28.1767	35.6805	22.00	43.00
No Instructions	14	39.5000	12.7022	3.3948	32.1660	46.8340	20.00	57.00
Total	42	35.1905	12.2857	1.8957	31.3620	39.0190	8.00	59.00

Table 5.1: Means and standard deviations of reading times

The total time to read the hypertext was recorded. The mean time to read the hypertext was 35.2 minutes with a standard deviation of 12.3. There was no significant difference between the reading times based on the different reading goals ($F(2, 39) = 1.436$, $p=.250$). Nevertheless, there was a difference in the reading times

between the groups with no instruction group having the highest mean (40), the general instruction group having the second highest (34), and the specific instruction group having the lowest (32). A post hoc test was conducted (Tukey HSD) to examine if there is any significant difference between groups. The test indicated that there was no significant difference between general instructions and specific instructions groups ($p>0.05$), between general instructions and no instructions groups ($p>0.05$), and between specific instructions and no instructions groups ($p>0.05$).

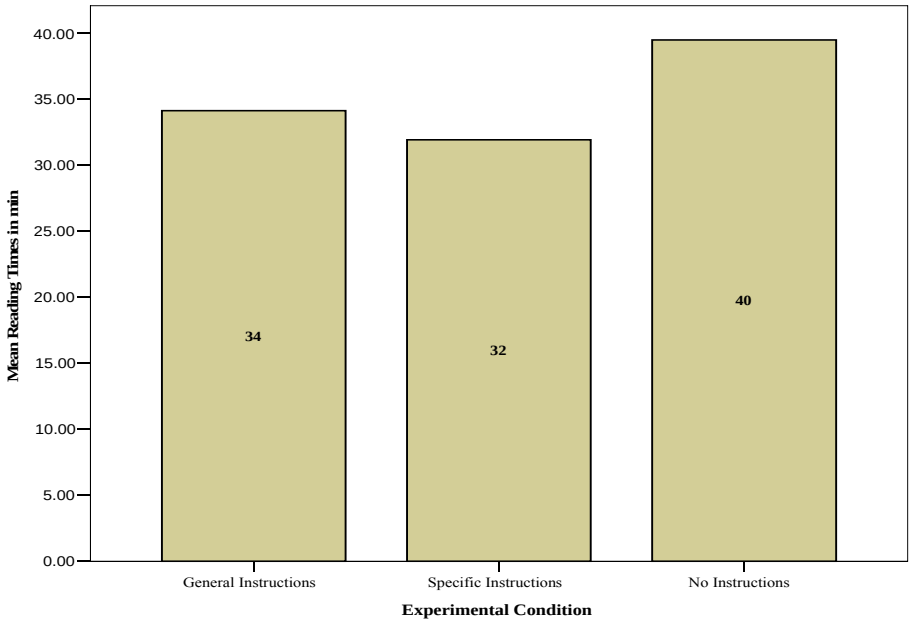


Figure 5.5: Reading times per condition

With regard to time difference tasks, the best performance was shown by the specific goal group. That result was predicted by the hypothesis. The difference however, is not significant.

5.3.3 Comprehension scores

One type of measuring comprehension was obtained. The measuring of comprehension was calculated of grading the multiple choice and the short answer questions. One score for each subject was calculated. The maximum achievable score was 20. There was no significant difference in comprehension based on different reading goals (F (2, 39) =2.012, p=.147).

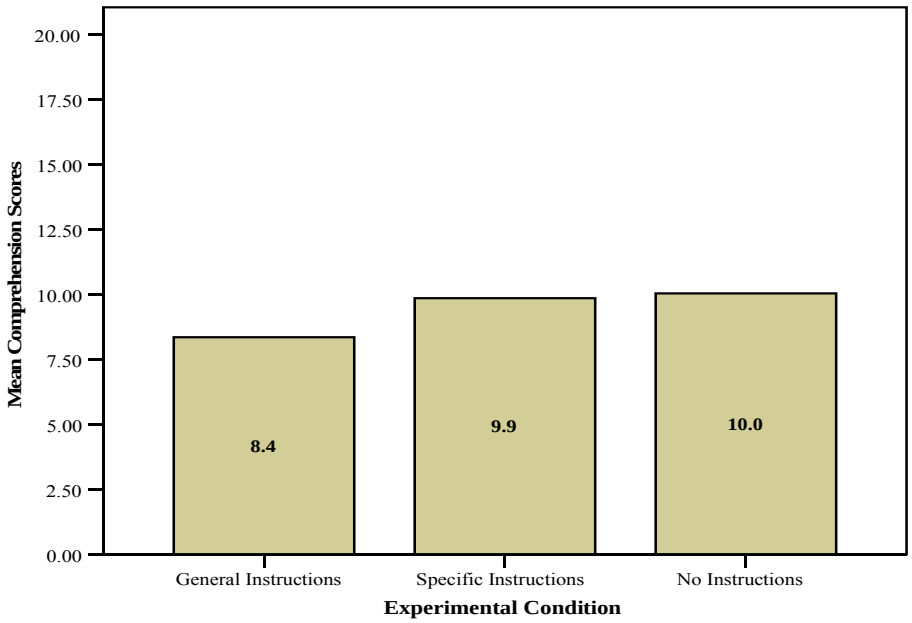


Figure 5.6: Comprehension scores

5.3.4 Hypertext strategies

The strategies that hypertext readers used during reading were made known by the think aloud protocols. The analysis of the subjects' transcripts revealed four strategies: a *serial* strategy, a *serial overview* strategy, a *mixed* strategy, and a *mixed overview* strategy. Figure 5.7 shows the number of subjects who used the different strategies. The *seriar* strategy was used by 19% (8) of the subjects. The *serial overview* strategy was use by the 16.7% of the subjects which count for 7 subjects

out of 42. The *mixed* strategy was used by 9 subjects, which count for 21.4%. Finally, the strategy with the highest percentage, 42.9%, is the *mixed overview* strategy, which was used by the majority (18) of the subjects.

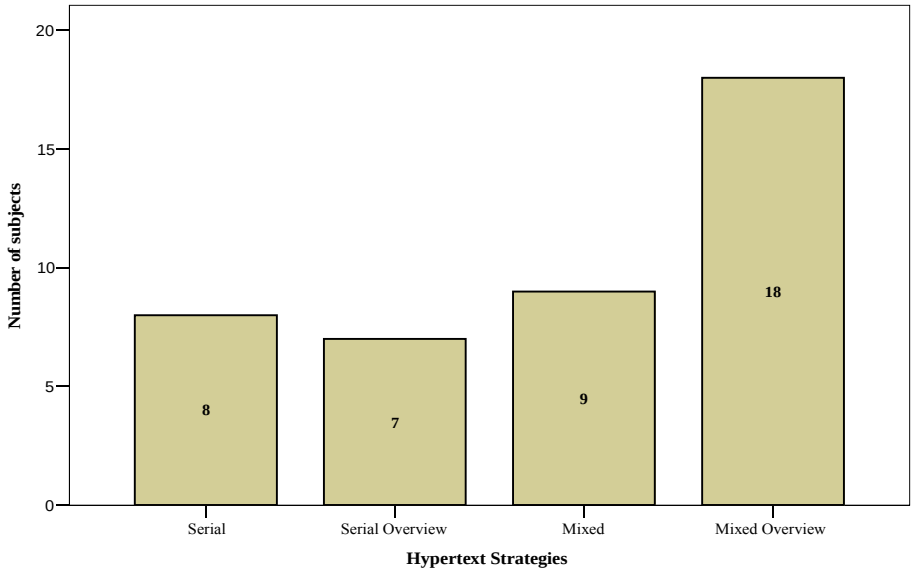


Figure 5.7: Hypertext strategies

5.3.4i Serial strategy

In the *serial* strategy subjects read the hypertext in a linear manner following the presentation order of the links. In other words, subjects followed the first link they came across without scanning or searching the document to see, what other links were available. For instance, subject 1 produced the verbalisation seen in Figure 5.8. That subject choose all the links in their presentation order as one can see in the lines 11 (*United States*), 15 (*In Canada*), 19 (*In New Zealand*), 23 (*Australia*), and 20 (*Indigenous Australian epistemologies and economics*). The first four links are presented as bullet points, thus there is not explicit order. However, subjects choose to read them from top to bottom in a serial/linear manner. Furthermore, subject 1 stated in line 10 that he/she does not know which one is the next page. That means

that he/she expected to find clues pointing towards the way the hypertext should be read. This reading pattern was evident throughout the hypertext.

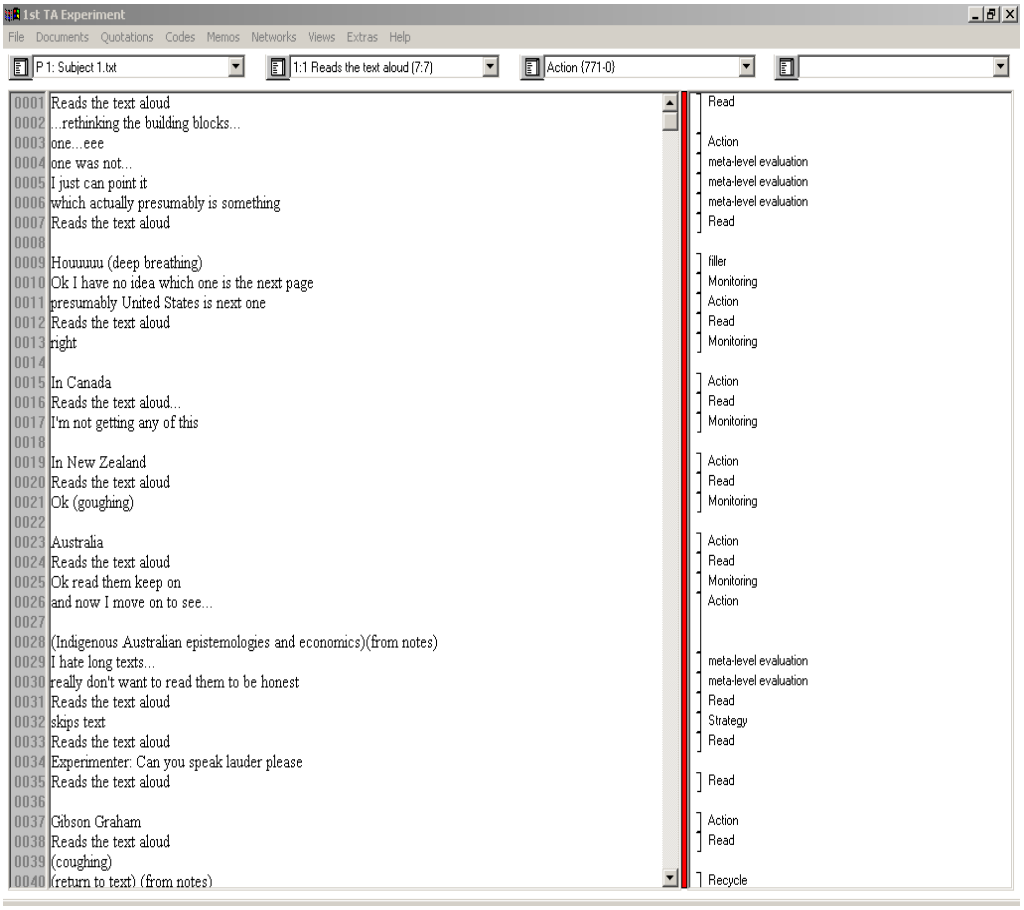


Figure 5.8: Subject's 1 protocol

Similarly, subject 3 produced the utterances presented in Figure 5.9. The protocol is very similar with the one produced by subject 1. Subject 3 choose the hypertext links in their presented sequence as it is evident from the lines 6, 9, 13, 19, 29, and 37 in Figure 5.9.

All subjects who were allocated to the *serial* strategy produced similar protocols with the ones described above and the same reading pattern was applied throughout the hypertext. The subjects selected the first link they came across and as soon as

they had to select another one, they again selected the first link presented after the one already read. This pattern was kept throughout the document.

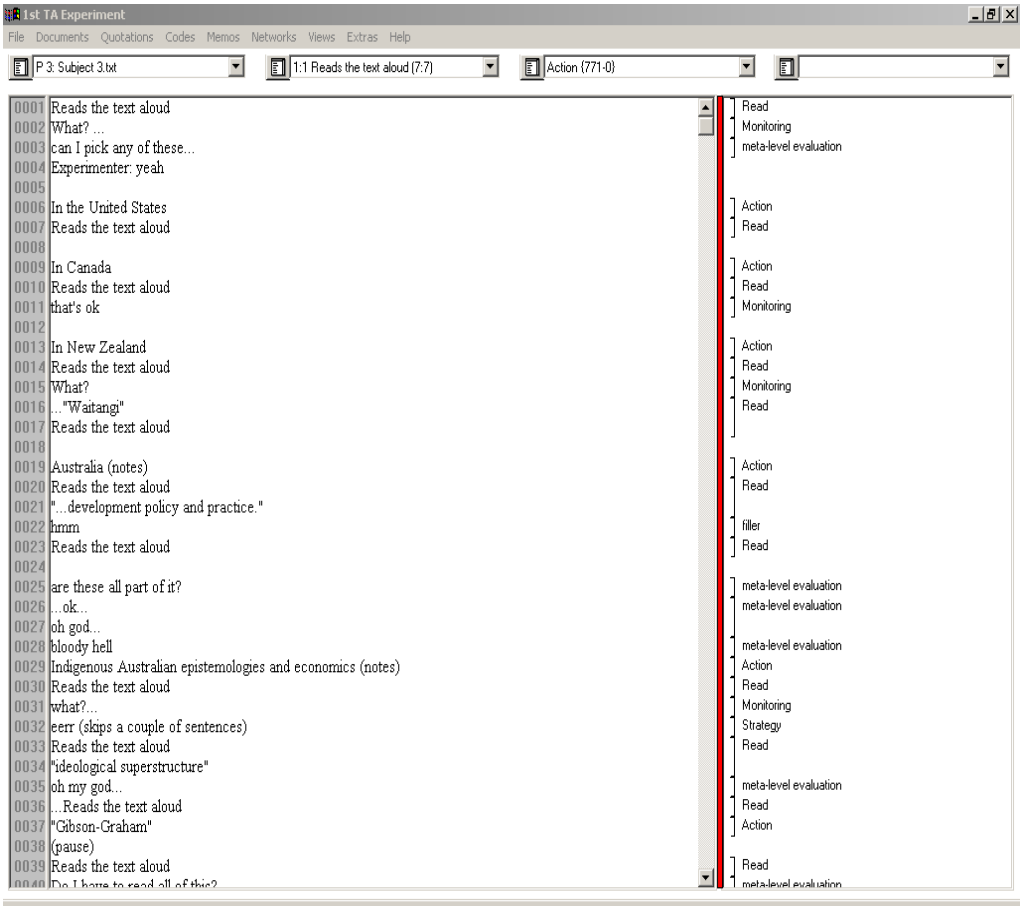


Figure 5.9: Subject's 3 protocol

5.3.4ii Serial overview strategy

In the *serial overview* strategy readers read the document primarily in a linear fashion. In that sense this strategy is the same with the one described above. Nevertheless, the difference lies in a scanning process that subjects used sometimes, before reading started and some others during reading. Subjects scanned the document to see what links were available and then chose one to proceed with, in a serial manner. The number of subjects using this strategy was the smallest and only seven subjects used

this strategy. An example of subject's (2) protocol using this strategy is given in Figure 5.10. It is clear from the verbalisations in lines 10, *first one is In United states*, 13 *and the next one is in Canada*, 16 *The next link is in New Zealand*, 19 *The next one is in Australia*, and 23 *click on Indigenous Australian* that subjects select the hypertext links in their presentation order, but before that in line 8 and 9 (*There are some links*, *and I'm about to click on them*) the subject scanned the document and got an overview of the links.

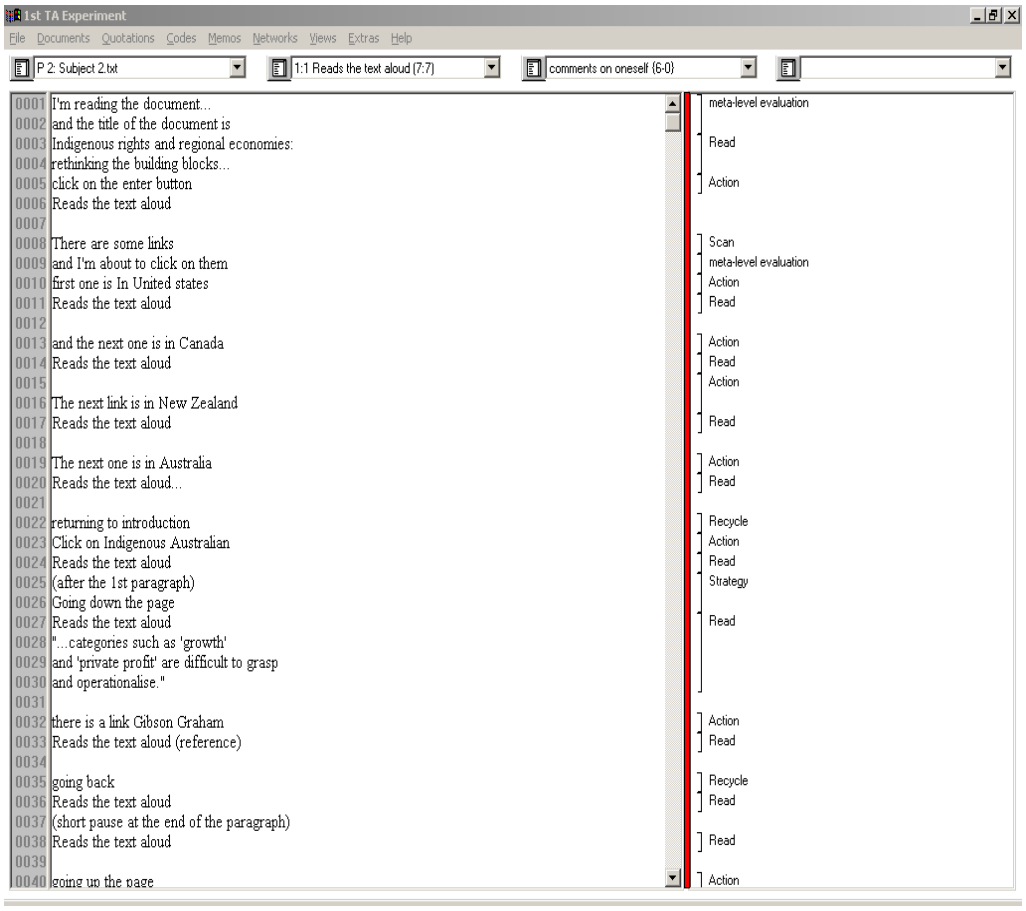


Figure 5.10: Subject's 2 protocol

Similarly, subject 25 (see Figure 5.11) at a different part of the hypertext, while reading the node under the link *key ideas in regional development discourse*, line 41, came across a few links. The subject then scanned through the links, by reading

quickly the available links, (lines 43, 44, 45, 46, and 47) to get an overview of the available information, and proceeded with reading the presented information by selecting the links based in their presentation order, in a serial manner. This indicates that the subject (25) selected the first link he/she came across as it is evident from the line 49, by selecting the link *planning*, and continuing with the links *Escobar 1992* in line 52, *management* in line 62, *capacity building* in line 75, and *institutional strengthening* in line 79 in the think aloud protocol in Figure 5.11.

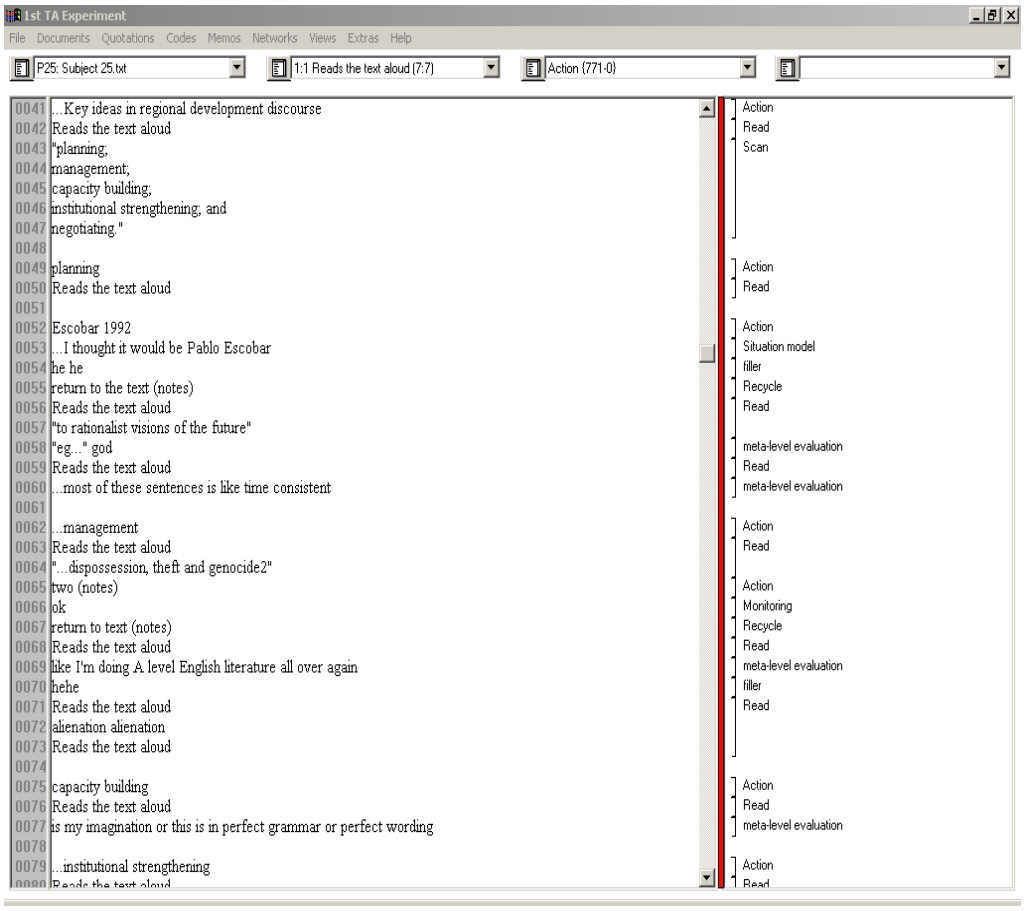


Figure 5.11: Subject's 25 protocol

5.4.3iii Mixed strategy

In the *mixed* strategy readers chose some links in a linear fashion while others in a random fashion. There was no scanning or over-viewing process taking place during reading. Readers selected the hypertext links as soon as they came across them. Subjects that have changed even once the way they followed the hypertext links from serial to arbitrary manner and vice versa were allocated in the mixed strategy.

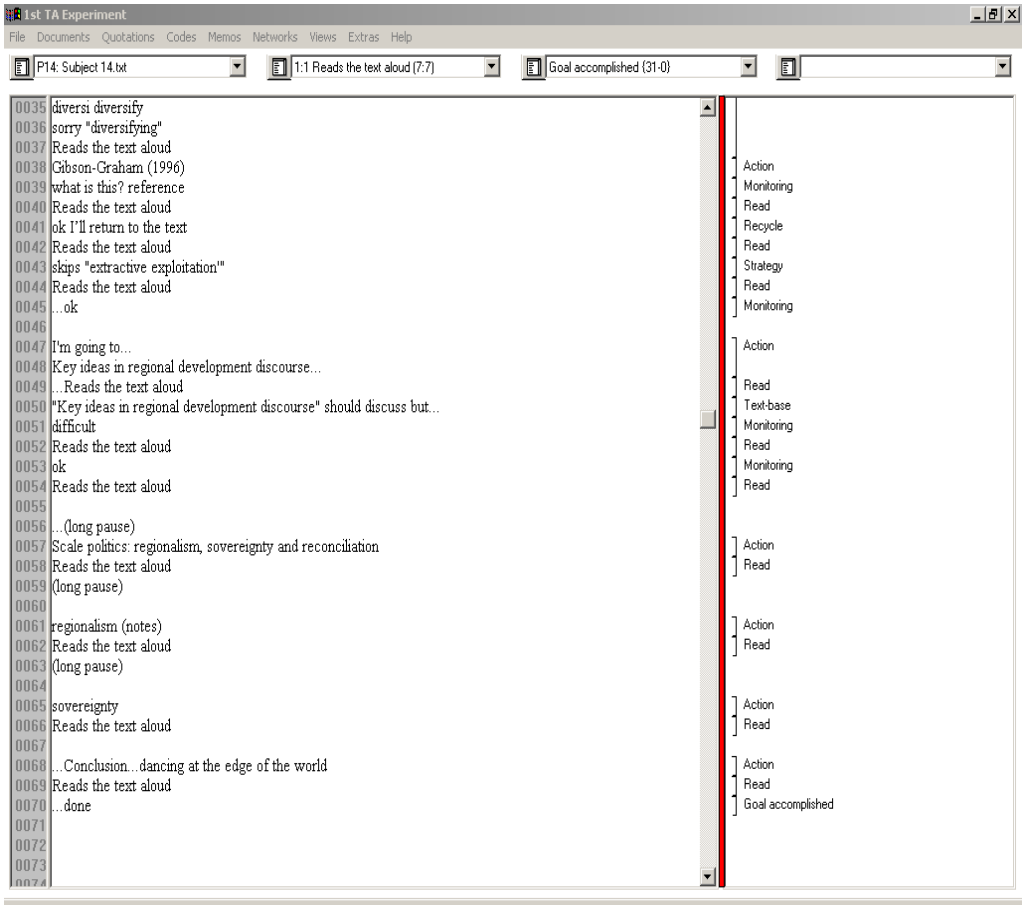


Figure 5.12: Subject's 14 protocol

An example of a protocol illustrating the mixed strategy can be seen in Figure 5.12. Subject 14 has started reading the hypertext in a linear fashion, selecting the links in their presentation order. For instance, subject 14 reads the node under the hypertext

link *key ideas in regional development discourse* in line 48. Under this link there are five other links expanding on the information presented here. However, the subject skipped all the sub-links breaking the serial reading he/she has been following until now. Following, subject 14 moved on to the link *scale politics: regionalism, sovereignty, and reconciliation*, in line 57. That link is exactly underneath the previously chosen link, thus the subject re-established his/her serial reading. However, again after choosing two other links in a serial manner, in lines 61 the link *regionalism*, and in line 65 the link *sovereignty*, he/she jumps away from the rest of the links and goes directly to the *conclusion: dancing at the edge of the world* hyperlink, choosing it in an arbitrary way. Subjects that used this strategy did not try to gain an overview of the available links but they rather selected the links sometimes in a serial/linear fashion while some other times in an arbitrary/random manner.

In the same vein subject 40 used the mixed strategy. Figure 5.13 presents a part of the subjects think aloud protocol. In line 215 the subjects selected the link: *scale politics: regionalism, sovereignty and reconciliation*. There were 3 sub-links in this node and subjects 40 selects first the link *regionalism* in line 223, then *sovereignty* in line 226, and then the link *reconciliation* in line 236. The links were selected in their presentation order, demonstrating a serial reading. However, the next selected link was the *conclusion* one in line 243. That link was selected in a non-serial way, breaking away from the previous reading pattern. All subjects allocated to this strategy used the same pattern during hypertext reading.

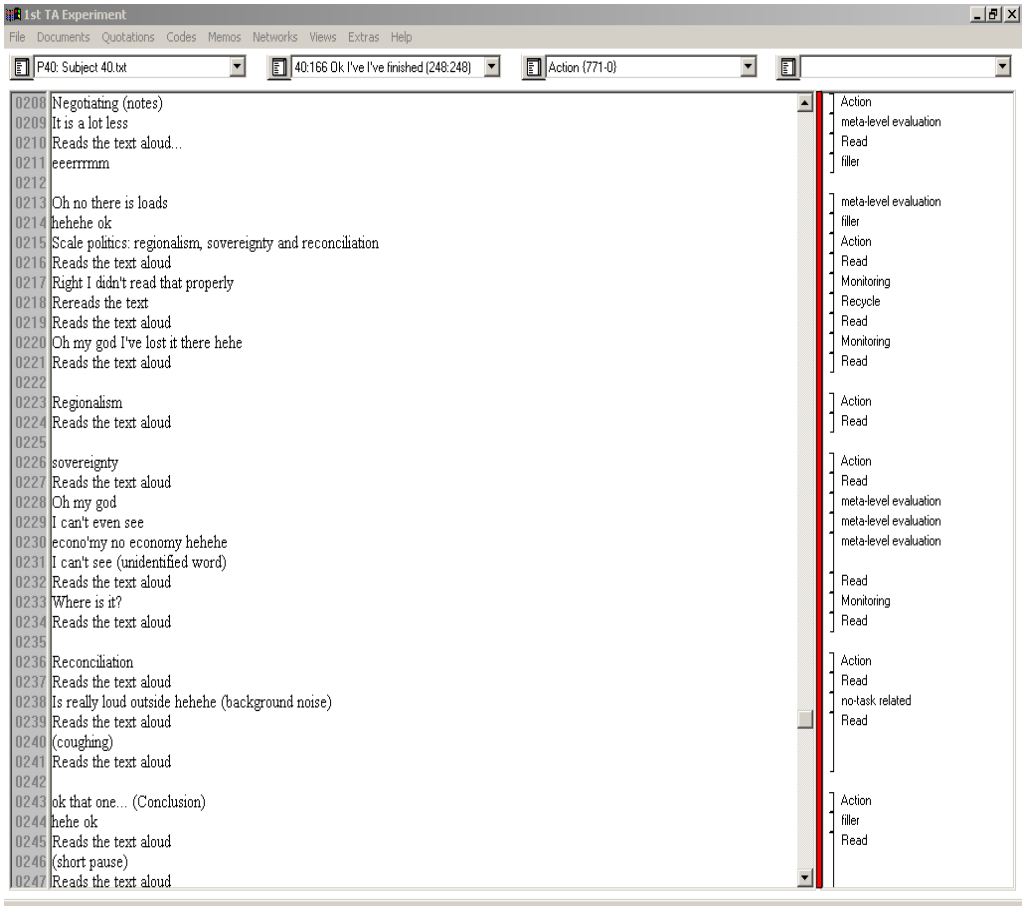


Figure 5.13: Subject's 40 protocol

5.4.3iv Mixed overview strategy

The fourth strategy is a rather more sophisticated strategy, and it is called the *mixed overview* strategy. It is called *overview* because subjects scanned the document to see what links are available either before they started reading or during, and then chose one to proceed with. Furthermore, they proceed with the links sometimes in a linear and sometimes in a random fashion, hence in a *mixed* manner.

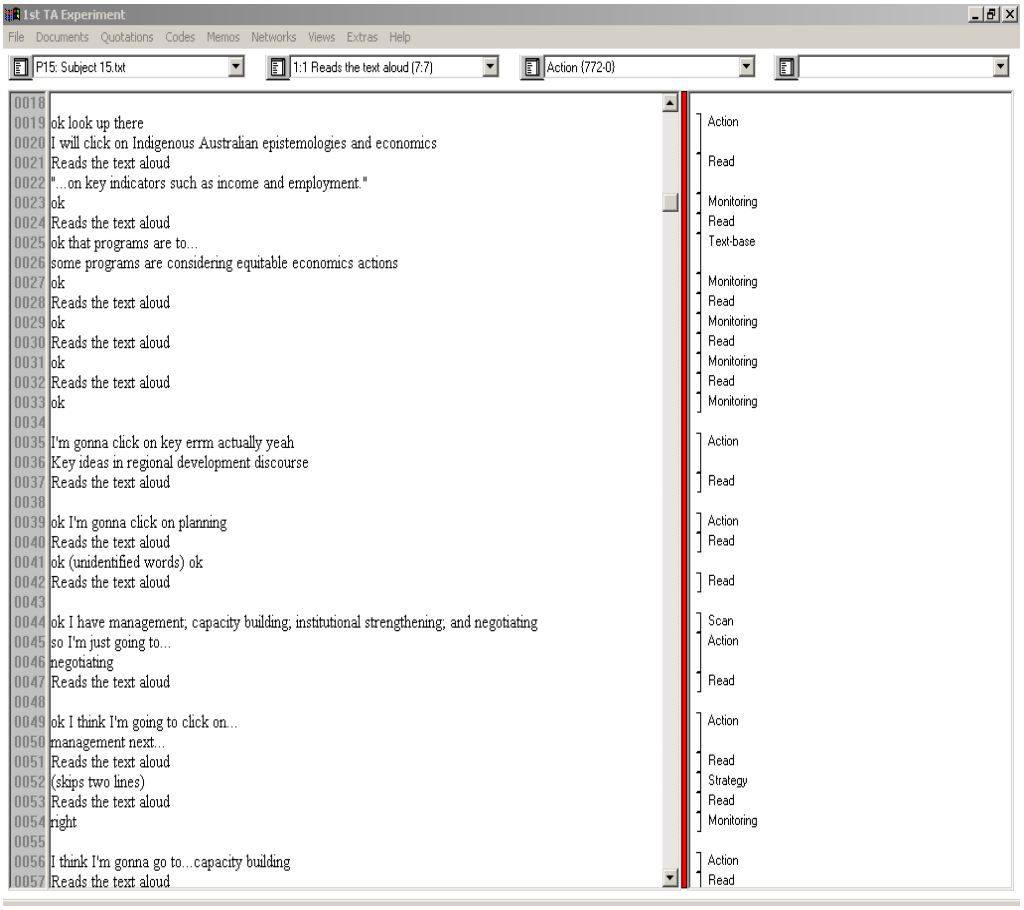


Figure 5.14: Subject's 15 protocol

An example of subject's (15) verbalisation using this strategy is given in Figure 5.14. Subject 15 says in line 20: *I will click on Indigenous Australian epistemologies and economics*, which is a hypertext link leading to a node. After that moves on to the next link called *key ideas in regional development discourse* in line 36, which is presented just underneath the one before. Next, the subjects selects the link *planning* which is the first link that he/she came across in the *key ideas in regional development discourse* node. All the link choices until now were made in a serial manner. Continuing reading the hypertext, the subject scans the available links, line 44, by saying: *ok I have management; capacity building; institutional strengthening; and negotiating*, over-viewing the available information. Afterwards, he/she selects the link *negotiating*, line 46, which is the last presented link, changing from the serial way used earlier to an arbitrary or random one. Then again, the subject will select the

next two links, *management*, line 50, and *capacity building*, line 56 in a serial manner changing his/her approach again. Verbalisations like those reveal that subjects may change their approach of a hypertext document many times during reading, by using a strategy with various different styles.

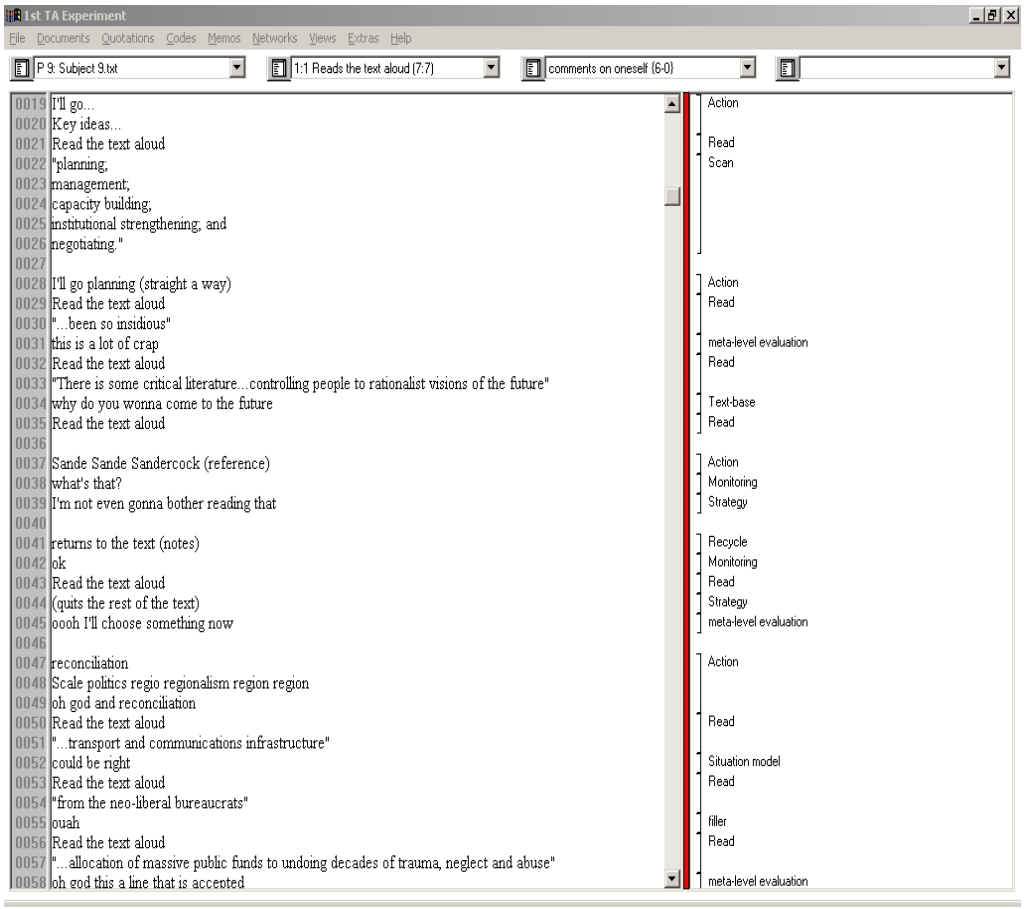


Figure 5.15: Subject's 9 protocol

Another example of verbalisation that indicates the *mixed overview* strategy is, subject's 9 verbalisation, presented in Figure 5.15. Subject 9 selected the link *key ideas in regional development discourse* by saying in lines 19, 20: *I'll go...*, *Key ideas...* Then he/she overviewed the available links, *planning*, *management*, *capacity building*, *institutional strengthening*, *negotiating* in lines 22, 23, 24, 25 respectively, before choosing the first available link, *planning*, in line 28. Such verbalisations

demonstrate the serial and the overview aspects of the *mixed overview* strategy used by subject 9. Then the subject selected a link leading to a reference node, again in a serial manner. Afterwards, all of a sudden he/she changes the way he/she selects the hypertext links by jumping to the *scale politics: regionalism, sovereignty and reconciliation* link in a random fashion. The subject decided for no obvious reasons to break his/her pattern and to not continue following the hypertext links existing in that node, but rather to select the next hypertext link to follow in a random way. That link was positioned in the menu provided in the hypertext document at the left hand side of the hypertext, while the ones followed before were embedded in the text.

Similar patterns were used by all the subjects in the mixed overview strategy.

5.3.5 Effect of different reading goals on hypertext strategies

The think aloud protocols reveal four different strategies, but it is not known, if the different reading goals arriving from the experimental conditions have influenced the use of strategies. Subjects from all three different conditions used all strategies. The *serial* strategy was used by three subjects with general instructions, by four subjects with specific instructions, and by one with no instructions. The *serial overview* strategy was used by three subjects with general instructions, one with specific instructions and three without any instructions. The *mixed* strategy was spread equally among the tree different conditions with three subjects from each condition. The *mixed overview* strategy was used again by subjects in all three conditions and it was the most often used strategy in all conditions compared to the other three. The spread of the three different conditions was as follow: five subjects in the general instructions condition, six in the specific instruction condition, and seven in the condition without any instructions. Figure 5.16 shows the different strategies according to each condition. The most often used strategy is the *mixed overview* strategy regardless the experimental condition.

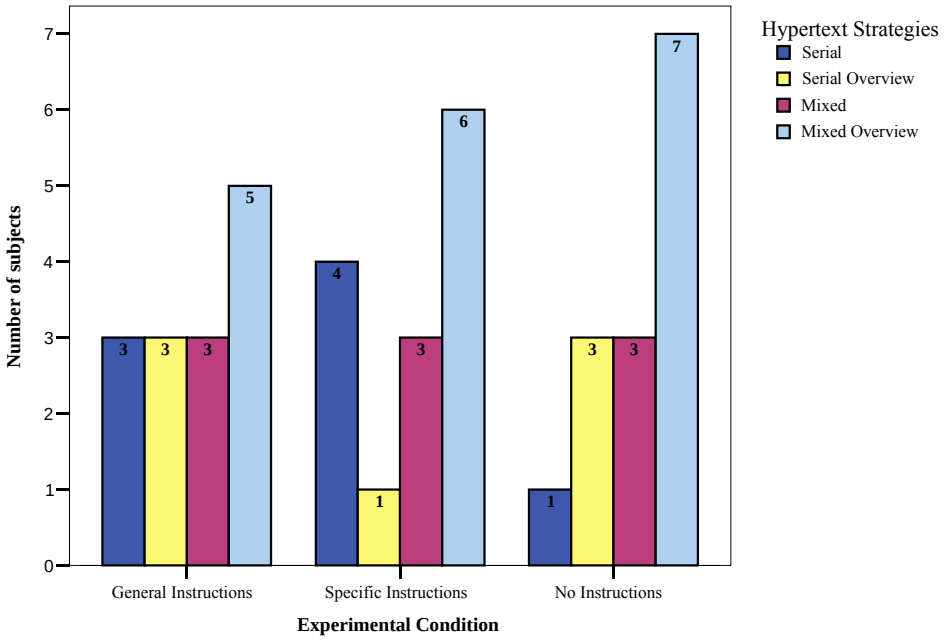


Figure 5.16: Strategies used by subjects

In order to analyse the relation between the different conditions and the strategies used by subjects a two way ANOVA unrelated was performed. The analysis of readers' strategies per condition shows that there was no significant difference between different conditions and the use of strategies, $F(3, 38) = .335$, $p = .800$. That means that the different reading conditions did not influence the strategies that hypertext readers used.

5.3.6 Analysis of the amount of hypertext visited/read

Another way to examine the strategies subjects used is to analyse the amount of hypertext nodes the subjects actually read. That approach shows, if subjects have taken advantage of the hypertext features that permit them to locate specific subsets of information quickly or, if they needed to visit most of the presented information to

locate what they are seeking. Figure 5.17 shows the mean percentage of the nodes per condition. A node was considered visited, if a subject had selected the node at least once. Very rarely subjects changed hypertext nodes without reading them. Thus all the visited nodes are considered as read. The amount of text each subject read and the nodes that he/she visited were revealed for the think aloud protocols, where subjects read out loud the presented information.

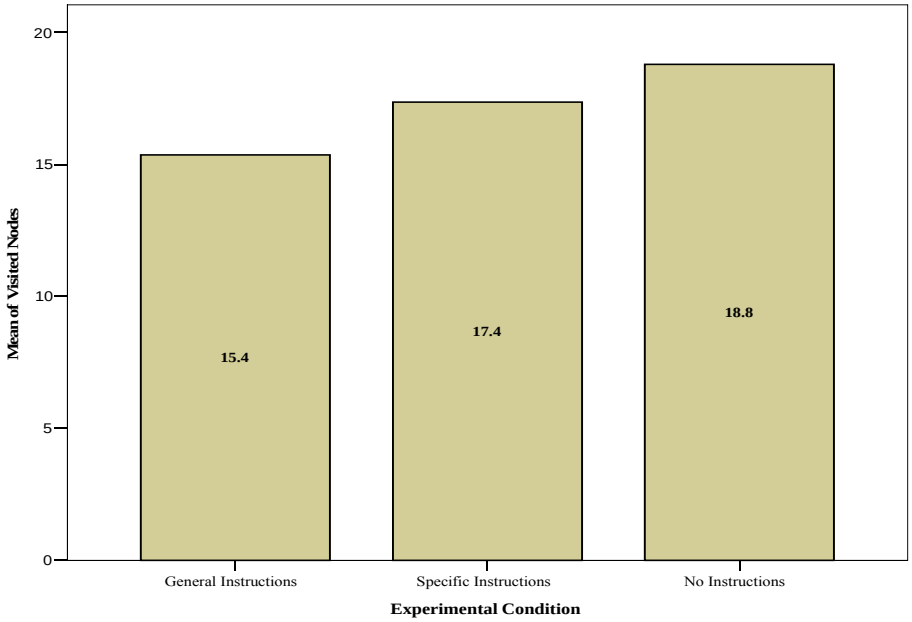


Figure 5.17: Mean of visited nodes per condition

The total number of the hypertext nodes read by subjects was calculated. The maximum amount of visited nodes that a subject could read was 23. Subjects visited 731 nodes in total. The range of visited nodes varies between 6 and 22 as Figure 5.18 shows. The mean number of visited nodes was 16.9 nodes per subject. There was no significant difference between the hypertext nodes that the subjects read based on the different reading goals (F (2, 39) = 1.253, p=.297). Nevertheless, there was a difference between the groups with no instruction group having the highest mean (18.79), the specific instruction group having the second highest (17.36), and last was the general instruction group (15.36). A post hoc test was conducted (Tukey

HSD) to examine, if there is any significant difference between groups. The test indicated that there was no significant difference between general instructions and specific instructions groups ($p>0.05$), between general instructions and no instructions groups ($p>0.05$), and between specific instructions and no instructions groups ($p>0.05$).

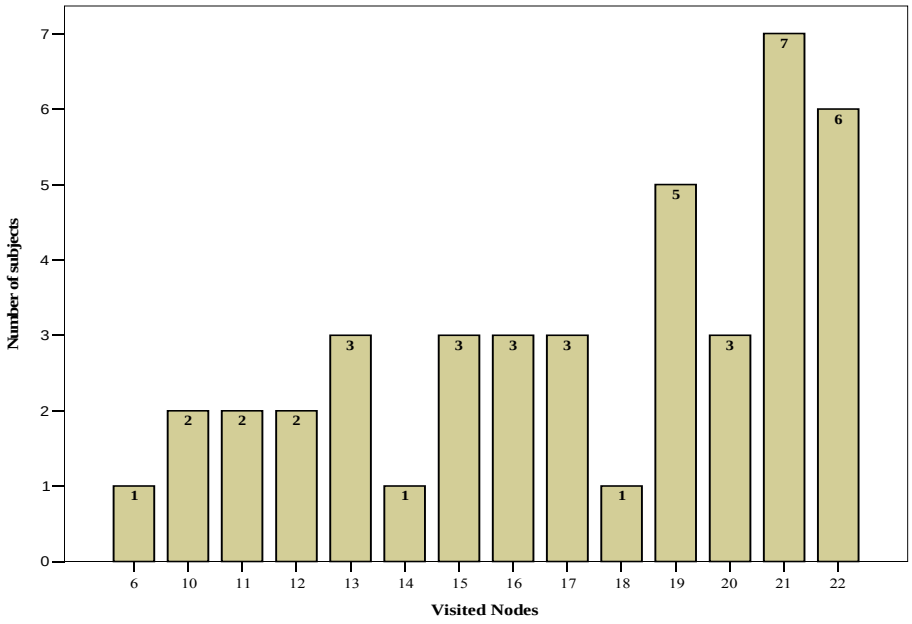


Figure 5.18: Number of visited nodes by different subjects

5.3.7 Factors influencing navigation strategies

The rules subjects use to get to the different nodes of the hypertext need to be considered in order to improve reader behaviour and development of electronic documents. The study revealed three such rules: coherence, personal interest, and link position.

5.3.7i Coherence

Coherence is a fundamental characteristic of comprehension in traditional documents. A coherent transition in the hypertext was considered a transition from one node to another in which both nodes were still within the same context. This included such cases as jumping to a parent, or child or sibling of the current node. In addition, cases such as following the presentational order of the nodes, which is closely related to the hierarchical structure, were considered coherent transitions. For instance, under the Introduction hypertext link there are four child nodes. Selecting any of the nodes in any order was considered as a coherent transition because all nodes are within the same context. If a participant chose to select another link from the menu without selecting any of the local links, that transition was considered as non-coherent. Each node was only counted once (first visit) regardless that some of the nodes might have been visited again after the first visit. Subjects tended to revisit some nodes for review purposes towards the end of their reading. However, the present study focuses on the first visit.

Subjects visited 730 nodes in total. Subjects made 93.70% of their transitions in a coherent way regardless of their experimental condition. Subjects in the general instructions condition made the fewest coherent hyperlink transitions with 14.67 transitions. Next was the specific instructions condition with 16.07 coherent transitions, and the condition with the most coherent transitions (18.21) was the no instructions condition. There was not a significant difference between the different conditions and the coherence of the link selection ($F(2, 39) = 2.235$ $p=.120$).

The majority of the subjects made coherent transitions between the different hypertext nodes. Even subjects who used the mixed overview strategy made the majority of their transitions in a coherent way. For instance, subject 4 chose to follow the presented sub-links in the Introduction node in a random fashion but without braking away from the node's contexts, by selecting all the sub-links belonging to the same context first and then move on to another node with different context. Thus he/she was not influenced from the positioning of the links but read the information in a coherent way.

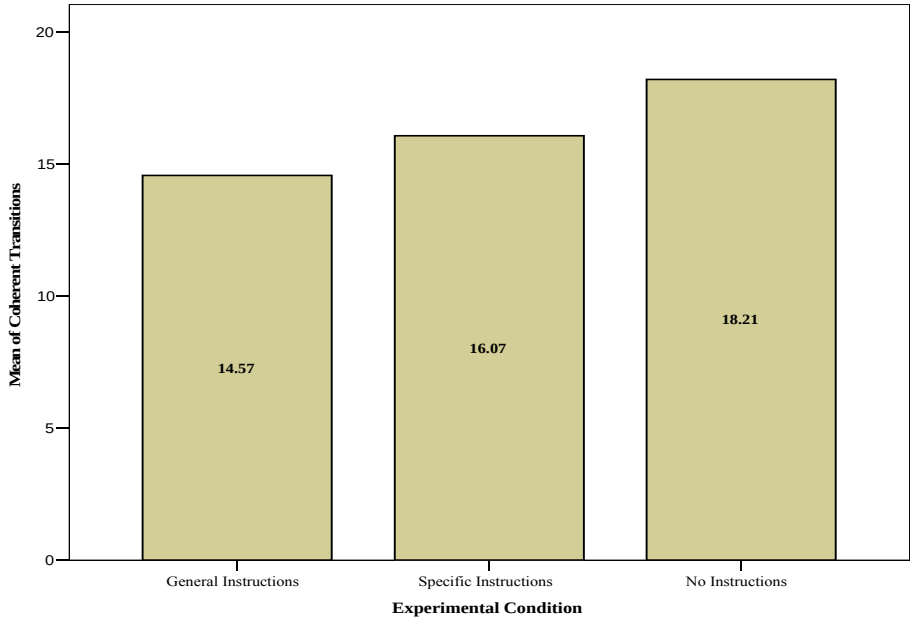


Figure 5.19: Number of coherent transitions per different condition

5.3.7ii Personal interest

The results show that another factor that influences readers' choices is personal interest. In general, when individuals show positive or negative feelings toward an activity, it is considered as interest (Schiefele, 1991 cited in Alexander & Jetton, 2000). Personal interest has influenced both the subjects reading patterns and the selection of the links. Subjects chose to read or to quit reading based on their interest or the lack of it. An example of subject's (5) verbalisation that influences the reading is the following:

Reads the text aloud
again I would agree with that errr although I didn't know they
were to to considering public health and well (unidentified word)
systems and if they indeed do that it would be interesting to find out where that...
the people that mainly use these
and I would imagine is the indigenous people eerrm
are actually would become better or worse off...
eerr

Reads the text aloud

Subject 5 found the information he/she read interesting and that made him/her to continue on reading.

Moreover, some other verbalisations illustrate that interest has influenced the selection of links. For instance, subject 24 gave the following verbalisation when choosing a link:

Key ideas in regional development discourse
Reads the text aloud
"They are:
planning;
management;"
ok
planning sounds interesting
Reads the text aloud
Ok

The subject found the link interesting but he/she does not explain the reason behind his/her assessment. On the other hand, subject 42 was interested in a link concerning a reference to an author and expressed the reasons for that interest by referring to his/her knowledge about previous work of her:

this woman ("Le Guin")
Ursula Le Guin I guess (clicks)
that's weird
oh yeah on
I'm quite interested now
Cos I've read some of her sci fi books
And though she is quite interesting

There is no justification by most of the subjects about why some information captured their interest. However, many of the subjects expressed their interest or the lack of it about the presented information. It is clear that interests are having a significant effect on the reading processes. Scholars suggest that there is a need for a more systematic

focus on interest and motivational factors, in reading in general and in hypertext environments in particular (Leu & Reinking, 1996).

5.3.7iii Links location

However, for the majority of readers the location of the links seems to be the determinant factor for choosing a hyperlink, starting from left to right and top to bottom, following the regular reading pattern. Users tended to select the first available link while reading. Every selection of hypertext link was considered and counted including those that the subjects selected more than once. The 42 subjects produced a sum of 865 links selection. From those links 87.51% was selected based on their location in the hypertext. Hence, subjects selected those links as soon as they met them following their reading pattern. Only 12.49% of the hypertext link selection was made in a different way not based on their positioning in the hypertext.

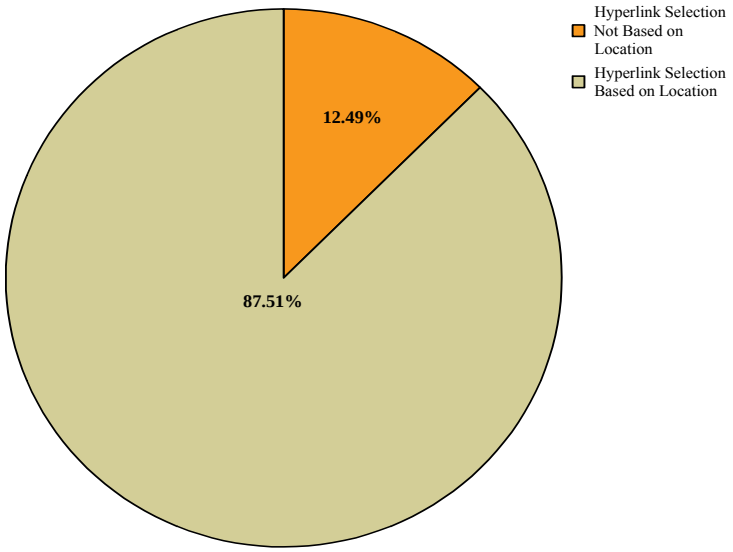


Figure 5.20: Selection of hypertext links based on their location

5.4 Discussion

5.4.1 Model

Text comprehension is a goal-oriented process of the human cognitive system, in which readers actively select and process information in order to construct mental representations (Schnotz & Bannert, 2003). Thus, a comprehensive model of hypertext comprehension should take this active and constructive nature of information process into account. Such a model should also take into account that people might access information in different ways using the necessary cognitive process in different sequences. The proposed model does exactly that, by including alternative sequences of processes and thus acknowledging its importance. The current results fully support the proposed hypertext reading comprehension model, because 100% of the task related verbalisations fit within the model. Therefore the results support the hypothesis because the hypothesis stated that, if the model is precise then the subjects' verbalisations should fit in the model. Nevertheless, no unpredicted processes occurred in the think aloud protocols demonstrating that the model is highly successful in predicting the subjects' processes during reading. Unpredicted processes that occur in the protocols show that a model is false (van Someren et al., 1994). Furthermore, the same applies for processes not found in subjects utterances but they were predicted by the protocol (van Someren et al., 1994). There were not such cases in the subjects' protocols. The current results are significant considering the large number of participants for a think aloud study.

The results indicate that hypertext users might either start reading the presented information straight away or they might scan the document to see what is available before they start reading. However, it is surprising that not many subjects scanned the document at the beginning of their reading, and instead they started reading immediately as they would probably do with a conventional text book. The vast majority of the subjects, 71.4% of them, chose to read the hypertext without scanning the available categories at the beginning of their reading. These results are in line with the findings of Hornbæk & Frokjær (2001). They found that only 30% of the subjects participating in their study spend time in the initial orientation phase as they called it, which is similar to the scan process in the proposed model.

Furthermore, subjects rarely used the scanning process even later on during reading as the 1.5% allocated to the scan category demonstrates. That finding is surprising as it was expected that the majority of the readers would take advantage of the hypertext's flexible nature by over-viewing the presented categories of information before they start reading. An explanation for this behaviour might arrive from the fact that the hypertext is organised hierarchically, which one can claim that this drives the subjects to access the hypertext in a conventional way, since hypertext navigation is highly dependent on the document's structure (Herder, 2003). However, this argument can not fully explain subjects' behaviour, because at least one of the experimental conditions used seem to lead to a more selective behaviour. Participants allocated in the specific condition had the opportunity not to follow the hypertext hierarchy because they were asked to locate and read the information about a specific topic, the *Key ideas in regional developing discourse* topic. This information was contained in a node under a hypertext link with the same name as the given topic. Thus, readers would not need to follow the inherited structure but they could easily scan the information to locate the relevant hyperlink. However, their condition did not influence their way of reading.

A much more plausible explanation for the subjects' failure to take advantage of the flexibility (subjects could easily locate and access information, create their own sequence etc…) that hypertext documents might offer, can be the lack of relevant schema referring to hypertext reading and navigation. Thus readers apply schemas referring to reading traditional linear text books in order to overcome that deficiency. For instance, subject 1 says: *ok I have no idea which one is the next page*. Such expressions show that readers expecting a sequence in the text. In addition, the use of the word "page" shows that they approach hypertexts thinking in traditional reading terms. Furthermore, subject 2 selected the links in the order they were presented but used words that illustrate that he/she believes this is the order he/she should select, by saying: *the next one is*, *or next link…*. This behaviour illustrates that readers use background knowledge or schemas about texts to read documents for which they lack the relevant schemas or knowledge. Research in the field (Dillon, 1991, 1996b; Gillingham, 1996) has proven that to be true. Besides, Dillon (1996b) argues that the lack of standards in electronic documents development means that readers can not acquire skills from one document that could be valuable during the use of another.

However, these hurdles may be overcome and readers will develop the appropriate schemas for hypertext documents as they get more familiar with the new information technologies, since such technologies are becoming part of everyday life. In addition, users will receive training, will be taught the appropriate strategies, and will be given the appropriate instructions, given that ICT technologies will become more established in the academic curricula.

Another notable finding was that the majority of the produced codes, 30.6%, in the think aloud protocols were allocated into the read coding category. That finding illustrates that reading remains the dominant activity in hypertexts. In addition, two other model components closely related to reading and comprehension, the text-base and the situation model of the presented information count for the 4.8% and 3.9% respectively. Those results show that reading and comprehension are very closely related and reinforce Thüring et al. (1995) view that the major purpose of reading a document is comprehension and reading a hypertext is no exception. Moreover, such findings do not support claims (Landow, 1997; Slatin, 1990; Sutherland-Smith, 2002) which advocate that reading in a hypertext environment is different compared to traditional reading of text books. Also, the fact that the representation of knowledge itself plays such a dominant role in the hypertext environment provides the perfect justification for adopting elements from van Dijk's and Kintsch's (1983) text comprehension model into the current model.

Another component of the model that seems to play a vital role in reading and comprehension in hypertext environment is monitoring. The 15.3% of the codes that the subjects produced belong to this category. Monitoring is a fundamental process in reading in traditional paper-based environments. However, the current study proves that it is essential in hypertext reading as well. Its importance arrives from the fact that it is the third highest process used by the subjects in the current study, being just (0.3% difference) behind the action process. One can assume that in hypertext, monitoring is even more essential because the reader needs to be aware of his/her position in the hypertext structure, something that is not always needed in traditional text books since the way readers move, most of the times, throughout the document is fixed. This additional awareness might explain why monitoring was the third most frequently used process by the participants. However, that extra load can be

cognitively costly for the readers because it requires more cognitive recourses compared to traditional texts. Macedo-Rouet et al. (2003) for instance, has shown that hypertext increases readers cognitive load compared to traditional printed material. Comprehension monitoring is largely enabled by prior knowledge. Much of whether a text is comprehended or not, is based on whether the message abstracted from the text makes sense relative to what the reader already knows about the topic of the text. Monitoring also involves awareness of how the new information relates to old knowledge and whether one's personal prior knowledge permits full appreciation of the text (Pressley & Afflerbach, 1995).

Furthermore, van Oostendorp and de Mul (1996a) argue that hypertext readers process text in a cycle that includes the selection of relevant passages and the evaluation of goal achievement, without that being compulsory in linear texts. The proposed model proves that claim with the *selection of the link* and the *monitoring* components and their emergence in the participants protocols. In addition, the model assumes either the one to one interaction between the different components or the circular process among the components.

5.4.2 Comprehension

Because goals influence learning for linear texts it is important to consider how they effect reading and learning in hypertext environments as well (Last et al., 2001). The results show that there is no significant difference on comprehension between the different reading conditions. The results contrast the hypothesis that subjects in the general condition will show higher understanding than any of the other conditions and subjects in the no guidance condition will also show better understanding than subjects in the specific condition because their conditions will facilitate better overall learning since their focus will be on the presented topic in general and not on certain fragments compared to the specific condition. Foltz (1996) found similar results between general and specific reading goals on three different text formats: linear, hypertext and coherent hypertext. Furthermore, the current results partially agree with the results found by Schoeller (2005). Schoeller (2005) found that different reading goals have an effect on learning but only for those participants who were

allocated to the heading condition. She found no significant effect for the participants who were allocated into the no headings condition, which is a similar to the results found in the present study.

However, in the present study, overall the comprehension scores were not that high, indicating that subjects had not performed that well. One of the reasons for this deficiency on comprehension is the lack of background knowledge. Subjects did not have the necessary background knowledge of the subject matter to build a complete situation model, resulting into incomplete comprehension and therefore low comprehension scores. In addition, the lack of comprehension can be explained based on the features of the hypertext. The features of text have a large effect on comprehension. Comprehension does not occur by simply extracting meaning from the text. In addition to content, the vocabulary load of the text and its linguistic structure, discourse style, and genre also interact with reader's knowledge (RAND, 2002). Subjects seemed to have had difficulties with the experimental hypertext in some of those characteristics as it is evident from their think aloud protocols. At the vocabulary level for instance, subjects often express their lack of knowledge about words. However, that problem can be overcome with the use of definition links. Definition links connect the use of special or unknown terms to their definitions so it would be easier for the readers to determine quickly the meaning of these terms (Blustein, 2000). Additionally, participants often expressed their unfamiliarity with the discourse style, since it was a scientific conference paper. The text characteristics influence reading comprehension and so they have influenced the understanding of the experimental hypertext. Different types of texts create different expectations in readers (Charney, 1994, p. 245).

5.4.3 Reading times

The current results, contrary to the hypothesis, which had predicted that subjects in general condition will take longer to read the material than the subjects in the specific condition and subjects in the no guidance condition will need more time to read the material than the subjects in the other conditions, did not reveal any significant difference on reading time between the conditions. However, there was a

difference between the two groups in absolute reading times, with general question condition taking longer than the specific question condition. Similarly, Schoeller (2005) found no significant difference in reading time between different reading goals while reading in a computer mediated environment. She asked participants to study the text in order to teach it, to undergo a test, and to learn it. However, she found that there was a significant difference with the time participants spent in rereading the information. Foltz (1992) found similar results where subjects searching for specific information in three different document platforms, including two types of hypertext, found no significant difference compared to those on the general knowledge instructions. However, he (Foltz, 1992, 1996) found significant difference when he converted the reading times in z-scores[5]. However, Rouet (2003) in a study investigating if general questions would result in longer search patterns compared to specific questions using two different hypertexts found that search time was significantly ($p<0.01$) longer for general questions than for specific ones. Though, Rouet (2003) counted in the search time what he called planning time which was the time spent reading the question and studying the menus. This time counted for about a third of the total search time. This time may have contributed towards this difference by effecting the overall time of reading.

5.4.4 Strategies

The effective use of hypertext documents rely on the effective use of strategies. However, readers need to rely on more than just text strategies (Goldman, 1996). They need to rely on navigation strategies as well. The current research has revealed four such strategies: the *serial*, *serial overview, mixed,* and *mixed overview*.

In the *serial* strategy readers read the hypertext in a very detailed fashion from start to finish selecting the hypertext links as soon as they see them. However, only very few subjects clicked on every link they came across. This strategy indicates that linear reading is still an essential part in hypertext environments. Thus, it seems that

[5] The z score for an item, indicates how far and in what direction, that item deviates from its distribution's mean, expressed in units of its distribution's standard deviation. The mathematics of the z score transformation are such that if every item in a distribution is converted to its z score, the transformed scores will necessarily have a mean of zero and a standard deviation of one.

readers rely on familiar strategies even in hypertext environments. One reason for using the serial strategy might be the fact that readers have not developed the relevant schemata yet, and so they rely on familiar processes and on existing schemata. Leu (2000) for instance, supports that argument by saying that readers are more accustomed to reading from linear texts than hypertext and may need to acquire new strategies for reading in electronic environments. However, in the current study subjects can be considered as relatively experienced since they used the web in regular basis for their studies. Subjects that used the *serial* strategy very often used words that indicate sequence, for instance subject 5 said: *first In the United States…* and *second one is being Canada….* This strategy is similar to the one of the two strategies that Dillon, Richardson, and McKnight (1989) found in traditional paper-based documents and they described it as serial/linear. This strategy is a serial detailed read from start to finish. Moreover, in hypertext environments research (Anderson-Inman et al., 1994; Foltz, 1992, 1996) has shown that strategies based on sequential access of information are largely in use. More precise, Eveland and Dunwoody (1998) found that subjects use linear strategies as well. They studied navigation patterns when using "The Why Files," a Web site that explains science to the general public. They found that participants read the presented information much as they read newspaper articles, in a linear fashion.

The next strategy used by the readers was named *serial overview* strategy. Subjects used this strategy reading the hypertext also in a very detailed fashion as in a serial strategy but in addition they overviewed groups of links especially when those links were grouped together. This strategy is in line with Hornbæk and Frokjær (2001) findings in their study about reading patterns using three different interfaces. They identified one way of reading, consisting of three different phases, used in a different way by different subjects. The stages however, include an initial orientation stage followed by a linear thorough reading and finishing with a review phase. The orientation phase is very similar to the overview phase found in the current study with the difference that the overview phase did not only take place at the beginning of the reading process, as in their study (Hornbæk & Frokjær, 2001), but also at any other time depending on the readers needs. Readers tended to scan and overview the available categories of information, particularly when the links were presented as a list. While, when the links were in the text readers tended to ignore them. The second

phase which included the reading through phase is identical with the serial reading found in this study. The last phase however, the review, can be regarded as similar to the mixed overview strategy where readers accessed some of the links in a random way mainly to fill in the comprehension gaps.

In the *mixed* strategy hypertext readers tended to select the links in a dual way sometimes sequentially while others randomly. The random selection of links seems to offer an explanation for the increased incidental learning reported in hypermedia studies (Egan, 1995 and Leventhal et al.,1993 cited in Crow, 1996) compared to studies with traditional texts. These random selections however, are in agreement with findings from other studies. For example, Last and O'Donnell (2001) stated in their study that a number of participants appeared to make unsystematic and even random selections. They mentioned that these choices were made by students with high prior knowledge of the subject matter. However, the present study indicates that random link selections are also used by readers with low or no prior knowledge of the subject matter, since in the present study all students had no prior knowledge. However, these random selections of some of the links might be proven cognitively costly because combining elements randomly and testing the effectiveness of combinations requires substantial working memory resources (Sweller, 1988).

The last strategy extracted from the readers think aloud protocols is the *mixed overview* strategy. This strategy was the most sophisticated, because readers used all the reading/navigating patterns used by the other readers, together. Thus, in addition to sequential and random way of link selection, readers overviewed blocks of links before they made a selection. Another explanation for readers' random selection of links is in line with the lack of available schema to coordinate the processing of new information. According to Sweller (2003) when learners process well-learned material, the existing schemata act as a central executive when brought into working memory and coordinate the information. However, when learners try to comprehend new information they have problems understanding it, because there is no well-defined, schema-based central executive to deal with the information. To overcome this problem, learners have to use a problem-solving process to determine which relations are appropriate. Some attempts will be random. In the present experiment, subjects had no prior knowledge about the subject matter, so they lacked a central

executive to coordinate the process of information and also the selection of links. In order to overcome that problem they made random selections. This strategy seems to be equivalent to the strategy found by Dillon, Richardson, and McKnight (1989) in traditional text-based documents. They identify a strategy which they described as *to scan-read* in a non serial fashion to rapidly extract relevant information. That indicates that again readers used a strategy that is familiar to them.

Overall, additional support for the current results comes from Anderson-Inman, et. al., (1994) work. They identified three types of hypertext readers on their research with the Electro Text Project. The first one was called *book lover*, a person who typically reads everything in linear form, and uses the available resources carefully. The second type of hypertext reader was called *studier*, a reader who navigates through pages in a linear form, backtracks for reviewing and checking information, and more frequent use of comprehension monitoring questions. The last type of hypertext readers was coded as a *resource junkie*. A reader of this type spends most of his/her time looking for and using resources. It is, in fact, his/her navigation patterns and strategies that are the most varied and complex.

The think aloud protocols revealed the strategies that participants used. However, this study was also concerned on the effect that difference goals might have on the use strategies during reading a hypertext. The results do not reveal any significant difference between the reading goal and the reading/navigation strategies. These results do not support the finding by Foltz (1992; 1996) where he found that readers with different reading goals used different strategies. He found that subjects with a general reading goal used a *depth-first* method throughout the whole hierarchy, and some others used a combination of *depth-first* with *cross-hierarchical* method. However, subjects with specific reading goals used a much more selective method. Perfetti et al. (1999) states that the task or the goal has a strong influence on how readers read. In the same vein, Rouet (2003) states that there is evidence that specific and general questions trigger different search strategies in adult students. Similarly Rouet et al. (2001) found when answering specific questions readers use a *locate and memorise* type of strategy while when answering general questions use a *revise and integrate* search pattern. The current results show no significant difference between the reading conditions and the use of different strategies. The strategies that

readers used did not influence their reading goal since subjects from all different goals used all four strategies.

In conclusion, a variety of results indicate that readers in hypertext environments relay on traditional linear reading to comprehend the material. Even in the *mixed* and *mixed overview* strategies the majority of the link selection was made in a serial manner. This result comes in contrast with the widely advocated liberating nature of hypertext, where readers can follow their own sequence of information by selecting their own links. However, such a view assumes that readers know what information they need and in what order they should read it, which is not usually the case especially when readers read to extract new information.

5.4.5 Visited nodes

One variable affected by the use of strategies during reading is the number of nodes that a reader might read. The hypotheses about the visited links predicted that subjects who have been assigned for the general condition would visit more links than the subjects assigned for the specific condition, and subjects with no guidance would visit more links than the other two conditions. However, the results did not support the hypotheses because they did not reveal any significant difference on the number of nodes that subjects visited in order to complete the task. However, that result seems consistent with the previously discussed findings about the strategies and the comprehension. It is reasonable to assume that, since subjects in different reading conditions used similar strategies in reading the hypertext and there was no significant difference in their comprehension scores, they have probably seen approximately the same amount of nodes.

5.4.6 Factors influencing link selection

The results indicated three factors that play a central role in the link selection. One factor is the *location of links*. There is no extensive research on the role that the

location of links might play in a hypertext environment. Thus the current results offer a valuable insight into the importance of the hyperlinks location into the hypertext.

Despite claims (Bolter, 1992; Landow, 1997; Slatin, 1990) that support that a hypertext has no canonical order and every path defines an equally appropriate reading, there are some limitations on the visual space, because of the two dimensional nature of the screen, and the linguistic sequence of the message that effect the location of the links. In essence, hypertext still influences the sequence of the presented information and the sequence of the links because of these factors. The results revealed that the selection of the links in a hypertext environment is largely influenced by their location. Participants chose the links primarily either from left to right following the linguistic sequence of the information or from top to bottom, particularly when links were grouped together. The current results are similar with the ones found in other studies (Dunwoody, 2001; Eveland & Dunwoody, 1998). The studies show that participants approached the hypertexts (Web-based) as if they were linear stories, moving through the text as they were reading an article in a print format. Furthermore, Eveland and Dunwoody (1998) pointed out that although participants were given the opportunity to jump to another spot at the site, almost no one did so. A possible explanation for this can be again the lack of relevant schema referring to hypertext reading and navigation. Readers apply schemas referring to reading traditional linear text books in order to overcome these difficulties. For instance, subject 1 says: *ok I have no idea which one is the next page*. This subject is expecting a sequence in the text and in addition, he/she approaches the document thinking in book terms by using the word "page". Furthermore, subject 2, who used the *serial overview* strategy not only selected the links in the order they were presented but used words that illustrate that he/she believes this is the order he/she should select, by saying: *the next one is*, or *next link…*. This behaviour illustrates that readers use background knowledge or schemata about texts to read documents for which they lack the relevant schemas or knowledge. According to Charney (1994) readers find it hard to decide an appropriate sequence through material. Maybe that explains why they use familiar patterns (sequential) to access unknown territories, by choosing to follow the hypertext link as soon as they see them following the linguistic sequence, so they would not have to decide which the appropriate sequence is. Similarly, Dee-Lucas and Huston (1999) found in their study that readers that do

not feel confident in their ability to choose the best nodes they may use strategies more appropriate for traditional texts than hypertexts.

Researchers (Eveland & Dunwoody, 1998; Foltz, 1996) suggest that there is a need for some clues that assist linear reading, which comes with the need to understand the concepts underlying the linguistic message. From the presented results it is clear that having embedded links in the text this largely influences the selection sequence, while reading largely resembles traditional text book reading. However, using a network presentation format may conflict with the concept of the linguistic principles of creating a message and communicating the message across. Additionally, the use of different types of links such as menus, indexes, and site maps might offer alternative strategies. Furthermore, it seems that reading instructions can play a vital role in the future providing hypertext readers with the necessary strategies for hypertext environments. Similarly, Dillon (1996b) argues that the lack of standards in electronic documents development means that readers can not acquire skills from one document that could be valuable during the use of another. Nevertheless, Troffer (2000) argues that readers feel comfortable with hierarchical structures because many print texts are organised this way. Researchers have argued that in order to improve hypertext performance and reduce readers dissatisfaction and disorientation, structures should be borrowed from traditional paper texts (Gillingham, 1996).

Readers seem to prefer the sequence of the linguistic message in hypertext environments. Human readers capitalise on the guidance provided by the structure and organisation of words in sentences, sentences in paragraphs, and paragraphs in longer texts. Doing so requires knowledge of the meaning implications of those structures at both local and global coherence levels (Goldman & Rakestraw, 2000). Brown (1998) states that standard structures are more familiar to users than new structures created by hypertext designers. Sequentially reading a text seems to provide a good basis for summary and recall tasks (Goldman, 1996). In addition, the present results show that the discontinuous text processing (Dee-Lucas & Larkin, 1995; Lee, 1998) is not always the case in hypertext environment.

The second factor found influencing the selection of links in hypertexts, is *personal interest*. The think aloud protocols have shown that readers select links that

are related to their interests. Similar results were obtained form the pilot study as well (Protopsaltis & Bouki, 2004a) where readers tended to make some selection based on their personal interest. Personal interest seems to be important and readers often pointed on links that sounded or seemed interesting. This behaviour is consistent with research showing that readers first select the text content they considered as most important (Britt et al., 1996). In the same vain, Ainley et al. (2002) show that high school students first selected sections they considered most interesting and then the less interesting ones. In another study, Salmerón et al (in press) found that 27% of their participants followed the hypertext links based on interest. Similarly, Altun (2000) found that the appeal and the attractiveness of the links related to personal interest are important in making decisions to navigate between the hypertext links. It is clear that in hypertext as in traditional paper-based documents personal interest plays an essential role in motivating readers to carry on reading. However, in hypertext environment interest might be more important because it does not only affect the allocation of attention on certain subsets of information, but also, it influences the sequence of the selection of the links, which in turn, influences comprehension. The reason is that readers who read the same information in a different sequence build different situation models (Salmerón et al., 2005). Taking the readers interests into consideration when building a hypertext could be significant in supporting comprehension.

The last factor influencing the link selection identified in this study is *coherence*. The findings show that coherence is not influenced by the different reading goals that readers had. Subjects made the majority of the transitions in a coherent manner. That shows that coherence remains an important factor in hypertext reading as well. The role of coherence in comprehension in paper-based and in hypertext documents, is well documented in the field's literature. These results are in line with results from other studies. Foltz (1996) for instance has found that readers made 80%-90% of their transitions in a coherent manner. In addition, Carter (2000, p. 90) points out that "in hypertext, coherence must be felt no matter in what sequence the text is encounter". Similarly, Bromme and Stahl (2002) suggest that decisions about links need to be made prudently in order to ensure coherence of the information. Content coherence is a fundamental prerequisite for comprehension (Kintsch, 1994, 1998; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). The notion of coherence in

hypertext is very close to what Landow (1987) and Zellweger (1998) refer to when they insist on the necessity to help readers to discover the relation between the source and the destination of a link. Tosca (1999) calls it the bridge metaphor. Finally, Mayer (2001) argues that for successful understanding of a multimedia message the presented material should have a coherent structure. If not, then the learner's comprehension efforts will be fruitless.

5.5 Conclusion

The current chapter discourses the experimental evaluation of the reading comprehension model for hypertext environments. The hypothesis about the model stated that, if the model is accurate then the produced verbalisations in the think aloud protocols should fit in the model. The results largely support the proposed model by predicting the contents of the subjects think aloud protocols.

Another focus of the study was the effect that the reading goals might have on comprehension, reading time and on the amount of visited links. First, the hypothesis about the comprehension scores had predicted that subjects in general condition would score better in the comprehension test than subjects in the specific condition and subjects in the no guidance condition would score better than subjects in the specific condition. Second, the hypotheses about the reading time and visited links had predicted that subjects would take longer to read the material and would visit more links than the subjects in the specific condition and subjects in the no guidance condition would need more time to read the material and would visit more links than the subjects in the other conditions. However, the results did not reveal any significant difference on reading times and on visited links between the conditions.

Another major focus of the present study was on readers' strategies. The strategies were extracted from the think aloud protocols. The data revealed four different strategies used. The strategies are: *serial*, *serial overview*, *mixed*, and *mixed overview*. The different reading goals had no significant effect on the use of the strategies contrary to the hypothesis. Readers from all different goals used all strategies. One notable finding is that readers seem to rely on familiar

reading/navigation patterns, taking advantage of the linguistic structure of the presented information.

The last part of the study focused on the factors that influence the selection of hypertext links. Three major factors were identified, *the location of the links*, *personal interest*, and *coherence*.

The present results were obtained with the use of the think aloud method. However, in the next chapter a pure quantitative approach will be adopted in order to replicate the results and verify the validity of the study.

Chapter 6

Experimental Evaluation: 2nd Experiment

A second experiment has been conducted to validate the results of the first study. The method used in this experiment is purely quantitative and it is a field experiment. A field experiment is a study carried out in the natural environment of those studied. The experimental method requires an independent variable to be manipulated and participants are randomly allocated to conditions. Experimental designs can be separated into four basic types: repeated measures, independent samples, matched pairs, and single participants (Coolican, 1999). The experimental method will be described in the following text, where the results will be presented and discussed.

6.1 Method

This study is an independent samples design experiment. Therefore an entirely different group of people is allocated to each condition. This experimental design belongs to the unrelated designs since the scores from one independent variable are quite unrelated to the scores of the other variable. The method offers the opportunity to control all relevant variables and to alter only the independent variable. The reason for this is that, if all other variables are controlled, only the independent variable can be responsible for changes in the dependent variable. Although, the same variables were used in the first study the main difference between the two studies is that, in the first experiment the focus was on the results obtained from the qualitative method of think aloud, where the second experiment focused entirely on the quantitative method.

6.1.1 Subjects

Ninety undergraduate students from the computer science department participated. All subjects were volunteers. Subjects were screened to ensure that they had not taken any courses in economics, and had no reading disabilities (see appendix I). All subjects were familiar with online (Web) documents. They were using the Web as a source of information for their course works and on top of that they were computer science students.

6.1.2 Material

All material, hypertext, and comprehension material, were the same as in the pilot study and in the first study, described in chapters four and five. However, a Java Script cookie (see appendix VII) was used in this experiment to record the times and the moves throughout the hypertext. Records of the time spend in each node, the total reading time, and every transition made by the readers was obtained.

6.1.3 Apparatus

All equipment and the specifications were the same as in the pilot study and in the first experiment described in the previous chapters.

6.1.4 Design

The experiment was again a 3 by 1 (one independent variable with three conditions) between subjects design, manipulating the reading goals. The reading goals were manipulated by providing different instructions about what the subjects should read in the text, in the same way as in the first experiment. The specific instructions group was instructed to read the hypertext in order to answer questions on a given sub-topics of the hypertext. The general instructions group were instructed to read the hypertext in order to give answers to questions related to the topic described by the documents title. Finally, the no instructions group was the control group and were given no instruction concerning the kind of questions they will be asked to answer after reading.

The questions under investigation are the same as the ones in the first experiment described in chapter five. However, it is not possible to assess the model again due to experiment's nature and therefore those hypotheses are not examined here. For the rest of the hypotheses it was expected that the different reading conditions would influence comprehension scores, reading times, the number of visited nodes and the amount of hypertext link selection.

6.1.5 Procedure

Subjects were tested in a computer science laboratory. The laboratory contained twenty workstations. Subjects were randomly assigned to one of the three experimental conditions, reading for answering specific questions, reading for answering general questions, and reading with no instructions. A cookie was recording the readers' transitions in the hypertext document throughout the session.

Participants were briefly told the aim of the study (see appendix III, IV, V for the complete instructions). They read the text until they felt satisfied that they were able to answer questions on the subject matter. After the reading task, subjects received the booklet with the recognition material. All subjects answered the same set of questions without consulting the learning material. The experiment was conducted in five individual sessions with a maximum of twenty participants per session. Each session took approximately one hour to be completed.

6.2 Results

The data collected was quantitative and consists of reading times, amount of visited links, amount of coherent transitions, and amount of selected links. All the data was received from the time stamped records of all the actions made by the subjects through the hypertext. Nevertheless, comprehension scores were calculated from the comprehension booklet. To examine those results a one-way analysis of variance (ANOVA) was conducted.

6.2.1 Reading times

Means and standard deviations of the time difference tasks performance between the three groups are shown in Table 6.1.

Reading Times

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
General Instructions	30	13.3094	9.18001	1.67603	9.8816	16.7373	1.65	43.60
Specific Instructions	30	16.9122	10.08666	1.84156	13.1458	20.6786	.15	43.22
No Instructions	30	16.3828	7.70668	1.40704	13.5051	19.2605	2.28	32.95
Total	90	15.5348	9.08378	.95751	13.6323	17.4374	.15	43.60

Table 6.1: Means and standard deviations of reading times

The total time to read the hypertext was recorded by the Java Script cookie. The mean time to read the hypertext was 15.5 minutes with a standard deviation of 9.1. There was no significant difference between the reading times based on the different reading goals (F (2, 87) = 1.388, p=.255).

6.2.2 Comprehension scores

One type of measuring comprehension was obtained. The multiple choice and the short answer questions were graded and one score for each subject was calculated. The maximum achievable score was 20. There was no significant difference in comprehension based on different reading goals (F (2, 87) =.563, p=.571).

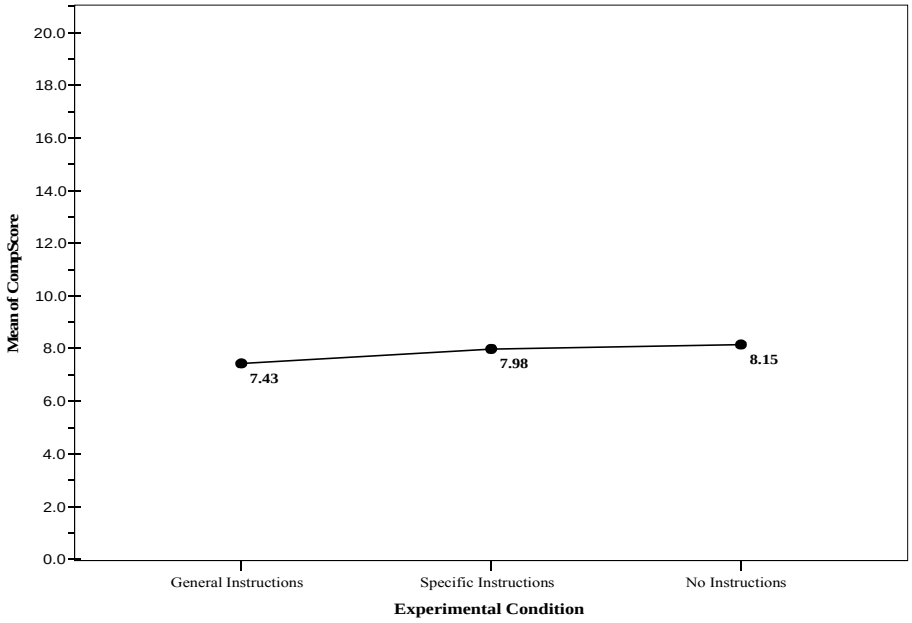


Figure 6.1: Comprehension scores

6.2.3 Analysis of the amount of hypertext visited/read

Another approach to gain an insight about the strategies subjects used, is to analyse the amount of hypertext nodes the subjects actually read. That approach shows, if subjects have taken an advantage of the hypertext features that permit them to locate specific subsets of information quickly. Figure 6.2 shows the mean percentage of the nodes per condition. A node was considered visited, if a subject had selected the node at least once. Thus all the visited nodes are considered as read. However, if a node was visited more than once it was not counted a different visited node. The number of nodes visited by the subjects was revealed by the Java Script cookie.

The total number of the hypertext nodes read by subjects was calculated. The maximum amount of visited nodes that a subject could read was 23. Subjects visited 1,210 nodes in total. The range of visited nodes varies between 2 and 22 as Figure 6.3 shows. The mean number of visited nodes was 13.4 nodes per subject. There was no significant difference between the hypertext nodes that the subjects read based on the different reading goals ($F(2, 87) = .902$, $p=.409$).

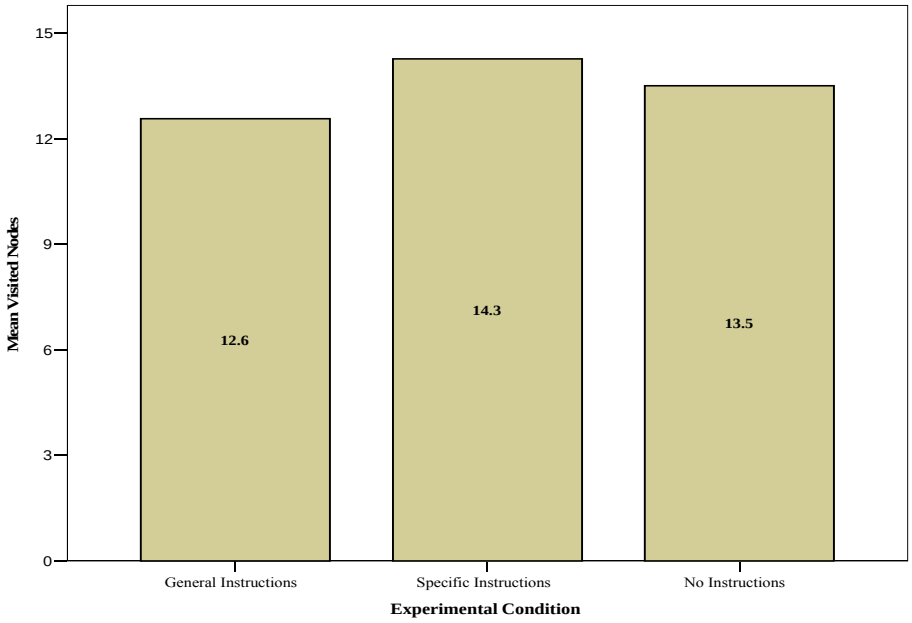


Figure 6.2: Mean of visited nodes per condition

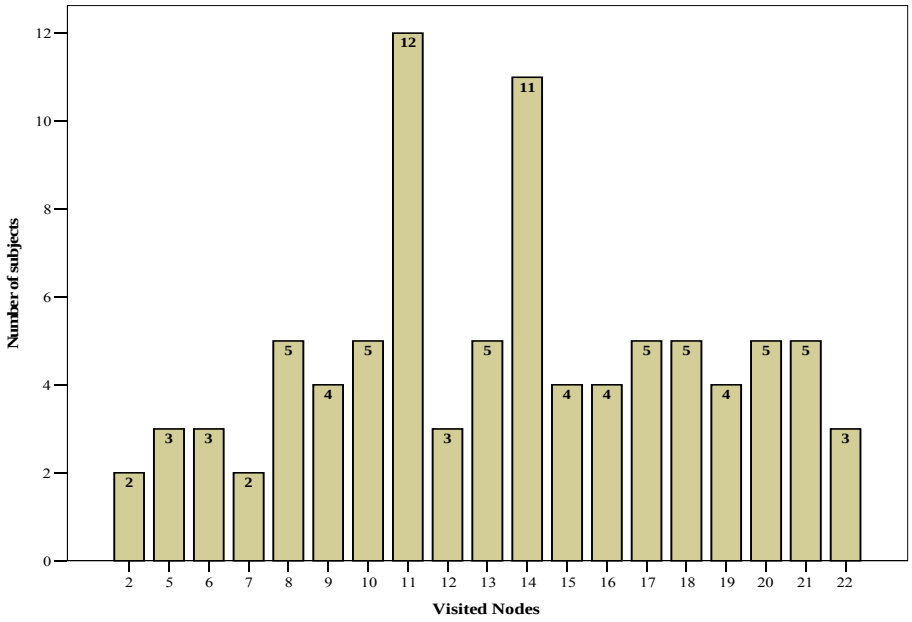


Figure 6.3: Number of visited nodes per subject

6.2.4 Factors influencing navigation strategies

The rules subjects used to get to the different nodes of the hypertext need to be considered in order to improve reader behaviour and development of electronic documents. In the first study the use of think aloud protocols revealed three such rules: *coherence*, *personal interest*, and *link position*. However, it is impossible to investigate the personal interest without verbal input. Thus the second study investigated only two factors, the coherence and the location of the links.

6.2.4i Coherence

A coherent transition in the hypertext was considered a transition from one node to another in which both nodes were still within the same context in the same way as it was described in the previous chapter. Contrary to the first study, where the examination of coherence had focused on the first time that readers accessed/read a

node, and thus each transition was counted only once, here each node was counted as many times as it was selected, taking into account every single visit. That variation was considered necessary in order to assess more comprehensively participants' reading behaviour. The participants' transitions were extracted from the cookie records kept in the server.

Subjects selected 2,723 hypertext links in total. They made 76.57% of their transitions in a coherent way regardless of their experimental condition. Subjects in the general instructions condition made the fewest coherent hyperlink transitions with 20.73 transitions. Next was the specific instructions condition with 21.9 coherent transitions, and the condition with the most coherent transitions with 26.87 was the no instructions condition. There was not a significant difference between the different conditions and the coherence of the link selection (F (2, 87) = 1.132 p=.327).

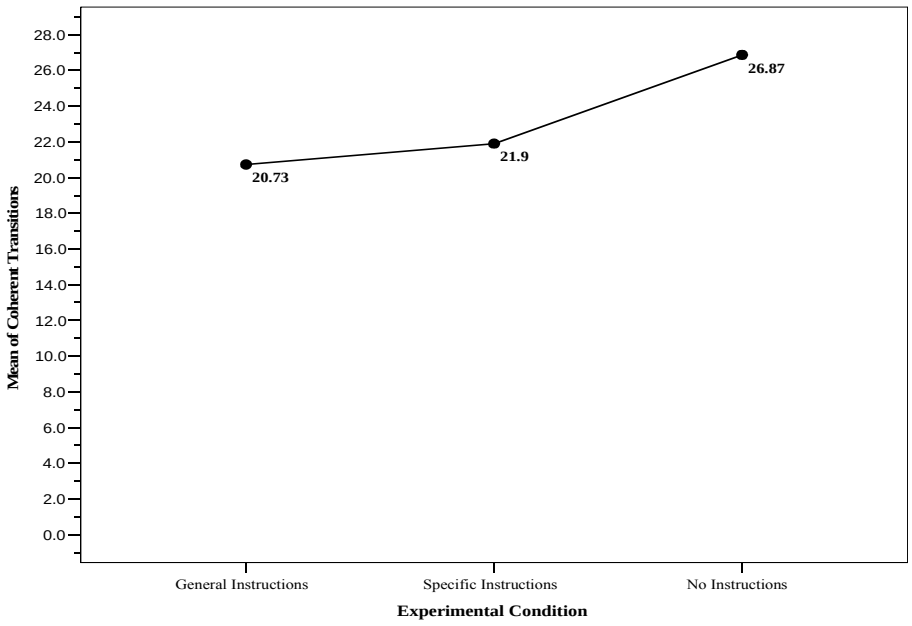


Figure 6.4: Mean of coherent transitions per condition

6.2.4ii Links location

The first experiment revealed that the location of the links influences its selection. The location was defined by the linguistic sequence, starting from left to right and top to bottom, following the regular reading pattern. Users tended to select the first available link while reading. Every selection of hypertext links was considered and counted including those that were selected for more than once. The 90 subjects produced a sum of 2,723 link selections. From those link selections 55.38% were made based on their location in the hypertext. Hence, subjects selected those links as soon as they encounter them following their reading pattern. The 44.62% of the hypertext link selection was made in a different way not based on their positioning in the hypertext.

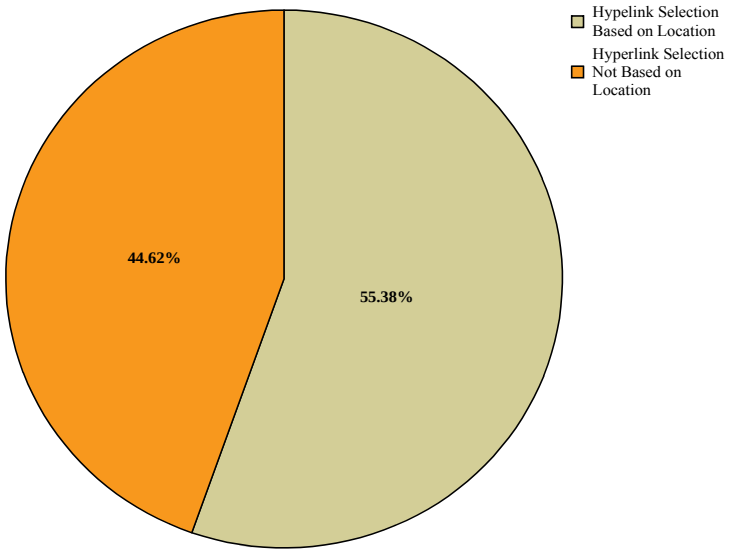


Figure 6.5: Selection of hypertext links based on their location

6.3 Discussion

The current results did not reveal any significant difference in reading time between the three conditions. The results are in harmony with the results of the first experiment, strengthening its unexpected findings, that different goals did not

influence the time readers spent reading a hypertext in order to answer questions. Similar results were found regarding comprehension. The current experiment replicated the results of the first experiment by revealing that different reading goals have no significant difference in comprehension in a hypertext environment. However, it seems that there are some miscellaneous results (e.g. Foltz, 1996; Protopsaltis & Bouki, 2004a, 2005; Rouet, 2003; Schoeller, 2005) concerning the effect of the goals in reading in general and in hypertext in particular. One explanation for that might arrive from the observation that the research in that area is still in its infancy and thus there are no conclusive findings (Schoeller, 2005).

Another way to gain an insight about reading behaviour in a hypertext environment is to investigate the amount of visited nodes. The number of visited/read nodes are very closely related to reading comprehension because it is affecting the formation of the text-base (Salmerón et al., 2005). The findings show no significant difference between the different reading goals and the amount of visited nodes by readers. However, the results are not surprising since participants spent roughly the same time to read the hypertext and had similar comprehension scores, implying that they visited similar amounts of nodes. Those results show that readers seem to like going through the hierarchy of the hypertext trying to read as many information as possible despite their task ahead. Additionally, it is likely that participants used similar strategies since there is no difference in any of the variables measured. However, participants' strategies were not under investigation in this experiment and therefore this assumption could not be verified.

The findings regarding the coherence of information and location of the links, also replicate the results from the first study. The results attributed to coherence revealed that different strategies do not affect the amount of coherent transitions during reading in hypertext environments. Furthermore, the results show that coherence is very important not only during the first visit/read of the information as in the first experiment, but even when readers revisit the hypertext nodes. Although the hypertext permitted participants to make non-coherent transition, by offering easy access to the other hyperlinks, they chose to make their transition in a coherent manner. Additionally, even when the subjects revisited the hypertext nodes to reread the information, or when they reviewed information towards the end of their task,

they chose to do it in a coherent manner. That shows that coherence of the information is central in comprehension, not only in the traditional texts (Kintsch, 1994, 1998; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983) but in hypertext environments as well. As a consequence, it seems that readers maintain a stance towards texts independent of the medium. Mishra and Nguyen-Jahiel (1998) reached a similar assumption in their study on the process of meaning making in print and hypertext environments.

Yet again, it would appear that the location of the links is a strong factor influencing more than half of the link selections. The results replicate findings from the first experiment. Participants made more than half of their link selections based on their position in the hypertext. This indicates that readers were more comfortable selecting the links following their linguistic sequence, rather than breaking away and selecting the links in a different way. Participants, tended to select the first link they came across from left to right and also from top to bottom. For example, when readers had to read information lying underneath some links grouped together in a bullet point format, they primarily chose to start with the top link, and continued with the one straight below. Likewise, Ainley et al. (2002) found that approximately 50% of the participants in their study just read the text following the order in which they were presented in the screen. Researchers (Charney, 1994; Dee-Lucas & Huston, 1999) have argued that readers have difficulties to find the appropriate sequence of information in hypertexts. Therefore, selecting the hypertext links based on their location in the hypertext seems to offer them great support. Similarly, Charney (1994) argues that predefined sequence plays an important role in text comprehension processes because readers tend to consider early information as important, and they are also sensitive to textual cohesion.

Both results about the coherence and the location of the links indicate the importance of the linguistic nature of the information in a hypertext environment, supporting the concept that the major purpose of reading a document is comprehension and reading a hypertext is no exception (Thüring et al., 1995).

One notable difference in the results between the first and the second experiment is that readers tended to review the information at the end of their reading much more by revisiting the hypertext nodes and skimming through the information. In the first

experiment, participants tended to stop reading as soon as they read the information under the hyperlink named, "Conclusion", without usually revisiting any of the nodes. This difference however, might be due to the difference in the experimental procedure. Participants in the first experiment were tested individually and thus they might not have felt very comfortable to browse around exploring and revisiting the information in the hypertext.

6.4 Conclusion

The current experiment took place to validate the results of the first experiment. The results indicate that different reading goals did not affect comprehension and reading time in a hypertext environment. Furthermore, the current findings show that coherence plays a central role in the reading process, influencing the majority of readers' moves during reading in hypertexts. Finally, the location of the links seems to be another influential factor on readers' hyperlink selections. All the results largely replicate the finding from the first experiment, strengthening their value.

Conclusions and Future Work

Notwithstanding claims that hypertext would change the way we read and bring significant advantages for reading and learning. The temptation is strong to simply assume that using multiple forms of displaying information, and providing multiple possibilities to interact with information results generally in better learning (Schnotz, 1999). However, thus far, studies have reported mixed results. Researchers have suggested that some reasons for such results might be the fact that there is no theoretical framework to locate hypertext reading and also, most of the research has been based on computer rather than on cognitive perspectives. The present study adds to a growing body of studies trying to draw a picture about the cognitive process involved during hypertext reading and the strategies that hypertext readers use.

This chapter serves multiple purposes. Firstly, to summarise the findings of the current research, secondly, to outline the contribution of the work described in this thesis, and finally to portray what future work can be carried out in the same area and direction. The aim of this thesis was to systematically explore the cognitive aspects of hypertext reading by modelling its main processes. Further aims also sought to

examine the reading strategies readers used in a hypertext environment, the effect that different reading goals might have on hypertext reading and understanding, and the factors that influence hyperlink selection.

1. Main Conclusions

The multi-linear nature of hypertext environments offers certain difficulties as well as opportunities for learning, thus making the design of such systems both complex and challenging. Hypertext users and electronic document readers, in general, need tools that will enable them to browse the contents of the documents quickly and effortlessly. The need to provide hypertext readers with such facilities was identified during the early days of hypertext research (Nielsen, 1990). Systems that lack such facilities would find little acceptance among users and probably be rejected.

In the present study, the facets of reading in general and reading in hypertext environments in particular were explored under the current research in the field. The literature review highlighted the need for further research about the cognitive processes during reading in an electronic environment and stressed the need to model those processes. Furthermore, it revealed that there is remarkably little knowledge available about the use of strategies, the successful use of hypertext and the effect of reading goals in hypertext comprehension.

This thesis aims to enhance the understanding of how people read a hypertext document by proposing a model that accounts for hypertext reading comprehension. The model focuses on the linguistic information and on the cognitive processes taking place during hypertext reading. It was influenced by Kintsch's and van Dijk's (1978; 1983) model for text comprehension and by Guthrie's (1988) model for locating information in documents. The proposed model is a procedural one; hence it describes a sequence of steps. All steps were described and explained in detail. The model provided a theoretical framework for research on reading and the construction of meaning through the processing of textual information.

The method used to evaluate the hypertext comprehension model was qualitative and it is called think aloud. A pilot study was run to validate the experimental design and to serve as a task analysis for the model. The result helped to finalise the experimental design and to revise the model. The data gathered from the think aloud method were verbal protocols. A protocol is produced when a reader verbalises his or her thoughts while completing a given task. Verbal protocols were transcribed, coded and finally compared with the model's components. The results significantly supported the proposed model since all verbalisations matched with the model's components and could be explained within the framework.

In addition to the model, the study examined the effects that different reading goals might have on reading. This was accomplished by testing reading times, comprehension scores and the number of visited links. The results demonstrated that there was no significant difference between the conditions, and thus the different goals had no effect on neither the time that participants spent to read the subject matter, nor on their comprehension scores, nor on the amount of links they visited.

Another focus of the study was on the strategies that readers used while they read a hypertext. The study revealed four different strategies: *serial*, *mixed serial*, *mixed*, and *mixed overview*. Furthermore, the results revealed that the uses of strategies were not affected by different goals of the readers since all strategies were used by subjects in all different conditions. Nevertheless, the research revealed three important factors that influenced the selection of hypertext links. The factors are: *coherence*, *link location*, and *personal interest*.

Following the first experiment, a second experiment was conducted for validation purposes using a different experimental method. The method used was an independent samples design experiment. The participants in the second experiment had not taken part either in the pilot or in the first study. However, the second experiment could not test the proposed model and the strategies that readers used, since all collected data was quantitative. Though, reading times, comprehension scores, number of visited links and the two factors found in the first experiment which influence link selection, the link location and the coherence, were examined. The results replicated those found in the first study.

2. Contribution

Hypertext documentation is a powerful way to provide readers with the support to select links that are meaningful to their goals and objectives, and to provide them with a medium that facilitates reading as opposed to hindering it. The purpose here is to demonstrate how a theoretical perspective can provide important insights into the important changes taking place to literacy, as the hypertext and other electronic formats of information gain widespread use. The influence of the present findings can be seen at two levels, theoretical and practical.

At a theoretical level, a theoretical framework about hypertext understanding such as the one proposed in this thesis, helps to improve reading, text design and complex learning. Models provide educators with a deeper understanding of the reading processes, where breakdowns in comprehension can occur, and what strategies could improve the reading processes. Firstly, with respect to understanding reading as a process, a model integrates research findings, makes theory graphic, and provides explanation of how reading takes place in accordance with what we currently know. Furthermore, once we have begun to make our understanding of reading more visible through models, we tend to move those models towards greater sophistication. Secondly, a model of hypertext reading will help us to detect where breakdowns in comprehension could occur. A model helps us to visualise what components may fail to contribute to an effortless meaning making while reading. For example, weak or slow word recognition can cause poor comprehension. Thirdly, a model provides clues about instructional approaches and intervention strategies that could help readers at different stages in reading development. We can use models as resources for good hints (Ruddell & Unrau, 2004). Thus, the theoretical contribution of the present thesis is that it provides a procedural model regarding reading and comprehension in hypertext environment, and makes this model graphic.

At a practical level identifying the reading models and the strategies readers use while reading a hypertext can help us to design and test aids that would help hypertext readers to browse hypertext documents effortless and quickly. This will decrease cognitive overheads and hypertext users will be positive in further exploring

the hypertext document. In this way, the results can serve as guidelines, which are enhanced to promote design supporting effective learning processes.

Therefore, the practical contribution of the thesis takes the form of guidelines that serve the design of supporting effective learning platforms. For example, the results have shown that readers had problems with unknown words because of the lack of prior knowledge. That suggests that hypertext designers could easily include definition links to overcome such problems.

Additionally, it is evident from the findings that forms of linearity are present in the way readers access information and thus it should be considered during the development of hypertext environments, for example, by offering to the readers multi-linear routes to the information. Similarly, the significance of coherence in hypertext links selection is manifested by the results of this study since readers primarily made transitions to highly related nodes. Readers do not always generate the correct inferences about the link and the information and they do not incorporate the new information into their representation of the text when links are not coherent. That suggests that designers should focus more on the information perspective of the document, if they want the presented information to be understood by the readers and place the coherence of the links at the centre of their attention.

Another practical implication can be seen from the use of overview in the linear overview and the mixed overview strategies, which pinpoints towards the use of overview facilities in electronic documents to facilitate reading effectiveness. The results suggest that there is a need for some clues that assist reading. There is a need for some clues that assist multi-linear reading, which comes with the need to understand the concepts underlying the linguistic message, where forms of linearity are present. Furthermore, from the findings in this thesis it is clear that having embedded links in the text, they largely influence the selection sequence and reading largely resembles traditional text reading. Thus, using a network presentation format may conflict with the concept of the linguistic principles of creating a message and communicating the message. However, the use of different types of links such as menus indexes and site maps might offer alternative ways of reading and using strategies.

It was also evident that users' navigation is highly dependent on the structure of a document since they primarily followed the given hierarchical structure. Thus developers should pay more attention on the structure of the subject matter than on the design when the documents primarily communicate textual information.

Also, the findings show that readers rely on familiar reading patterns and strategies. Those results pinpoint towards the use of familiar structures. However, if that is not possible, then instructions might assist in order to overcome this problem. Educators could fill-in the gaps by providing adequate instructions to the hypertext readers and especially to those readers who lack relevant background knowledge or schemata. The readers then would be more able to take full advantage of the medium and explore its potential.

3. Research Strengths and Weaknesses

This study is distinctive in that it proposed a procedural model to account for hypertext reading comprehension. Also, it used a large number of participants, something which is not usually the case with the think aloud method, since most studies in the field have used a small number of subjects. The large sample of participants enabled to achieve a greater statistical power than previous studies exploring these aspects of hypertext reading. This research is either the first or one of the first to rigorously examine and reveal some of the factors, except coherence, that influence hyperlink selection in a text dominated hypertext.

Another strong point of the present study is the use of qualitative and quantitative methods to obtain data. The use of two different methods increases the validity of the results and strengthens their potential to be generalised.

Furthermore, the strength of this study lies on the experimental material used. The material was rather similar to the vast majority of the information published on the Web. Also, it used a lengthy document compared to abbreviated documents that other studies have used. By doing so the study closely replicated a real reading experience.

While many aspects of this thesis were comprehensive there were nevertheless areas that could be enhanced upon in the future. For instance, the number of participants in the study could have been larger, and also it could have used a variety of people other than students. Also, the type of information used can be expanded to include different genres and they could also be combined with multiple forms of media such as images or video.

4. Future Work

The present research has primarily focused on one type of text, scientific, and on one format of hypertext, hierarchical. The studies have produced some encouraging results, which however are limited to that particular genre of text and that particular structure. Future research will try to replicate these results on different genres of text using different or multiple structures of hypertexts, reinforcing the validity and the applicability of the proposed model. In addition, a larger sample and a different type of subjects will also contribute to the validity of the model.

Furthermore, the think aloud protocols revealed four strategies that the subjects used during their on-line reading. The strategies were not part of the proposed model since they were not known when the model was created. Thus, another direction for future research will be the extension of the proposed model with the four strategies and a new study to validate the accuracy of the modified model. Besides, an investigation on the browsing/reading strategies will be continued, since the results in the field are not conclusive. A possible direction will be the distinction between reading and browsing strategies and between cognitive and meta-cognitive strategies and their influence on the reading process in hypertexts. The proposed expansion of the present research will be a combination of think aloud protocols along with the use of new software such as Camtasia studio 4.0, in order to obtain even richer results and to conduct more detailed observations than before.

Hypertext technologies can integrate different types of information such as verbal information presented visually or auditory, pictorial information presented visually in a static or dynamic way, and sound information. The present research has

focused on verbal information presented in a visual form. However, hypertext or multimedia systems embedded with multiple forms of media, such as sound, video, images and their implications in comprehension will be considered in future research. In addition, since the research on factors that influence hyperlink selection is still in its infancy, further research will try to replicate the current results and examine different types of links and their role in hyperlink selection.

Furthermore, adaptive hypermedia that considers individual differences, cognitive styles, and different social backgrounds is another direction for further and future research. Finally, the parameters of reading comprehension on the Internet should be expanded to include problem identification, search strategies, analysis, synthesis, and the meaning construction required in e-mail messages and other communication technologies.

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Appendix I

Pre-test questioner

Sex: (Please tick one)

- Male
- Female

Age range: 18-25
26-35
36-45
46+

Language proficiency (English):
(Please tick one)

- Mother language
- Second language

Course:
.....
(Type of degree and area of study)

Year of studies: 1st
(Please circle one) 2nd

3rd

Do you have any background knowledge on economics? (If yes please specify)

Yes No

.....

.....

What is your experience on the WWW?
(Please tick one)

- Experienced
- Inexperienced

Do you have any reading disability? (If yes please specify).

Yes No

……

Appendix II

Warm up exercises for the think aloud method

Before we run to the real experiment, we will start with a couple of practice problems. I want you to practice with these exercises.

Talk aloud while you multiply: 22 times 36

Talk aloud while you multiply: 17 times 342

Talk aloud while you try to solve this problem:
A bottle of white wine costs £5.50 and a bottle of red wine costs £5.20. The "bottle" (only) of the white wine costs £4.50 less than the wine and the "bottle" (only) of the red wine costs £4.40 less than the wine. How much does each bottle costs, and how much one has to pay for both of "bottles of wine"?

Appendix III

Instructions to participants in the no guidance condition

Instructions to participants

The aim of this experiment is to study the strategies and comprehension process that readers apply during reading an electronic document.

Please read the text aloud from the screen monitor, and while you do so, try to say aloud everything that goes through your mind. What I mean by talk aloud is that I want you to say out loud everything that you say to yourself silently. Just act as if you are alone in the room speaking to yourself. If you are silent for any length of time I will remind you to keep talking aloud. Read the text until you feel satisfied that you can answer questions on the paper's topic and then state that you have finished.

As soon as you finish reading, a set of questions will be given to you, and you will have to answer all of them.

Please ask if you have any questions.

Appendix IV

Instructions to participants in the specific condition

Instructions to participants

The aim of this experiment is to study the strategies and comprehension process that readers apply during reading an electronic document.

Please read the text aloud from the screen monitor. Please read aloud the text from the screen monitor, and while you do so, try to say aloud everything that goes through your mind. What I mean by talk aloud is that I want you to say out loud everything that you say to yourself silently. Just act as if you are alone in the room speaking to yourself. If you are silent for any length of time I will remind you to keep talking aloud. Read the text until you feel satisfied that you can answer questions on the given topic. **The topic is:** "Key ideas in regional development discourse".

As soon as you finish reading, a set of questions will be given to you and you will have to answer all of them.

Please ask if you have any questions.

Appendix V

Instructions to participants in the general condition

Instructions to participants

The aim of this experiment is to study the strategies and comprehension process that readers apply during reading of an electronic document.

Please read the text aloud from the screen monitor. Please read aloud the text from the screen monitor, and while you do so, try to say aloud everything that goes through your mind. What I mean by talk aloud is that I want you to say out loud everything that you say to yourself silently. Just act as if you are alone in the room speaking to yourself. If you are silent for any length of time I will remind you to keep talking aloud. Read the text until you feel satisfied that you can answer questions on the given topic. **The topic is:** "Indigenous rights and regional economies".

As soon as you finish reading, a set of questions will be given to you, and you will have to answer all of them.

Please ask if you have any questions.

Appendix VI

Comprehension material

Please Answer the Following Questions:

Q 1. What is this paper about? Write a sort essay (no more than ten lines) describing the main points of the paper.

……
……
……
……
……
……
……
……
……
……

Q 2. What is the meaning of the term: “rethinking the building blocks”?

……
……
……
……
……

Q 3. What is the name of the indigenous Australian people?

……

Q 4. Describing the economic reality of many remote indigenous areas, the author claims that there is a backlog of:

(Please tick one)

a. Basic infrastructure and service provision
b. Basic infrastructure and bureaucrats
c. Public funds and service provision
d. Competition and service provision

Q 5. Which of the following countries does the Treaty of Waitangi concern?

(Please tick one)

a. United States
b. Canada
c. New Zealand
d. Australia

Q 6. How does this paper consider the indigenous peoples in economic activity?

(Please tick one)

a. Equal participants
b. Sovereign participants
c. Junior participants
d. Senior participants

Q 7. What is the indigenous rights movement's early emphasis?

(Please tick one)

a. Land rights
b. Human rights
c. Political rights
d. Economic rights

Q 8. Identify two key ideas in regional development that have been considered in this paper? (Please tick two)

a. Political stability
b. Planning
c. Infrastructure
d. Institutional strengthening
e. Social structure
f. Regionalism

Q 9. Identify two tools of management that have been mentioned in this paper.

(Please tick two)

a. Education
b. Negotiating
c. SWOT analysis
d. Transparency
e. Institutes
f. Production

Q 10. What does Cramer mean by the term "cleptocracy"?

(Please tick one)

a. Western pluralistic dictatorship
b. Western pluralistic economy
c. Western pluralistic democracy
d. Western pluralistic oligarchy

Q 11. According to the author the building of the "blocks" is based on: (Please tick one)

a. The transformation of the value of existing capacities.
b. The adaptation of the value of existing capacities.
c. The demolition of the value of existing capacities
d. The improvement of the value of existing capacities.

Q 12. Consider the following claim: **"**The importance of expert advice, legal sophistication and careful planning and strategising are factors that constitute 'negotiation' as an area in which the tension between decolonisation and deep colonisation is acute".

True False

Q 13. Does the author of this paper feel the need to thank anyone for contributing to this paper?

Yes No

Q 14. Systems with unruly institutional arrangements are difficult to manage.

True False.

Q 15. Howitt argues: "recognition" of indigenous rights opens up opportunities for "decolonisation" of indigenous spaces.

True False

Appendix VII

Java Script Cookie

```
#drawform.cgi
#!/usr/local/bin/perl
#output form fields that "remember" last state of being.
use CGI;
$cgiobject=new CGI;
#$cgiobject->use_named_parameters;

 &get_state_variables;

 #retrieve cookie data
 $cookie_data=$cgiobject->cookie("ArisSurvey");
 if ($cookie_data)
  { &crumble_cookie;
    $name=$vars[1];
    $greeting="The name of the cookie is  :: $name" }
 else {
      $greeting="Hello First Timer!" };

 &appendFile;

print $cgiobject->redirect("../$jump");

 #print $cgiobject->header;
 #print $cgiobject->start_html(-title=>'Survey',-bgcolor=>'white');
 #print "<H2>$greeting</H2>";
```

```
 #print "<H3>Params data | $data :: jump | $jump </H3>";
 #print $cgiobject->end_html;

#go to the page specified by jump
sub redirect()
{
}

#retrive command line data
sub get_state_variables()
 #retrieve from the CGI queries the keys and value we want to store in the file
 { $data=$cgiobject->param("data");
  $jump=$cgiobject->param("jump");
  #$otherData=$cgiobject->param("otherData");
  $time=time;
 }

 sub appendFile()
  {
   open(LOGFILE, ">>c:/Inetpub/webpub/FILES/$name") || die "cannot append: $!";
   print LOGFILE "$time \t $jump \t data\n";
   close LOGFILE;
  }

 sub crumble_cookie()
 #parses cookie data into variables and values
 { @vars=split(/:/,$cookie_data);
  # foreach $var (@vars)
  #  { @pair=split(/=/,$var);
  #    $evalstr='$'.$pair[0].'=';
  #    $evalstr.="\"$pair[1]\"";
  #  }
```

Appendix VIII

Publications

Conferences Abstracts

Protopsaltis, A., Bouki, V. & Sharp, D. (2000). Information Structure in Hypertext: from Linear to Multi-linear Text. Paper presented at OR42 conference, Swansea, Sept. 12-14.

Protopsaltis, A. & Bouki, V. (2002). Comprehension of an Electronic Document: what readers do and do not do. Paper presented at OR 2002 conference, Edinburgh, July. p. 70.

Conference Proceedings

Protopsaltis, A. & V. Bouki (2004). Cognitive Model for Web Based Hypertext Comprehension. 6th IASTED Int. Conference on Web-Based Education 2004, Innsbruck, Austria, ACTA Press, pp. 604-606, ISBN:0-88986-406-3/ ISSN:1482-7905.

Protopsaltis, A. & Bouki, V. (2004). Cognitive Aspects of Web-based Hypertext: An experimental approach. In Proceeding of the 3rd WSEAS Int. Conference on E-Activities, Rethymno, Crete, paper no. 217, ISBN: 960-8457-04-1.

Protopsaltis, A. & V. Bouki. (2005). Towards a Hypertext reading/Comprehension Model. In: ACM SIGDOC 23rd International Conference on Design of Communication, Coventry, UK, ACM Press, 2005. pp. 159-166, ISBN: 1-59593-175-9.

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Protopsaltis, A. & V. Bouki. (2006). The Effects of Reading Goals in Hypertexts Reading. In: ACM SIGDOC 24th International Conference on Design of Communication, South Carolina, USA, ACM Press, pp. 29-34, ISBN:1-59593-523-1.

Journals

Protopsaltis, A. & Bouki, V. (2004). Cognitive Aspects of Web-based Hypertext: An experimental approach. WSEAS Transactions, WSEAS Transactions on Information Science and Applications 1(5), WSEAS Press, 1118-1126, ISSN:1790-0832.