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Navigation, a matter of style?

Study on the relation between users' cognitive styles, mental models and navigation behaviors in a hypermedia environment

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Master's thesis for the Communication Studies programme

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Abstract

This study aimed at gaining more insights into users' navigation behavior in hypermedia environments. The relation between cognitive style and navigation behavior in a hypermedia environment was examined, as well as the relation between cognitive style and mental model of the information in a hypermedia environment. One hundred fifteen students were tested on the cognitive style characteristic 'field dependency.' The sample mainly contained field independent (or 'analytic') individuals. From the initial sample, the 20 students with the highest analytic scores and the 20 students with the lowest analytic scores were selected. Five 'low analytics' and five 'high analytics' were asked to do several tasks on a web site with information about writing, while thinking aloud. Further, 15 'high analytics' and 15 'low analytics' were asked to create a mental model of the same web site, by means of the card sorting method. The results indicated that users' cognitive styles did appear to be related to users' navigation behaviors. This is quite remarkable, because of the small number of participants, and the relatively small difference between the two cognitive styles, one would expect that significant differences were not likely to occur. However, cognitive styles did not appear to be related to mental models. Therefore, mental models do not appear to be an intervening variable between cognitive styles and navigation behavior in a hypermedia environment.

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Preface

De opdracht waar ik in september 2004 mijn afstudeerperiode mee begon, betrof het evalueren van de navigatiestructuur van het Writing Center van Colorado State University. Deze website, met daarop veel informatie over schrijven, werd door de afdeling Technische Communicatie van de Universiteit Twente gebruikt als ondersteuning bij een aantal vakken. Een verbetering van de navigatiestructuur van de website leek gewenst, aangezien informatie nog wel eens moeilijk te vinden was.

De afstudeeropdracht die ik in mei 2005 afrond en waarvan het resultaat nu voor u ligt, is in de kern nog dezelfde opdracht als die waar ik mijn afstuderen mee startte. De focus van de opdracht is echter verschoven van een te verbeteren navigatiestructuur, naar factoren gerelateerd aan navigatiegedrag. Welk resultaat dit heeft opgeleverd, wordt beschreven in deze afstudeerscriptie.

Graag bedank ik enkele mensen die mij hebben geholpen bij het afronden van mijn studie. Allereerst wil ik Thea van der Geest bedanken voor haar kritische meedenken en –lezen tijdens mijn afstuderen. Bovendien hebben haar gezelligheid en nuchtere peptalks ertoe bijgedragen dat ik terug kan kijken op een leuke afstudeertijd. Daarnaast een woord van dank aan Mark Gellevij voor zijn nuttige commentaar op mijn stukken. Het heeft mijn scriptie zeker aangescherpt. Ook bedank ik de leden van de afstudeerkring voor hun feedback. Further, I'd like to say 'thank you' to Don Donahue. He read my thesis, in order to improve the quality of my writings. His feedback was really useful to me. Mijn ouders wil ik ook bedanken voor hun studiebijdragen van zowel financiële als niet-financiële aard. Door hen heb ik kunnen studeren; een ervaring die ik niet had willen missen. Verder een 'dankjewel' aan mijn kamergenoten in C239, de gave mensen op de afdeling, mijn huisgenoten en vrienden voor hun gezelligheid en voor hun geduld met mij in de regelmatig terugkerende stressvolle momenten. Tot slot een groot 'dankjewel' voor Gideon. Het was een bijzondere ervaring om simultaan af te studeren, maar we hebben het allebei toch mooi gefixt. Dank voor je hulp in alles.

De afronding van mijn afstudeerproject betekent eveneens de afronding van mijn studie Toegepaste Communicatiewetenschap aan de Universiteit Twente; een moment waar ik tegenop heb gezien en een moment waarnaar ik heb uitgekeken. De ervaring zal leren of mijn studententijd inderdaad 'de mooiste tijd van mijn leven' was, of dat het burgerbestaan ook best mooie dingen te bieden heeft. Ik ga uit van het laatste.

Enschede, mei 2005
Eliane van Craaikamp

1. Navigating in hypermedia environments

'Hypermedia environments'; although the term may be unknown to a lot of people, almost everyone has been working with them at one time or another. Web sites belong to the category hypermedia environments. According to data of Statistic Netherlands, in 2004, 72% of the Dutch population 12 years and older, has used the Internet at least once. This has continued to grow over the years (Centraal Bureau voor de Statistiek, 2005).

Hypermedia environments are unique, in that users of a hypermedia environment are not bound to one particular route through the information, but are able to choose their own paths. In spite of this flexibility, the use of hypermedia environments does not appear to be free from problems. This can be illustrated by the fact that probably every Internet user can remember at least one situation in which he or she experienced problems with finding his or her way on the Internet. This phenomenon has been called 'lost in hyperspace' (Smith, 1996), and has been seen as one of the most common, and one of the most frustrating problems users experience in hypermedia environments (McDonald & Stevenson, 1998). Apparently, efficient and effective navigation is not as obvious as it seems.

Problems when navigating – not knowing where you are, where you came from, or where you have to go – are not desirable. Disorientation can cause negative feelings for the user, like confusion, frustration, and a loss of interest. But it can cause a decline in performance as well. For example, the user may not be able to find the intended information in the most efficient way, or the user may not find the information at all. Navigation problems are not desirable for designers, either. After all, a hypermedia environment fails when users decide not to come back.

It is useful to have a good understanding of users' navigation behavior, in order to adjust the design of hypermedia environments to users' needs as much as possible. How do users navigate? And what is it that makes users navigate in a particular way?

The study discussed in this master's thesis, aims at contributing to the knowledge about users' navigation behavior in a hypermedia environment. What follows in this chapter will discuss how this has been done. First of all, two research questions will be discussed in Section 1.1. Subsequently, Section 1.2 describes the hypermedia environment that will be used in this study, namely the Writing Studio of Colorado State University. Finally, in Section 1.3 a preview on the content of this master's thesis will be given.

1.1 Factors related to navigation behavior: two research questions

Different aspects can influence the way in which someone navigates. In this study, the focus will be on aspects related to users of hypermedia environments. What in users determines their navigation behavior?

A user-characteristic that will play an important role in this study, is user's cognitive style. A cognitive style is a kind of thinking style, and is about the way one processes

information. Ford, Wilson, Foster, Ellis and Spink (2002, p.728) describe it as “a tendency displayed by individuals consistently to adopt a particular information processing strategy.” Cognitive style is important in relation to navigation, because when users navigate through a hypermedia system, they process information. After all, while navigating, users have to decide which information is relevant to reach their goals and which is not.

Several studies have already been done on the relation between cognitive style and navigation behavior, and it appears that users with different cognitive styles show different navigation behavior. For example, Ford and Chen (2000), and Ellis, Ford and Wood (1993) found that cognitive styles were related to the use of navigational tools. However, a clear conclusion about the relation between cognitive styles and navigation behavior cannot be drawn. This is due to the fact that in previous research the relation between navigation behavior and cognitive styles has been measured in various ways, in various contexts, and cognitive styles have been determined using different instruments. Therefore, additional research on the field of navigation behavior and cognitive styles has a surplus value.

Because cognitive style appears to be an important factor for investigating navigation behavior, and because additional research on this area seems to be relevant, research question 1 has been formulated. Figure 1.1 shows the research question in a diagram. The study discussed in this master’s thesis, will mainly focus on this research question.

Research question 1. *What is the relation between users’ cognitive styles and users’ navigation behavior in a hypermedia environment?*

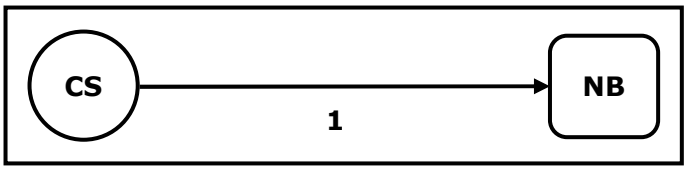

Figure 1.1 Diagram of research question 1 (CS = cognitive style, NB = navigation behavior)

Another aspect that can be related to user’s navigation behavior is user’s expectation about the hypermedia environment. What kind of image does the user have of the information in a hypermedia environment? Such an image can be called a mental model (Benjafield, 1997). Mental models get more accurate by experience (Preece, Rogers & Sharp, 2002).

In this study, a mental model concerns the following: people have experience with visiting hypermedia environments; after all, many people visit web sites on the Internet. This experience will contribute to the development of the mental model people create of web sites. But to what extent is the mental model correct and does it correspond to the actual hypermedia environment? It can be expected that when users’ mental models fit with the actual hypermedia environment, it will be easier for users to find their way through the information than when the mental model does not fit with the actual hypermedia environment at all. After all, in the case of a ‘match’, users get what they expect.

But what determines the correctness of users' mental models? As mentioned before, experience with the hypermedia environment helps users develop accurate mental models. It can be that users' mental models are determined by cognitive style, as well. Perhaps users' mental models play an important role in the relation between cognitive style and navigation behavior, as represented in figure 1.2.

This study will investigate whether there is a relation between users' cognitive styles and users' mental models of the hypermedia environment. This has led to research question 2. Because the relation has not been investigated earlier, the formulation of the question is quite open.

Research question 2. *Is there a relation between users' cognitive styles and users' mental models of the information in a hypermedia environment; and if so, what is that relation?*

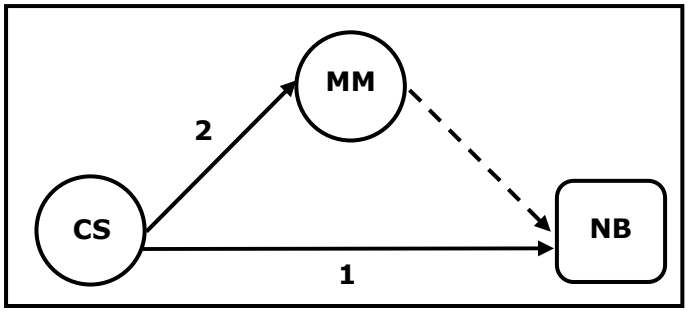

Figure 1.2 Diagram of research question 2 (CS = cognitive style, MM = mental model, NB = navigation behavior)

Mental model is assumed to be an intervening variable between cognitive style and navigation behavior. A comparison of the answers to research questions 1 and 2 may give an indication whether the suggested relations between cognitive style, mental model, and navigation behavior of figure 1.2 do exist.

1.2 Writing Studio, the experimental material

The hypermedia environment that will be used in this study, in order to get an answer on the two research questions, is the Writing Studio of Colorado State University. This web site is suitable for this study, because of several reasons. Before discussing these reasons in Section 1.2.3, background information about the Writing Studio and a description of the Writing Studio will be given (Section 1.2.1 and Section 1.2.2).

1.2.1 Background information about the Writing Studio

The Writing Studio is part of the web site Writing@CSU (http://writing.colostate.edu). Writing@CSU, which was visited 2.465.025 times in 2004 (M. Palmquist, personal communication, April 20, 2005), provides resources that support writers and writing instructors with their writing, such as writing guides, demonstrations and interactive

tutorials. The information varies from information about writing business letters, to information about writing poems or press releases.

The Writing Studio (http://writing.colostate.edu/studio) (see figure 1.3) provides more specialized writing support. Whereas Writing@CSU can be seen as an online version of a (traditional) writing classroom, the aim of the Writing Studio is simulating a computer-supported writing classroom. In computer-supported classrooms, computers are available, which students can use for writing during class. The Writing Studio is based on the idea that the computer-supported writing classroom is not only possible in face-to-face settings, but also in electronic sessions (Palmquist, 2005).

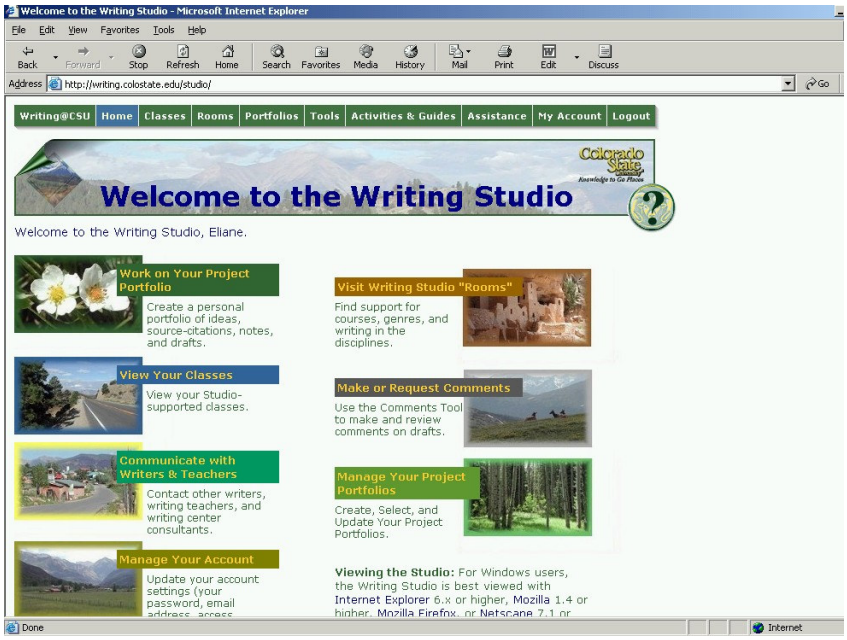

Figure 1.3 Homepage of the Writing Studio

The Writing Studio is used in different courses at Colorado State University. But it is used in the Netherlands as well, for the course Academic Writing of the University of Twente. In 2004 and 2005, this course was taught to students in Computer Science. These students could choose the course as an elective when writing their bachelor thesis. During the course, students are strongly advised to use the Writing Studio.

1.2.2 Description of the Writing Studio

In this section, some essential parts of the Writing Studio will be discussed. Roughly, a division can be made between parts with expository information about writing, and interactive parts of the Writing Studio. First of all, an example of an expository part will be given. Expository information is mainly stored in writing guides. One of the writing guides is the guide about writing summaries (see figure 1.4). In this guide, information is given about different types of summaries and about how to create a summary.

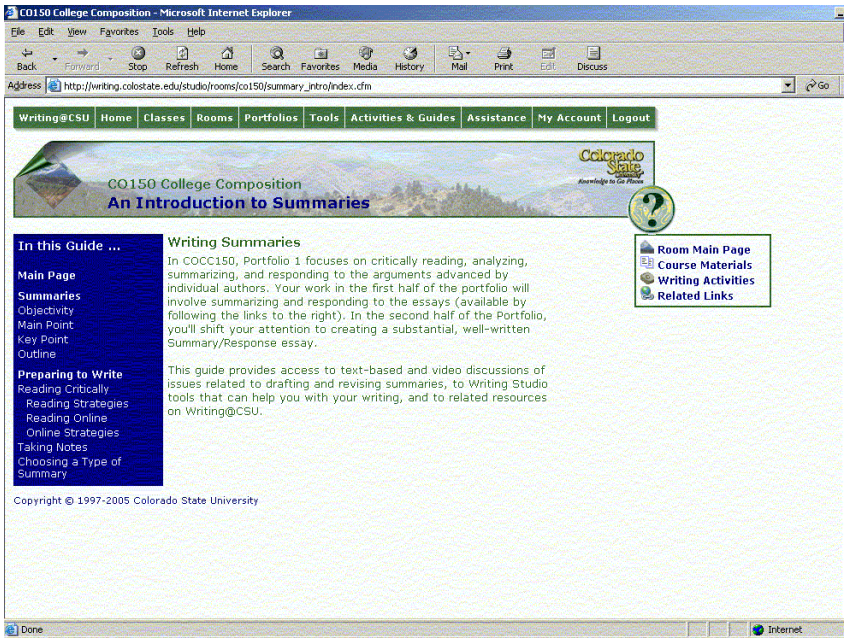

Figure 1.4 Main page of writing guide Writing Summaries

Further, the Writing Studio has interactive parts. For example, the Writing Studio contains several tutorials in which the user is guided through a number of different steps that may be useful in the writing process. An example is the brainstorm tutorial (see figure 1.5). Users can go through a brainstorming session by answering the given questions.

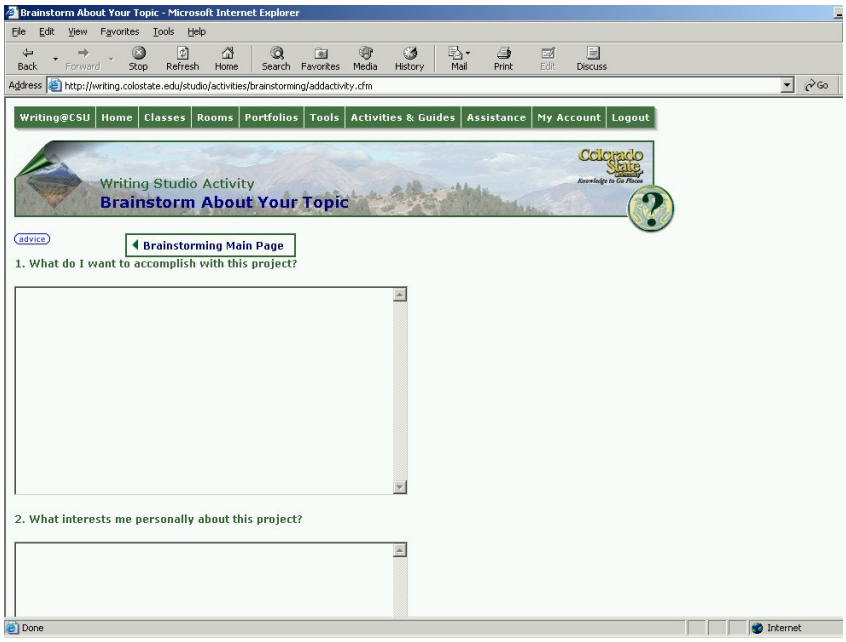

Figure 1.5 Tutorial that guides user through a brainstorm session

Besides these more 'traditional' interactive aspects of writing classes, the Writing Studio contains interactive elements that are more typical of computer-supported writing classes. One of these elements is the facility to save writings. The place in which writers can save their writings is called 'Portfolio.' In a portfolio one can save writings, and create a to-do-list, a list of ideas, and a list of references (see figure 1.6).

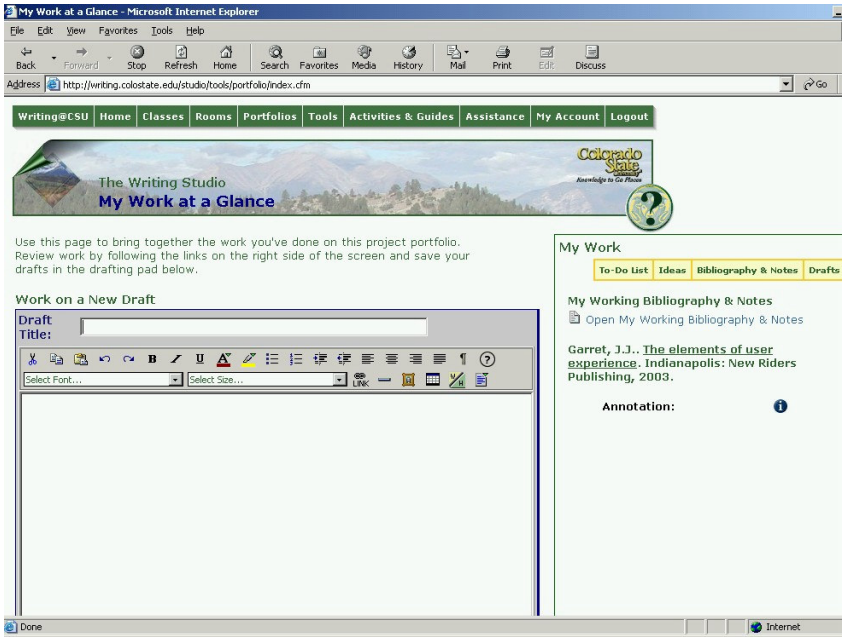

Figure 1.6 Portfolio working page

Another interactive element of the Writing Studio that refers to the computer-related writing class is the possibility to ask feedback of other writers or instructors. A user can get assistance in different ways, for example through a forum or a chat room. Another option is sending a draft to a writer or instructor (see figure 1.7).

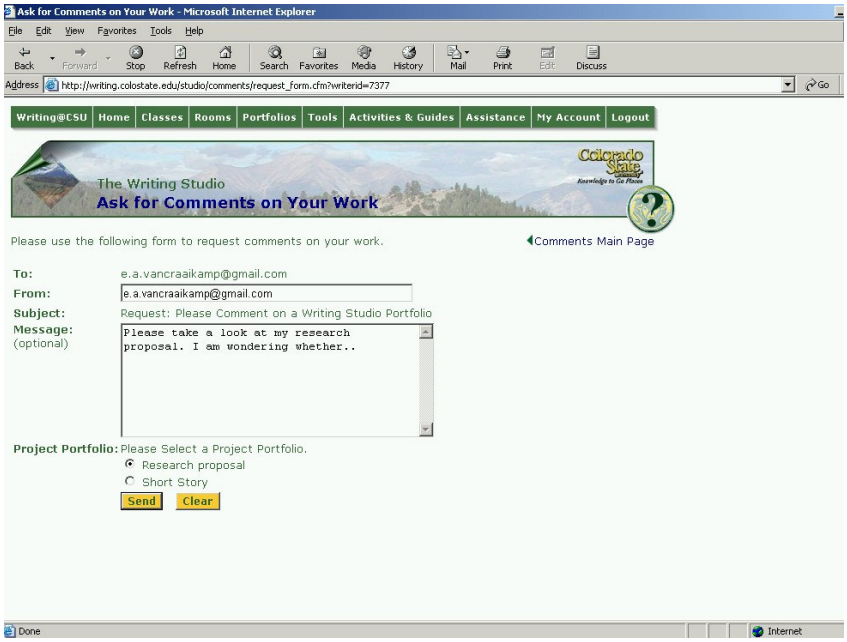

Figure 1.7 Possibility to ask a writer or instructor for comments on a writing product

1.2.3 Reasons for choosing the Writing Studio

The Writing Studio is a suitable hypermedia environment for this study, for several reasons. First of all, the Writing Studio is quite an open hypermedia environment. That is, the routes to information are not pre-determined, like in some other educational hypermedia systems. It is assumed that users can choose different navigation patterns.

Besides, the Writing Studio is a special web site. Namely, it contains different types of information: interactive parts such as tools and tutorials, but also 'simple' expository information. In addition, the Writing Studio contains a large amount of information. On a web site with a great deal of information consisting of different types, it is difficult for web designers to create a good information and navigation structure. Informal usability evaluation on the Writing Studio supports this assumption. It revealed several navigation problems, like too elaborate side menus on the web site, and navigation tools that attracted too little attention (Palmquist, 2005). It is useful to get more insights into users' behavior in, and users' mental models of special hypermedia environments such as the Writing Studio. Besides, for the Writing Studio, a formative evaluation will be useful to investigate more thoroughly the problems that users experience.

Further, because a lot of people have to write regularly, the subject of the Writing Studio will be familiar for a large number of persons. Moreover, it is not necessary to have particular knowledge before one is able to use the Writing Studio. So, it is not needed to look for a very specific group of test participants for this study.

1.3 Preview

The structure of this master's thesis is as follows. First, in Chapter 2 the theoretical framework will be discussed. This framework explains the different concepts of the research questions: hypermedia environment, navigation behavior, cognitive style, and mental model. It also contains hypotheses that belong to the first research question. (No hypotheses will be formulated about the second research question, because that question is explorative.) Then, in Chapter 3, the design of the study will be given. In this design the three research methods will be discussed, namely a Cognitive Style Test, the Thinking Aloud Method to answer the first research question and the Card Sorting Method to answer the second research question. It will be explained why the particular methods have been chosen, how they work, and how the data will be analyzed. Chapters 4 to 6 discuss the results of the three research methods. In Chapter 7, conclusions will be drawn, in order to answer both research questions. Finally, Chapter 8 discusses limitations of the study and gives suggestions for further research.

2. Theoretical framework

In this chapter the different terms of the research questions will be discussed, in order to get a clear view of their meanings in this study. First of all, Section 2.1 discusses why a web site such as the Writing Studio can be reckoned among hypermedia environments. Subsequently, to get a clear view of navigation, navigation will be discussed from two perspectives: from the designer's point of view (Section 2.2) and from the user's point of view (Section 2.3). Next, Section 2.4 discusses cognitive styles, and in particular the cognitive style 'field dependency.' In Section 2.5 the hypotheses belonging to the first research question are given. Finally, Section 2.6 discusses the last concept of the research questions, namely the concept 'mental model.'

2.1 A web site as a hypermedia environment

A web site is maybe the most well known example of a hypermedia environment. A hypermedia environment is a kind of system that connects 'chunks of information' to each other, by means of hyperlinks. These chunks of information are often called 'nodes', and can consist of text, data, image, video, and audio. There is no predefined structure of the nodes; the nodes can be connected hierarchically, non-hierarchically or both (Farkas & Farkas, 2002; Rosenfeld & Morville, 2002). A special characteristic of hypermedia environments is the possibility to 'jump' from one node to another in a non-linear way through links. Because of that, users have more freedom to control their own behavior, than on, for example, text on paper. The prefix 'hyper' expresses to this way of moving through the information (Farkas & Farkas, 2002).

2.2 Navigation from designer's point of view

In this section, navigation in a hypermedia environment will be discussed from a design viewpoint. Therefore, a distinction between information design (Section 2.2.1) and navigation design has been made (Section 2.2.2). Information design is about structuring information; navigation design is about providing the ability to access information. Good information design can be seen as the basis for good navigation design. Rosenfeld and Morville (2002, p.106) use metaphors to explain this: "Structure and organization are about building rooms. Navigation design is about adding doors and windows."

2.2.1 Information design

Designing an information structure consists of different components (Rosenfeld & Morville, 2002). A component of building an information structure, is 'structuring': the designer of the information structure needs to determine the size of the information elements, or: 'nodes.' Another component is 'organizing'; this refers to the categorization of the nodes. Different information structures are possible: a hierarchical structure (which can vary in depth and breadth), a matrix structure, an organic structure and a sequential

structure (Garret, 2003). Further, 'labeling' is a component in building an information structure. This is about giving names to the formed categories.

2.2.2 Navigation design

Two factors are important in navigation design: building context and providing flexibility. Building context means that users have to be able to locate their current position. Providing flexibility refers to providing freedom for users to determine their own path through the information (Rosenfeld & Morville, 2002). Navigation design can be shaped in different ways. In this section, two groups of navigation systems will be discussed. The first group consists of systems that are embedded within the structure of the web pages, and the second group consists of systems external to the basic hierarchy of the site, providing complementary ways to reach the desired information. The latter ones are called supplemental navigation systems (Rosenfeld & Morville, 2002).

Embedded navigation systems

Embedded navigation systems can be built by using different navigation means, for example navigation bars, menus of hyperlinks, buttons, and links in the text, and so forth. Navigation means that are not being created by web designers, but which web designers have to take into account, are the browser's buttons. Examples of browser's buttons are the back/forward buttons.

Navigation systems that are embedded in the structure of web pages can be divided into global, local and contextual navigation systems. Due to the multitude of navigation possibilities, it is difficult to distinguish different navigation categories strictly. Therefore, the division of navigation systems in this section should not be read as a rigorous one.

Global navigation systems (also called site-wide navigation systems), provide access to key areas and functions (Rosenfeld & Morville, 2002). Global navigation is often in the form of a navigation bar on the top of the page. 'Global' doesn't necessarily imply that this navigation appears on every page in the site, although it is in fact intended to (Garret, 2003). Garret mentions a subcategory of global navigation, namely, courtesy navigation. This means navigation elements that appear throughout a site, such as links to contact information and policy statements. In figure 2.1, global navigation within the Writing Studio is shown (number 1).

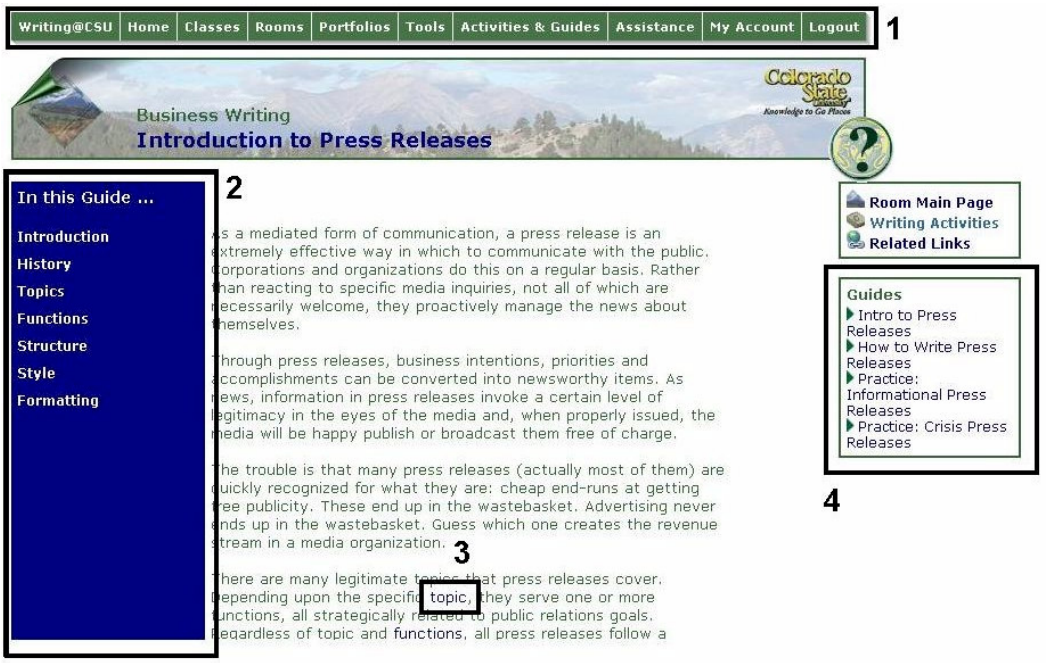

Figure 2.1 Embedded navigation systems in the Writing Studio

Local navigation systems are complementary to the global navigation. Local systems provide access to the immediate environment of the page they are located on, and are consequently more detailed than global navigation. In a strictly hierarchical structure, this means local navigation provides access to a page's parent, siblings, and children. (See number 2 in figure 2.1 for a local navigation menu in the Writing Studio.) Global and local navigation can be integrated into one system. Then the global navigation bar expands to provide local navigation options. The Writing Studio has such an integrated navigation bar (see figure 2.2). Sometimes, local navigation systems provide access to areas that stand rather on their own. These areas are referred to as 'subsites' or 'sites within sites' (Garret, 2003; Rosenfeld & Morville, 2002).

Figure 2.2 Global and local navigation in one navigation bar

Contextual navigation is embedded in the content of the page itself. It provides access to related information, which may not always be locatable when using the global or local navigation. Embedded links are links within the text, and are called 'inline navigation' (see number 3 in figure 2.1). When a specific area is used to give an overview of related links, one speaks about 'external navigation' (Rosenfeld & Morville, 2002). In figure 2.1 number 4, an example of external navigation in the Writing Studio is given. The list of hyperlinks refers to related information in the writing guides of Colorado State University's Writing Center.

Supplemental navigation systems
Some navigation elements are not embedded within the structure of the web pages, but stand on their own. They are called supplemental navigation systems (Rosenfeld & Morville, 2002) or remote navigation tools (Garret, 2003). There are diverse supplemental navigation systems (Garret, 2003; Rosenfeld & Morville, 2002):

- A site map gives a concise image of the overall site structure. Most of the time, it doesn't show the entire web site, but only the most important levels of the hierarchy. It is important to mention the direct access a site map provides to the different subjects of the web site. A site map can consist of graphical or text-based links.
- An index is an alphabetical list of topics with links to relevant pages. The hierarchy of the topics is not displayed. This supplemental navigation system is useful for users who know the name of the subject they're looking for.
- Search engines allow users to use their own words to look for information. This system is often used by users who know very well what they are looking for, and therefore do not need to navigate through the system.

The information and navigation design is not by definition perfectly adapted to the behavior of the user. Therefore, user testing is an almost indispensable step in the design process. User testing shows whether the design meets the expectations and desires of the user (Farkas & Farkas, 2002).

2.3 Navigation from user's point of view: navigation behavior

This study aims at gaining more insight into factors related to navigation behavior. Navigation behavior is the central theme of this section. First, a general description of navigation behavior will be given (Section 2.3.1). Next, ways in which navigation behavior can be measured will be discussed (Section 2.3.2). Finally, Section 2.3.3 discusses factors that appear to be related to navigation behavior.

2.3.1 Navigation behavior

Navigating in a hypermedia environment refers to finding a way through the information presented. Bachiochi, Berstene, Chouinard, Conlan, Danchak, Furey, Neligon, and Way (1997) point out four questions that are important during this 'wayfinding': where am I; where do I want to go; am I on the right path; and am I there yet?

Navigation can take place in one hypermedia environment (such as a web site), but also on the Internet. The first form of navigation is called 'intra-site' navigation behavior and the latter one 'inter-site' navigation behavior (Danielson, 2002). The study presented here is about intra-site navigation behavior.

On the basis of a literature review, Danielson (2002) describes navigation behavior as a process consisting of two steps. The first step consists of determining the navigation goal. This can be general purpose browsing, when the user consults sources with items of interest; or directed search, when the goal is known. Directed search may be further separated into subject-based exploration, in which the user attempts to gain a basic understanding of a specific subject area, and fact-finding search, in which the user looks for a specific piece of information in the space. The latter one can be classified as 'formal

search.' The second step of the navigation process is developing a strategy for achieving the determined goal.

Rosenfeld and Morville (2002) mention the fact that searching is an iterative process. This can imply different tries to find information, but also a change of the search-goal. As the user learns more about what he or she needs and what information is available, the information request can be modified.

2.3.2 Ways to measure navigation behavior

Many studies have been measuring navigation behavior. This has been done in various ways. In this section, an overview will be given of different ways to measure navigation behavior. Further, it will be discussed how navigation behavior will be measured in the study presented in this master's thesis.

Roughly, a distinction can be made between measuring navigation behavior and measuring the outcome of the behavior. First, two studies will be mentioned, in which a clear distinction between these two output variables has been made. Subsequently, some studies will be mentioned in which the distinction has not been made clearly.

Ford and Chen (2000) made a clear distinction between navigation behavior and outcome of the behavior. They measured whether individual differences, such as gender, age, and cognitive style, were related to learning behavior and learning outcome. (Ford and Chen probably mention 'learning' because the hypermedia environment of the study is a hypermedia learning program. Nevertheless, it seems to be that learning behavior and learning outcome are similar to navigation behavior and navigation outcome.) Ford and Chen measured learning behavior by counting the number of times that different navigation means were selected (such as hypertext links, next/previous buttons, map, index and back/forward buttons), the number of times that different subject categories were selected (such as examples and references), and the total number of navigational actions. Another aspect of learning behavior was the number of levels visited in the hierarchy and the time spent at each level. Learning outcome has, among other things, been measured by comparing the scores on the pre-test and on the post-test, and by measuring the time spent on the task. It is remarkable that in this study, Ford and Chen measured a wide range of navigation aspects.

The output variables of a study by Kim (2001) are comparable to the output variables of the study by Ford and Chen (2000). Kim investigated how cognitive style, online database experience, and task type influenced navigational style and search performance. Navigational style can be compared to Ford and Chen's learning behavior, and has been measured by counting the number of times that a participant used a particular navigation tool (such as embedded links, back button, home button, and so on). Although it is not specifically mentioned in either of the studies, 'behavior' seems to be more elaborate than 'style.' Search performance can be compared to Ford and Chen's learning outcome, and has been measured by the time spent retrieving information and the number of nodes visited while retrieving information.

McDonald and Stevenson (1998) do not make a clear distinction between behavior and outcome, although their measures seem to include both aspects. McDonald and Stevenson aimed at examining the effects of different hypertext topologies on navigation performance. Navigation performance has been measured as browsing and navigation

efficiency. Browsing measures were the number of nodes opened and the number of nodes repeatedly opened. Measures of navigation efficiency were the mean time to answer questions, and the mean number of additional nodes accessed per question. Additional nodes are nodes that deviated from the shortest route to the information.

Others did not make a distinction between behavior and outcome, as well, probably due to their focus on specific aspects of the navigation behavior. For example, Reed, Oughton, Ayersman, Ervin Jr., and Giessler (2000) investigated whether prior computer-related experiences predicted linear and nonlinear navigation in a hypermedia learning environment. Therefore, the number of linear and nonlinear steps, the percentage of nonlinear steps, and the time spent on the task have been measured. Linear steps can be determined on the basis of whether the step is the next logical, sequentially forward or backward movement.

Danielson (2002) also focused on hierarchical movements. He investigated the influence of a constantly visible sitemap on the behavior of information-seekers. Therefore, different navigation aspects have been measured, like page revisitation and browser-supported navigational acts. Further, Danielson registered the hierarchical relationships between two visited nodes (e.g. 'parent'), the direction of the movement (e.g. 'up' or 'down'), the hierarchical level, the time spent, and the rate of success.

Another reason for not distinguishing behavior from outcome is, when researchers aim at forming navigation styles, or profiles. In these kind of studies, navigation has been measured by logging a wide range of specific data such as path length, amount of revisits, page return rate, back button usage, amount of home page visits, view time, number of cycles, path density, level of depth, number of nodes opened, and type of nodes opened (Barab, Bowdish & Lawless, 1997; Herder & Juvina, 2004; Kim MacGregor, 1999).

The study presented in this master's thesis measures navigation behavior in a quite simple way that is similar to the study by Ford and Chen (2000). The outcome of the behavior will be measured as well, because insight in the quality of the outcome offers the possibility to compare navigation behavior in similar situations as for quality. This study does not aim at getting insight into specific navigation aspects or at forming navigation profiles, because detailed measures of navigation behavior are too elaborate for this study. The section with the hypotheses about cognitive style and navigation behavior (Section 2.5) describes and argues which specific aspects of navigation behavior will be measured.

2.3.3 Factors related to navigation behavior

When measuring navigation behavior, it is important to know which factors may be related to navigation behavior. This section is about such factors. The overview should not be read as an all-inclusive list of factors related to navigation behavior. It is intended to mention a number of relevant factors, in order to determine which factors will be taken into account in this study. First, several user characteristics will be discussed. After that, some task characteristics and characteristics of the hypermedia environment will be discussed. (The user characteristic 'cognitive style' will be discussed separately in Section 2.4 and Section 2.5.)

Characteristics of user

First of all, domain knowledge appears to influence navigation behavior. Domain knowledge is the prior knowledge someone has about the subject in question. Chen, Fan, and Macredie (in press) wrote a paper to illustrate the needs of students with different levels of prior knowledge, by analyzing findings of prior research on navigation in hypermedia systems. Because it appeared that novices (people with little domain knowledge) experience more disorientation problems in hypermedia systems than experts, aspects are mentioned that help reduce the disorientation. First, additional support, like visual cues, is more useful for novices than for experts. Besides, novices need different navigational tools than experts: tools like maps are more useful to novices, whereas search engines are more useful to experts. Further, the needs concerning content structure differ between the two groups: novices need structured paths, experts profit most from a learning system that provides flexible paths.

Besides domain knowledge, experiences with computers, and computer-related issues, appear to be related to navigation behavior. Ford and Chen (2000) found that high levels of prior experience in using computers, using the internet and creating web pages, are related to a high number of levels visited in the subject hierarchy, and many pages viewed. Online search experience appears to be related to navigation behavior, too. Novices tend to use embedded links and home buttons more frequently whereas expert participants tend to use jump-tools, such as the URL location box and the history list, more frequently (Kim, 2001). A more specific division of computer experience can be found in a study by Reed, et al. (2000). Experience with word processing, hypermedia software, and programming language appeared to influence navigation behavior.

Further, user characteristics such as locus of control (that is, whether an individual perceives being controlled by internal or external influences), spatial ability, and need for cognition, are found to be related to navigation behavior (Herder & Juvina, 2004; Kim MacGregor, 1999).

Characteristics of task

Besides characteristics of the user, the type of the task can be related to navigation behavior, too. In a study by Kim (2001), task type was related to navigation behavior. The effect interacted with the online search experience: for the known-item task, the novices tended to visit more nodes than the experienced. Further, for this type of task the novices used a greater number of embedded links than the experienced users did, and for the subject search task experienced participants used jump-tools more often than novices did.

Characteristics of hypermedia environment

Further, Danielson (2002) regarded the influence of a characteristic of a hypermedia environment. He found that a constantly visible site map was related to navigation behavior. Participants with a constantly visible site map dug deeper into the site hierarchy and spent more time at lower levels, made less use of the back-button, and made more movements outside the immediate hierarchical family of the current node than participants without a constantly visible sitemap. McDonald and Stevenson (1998) investigated the differences between hierarchical, nonlinear, and mixed hypermedia environments. The results showed that participants in the mixed conditions performed better than those in the other two conditions did.

The study presented in this master's thesis will measure several aspects that can influence navigation behavior. First of all, the user characteristic 'cognitive style' will be included in this study, as discussed in Chapter 1. Further, domain knowledge will be measured. The domain knowledge will be regarded as experience with online writing centers and experience with or knowledge about writing skills. Next, experience with using computers and visiting web sites will be taken into account. Other computer-related experiences will not be investigated, because it does not seem likely that they are relevant in this study. User characteristics such as locus of control or spatial ability will not be taken into account. Measuring these factors is too elaborate for this study.

All tasks of the study will be formal searches, to be conducted in one hypermedia environment. So, possible influences of task type and type of hypermedia environment can be controlled.

2.4 Cognitive styles

Cognitive style is an important variable in this study, because it appears to be related to navigation behavior. But before discussing the relation between both variables, cognitive style has to be defined. First, general information about styles and cognitive styles will be given (Sections 2.4.1 to 2.4.3). In this study is chosen to investigate one aspect of cognitive style, namely field dependency. Therefore, Sections 2.4.4 to 2.4.7 discuss field dependency. In particular, a description of field dependency and reasons for choosing this cognitive style will be given.

2.4.1 Personal styles in general

Style is a very common word, used in both everyday language and in a number of academic disciplines. It refers to a set of individual qualities, activities or behavior sustained over a period of time (Riding & Rayner, 1998). A style is not the same as a strategy. Namely, a style operates without individual awareness. A strategy on the other hand, is a learned and developed way to cope with situations and tasks. A strategy can be seen as a method of utilizing styles to make the best of situations for which they are not ideally suited (Riding, 1997). Further, style is something different than ability. In terms of style a person is both good and poor at tasks, depending on the nature of the task; while for ability the person is either good or poor. Worded differently, style refers to how you go about a task; ability refers to how well you do a task (Biggs, 2001; Riding & Rayner, 1998).

2.4.2 Cognitive style

Cognitive styles are about the way people process information. A cognitive style is a kind of a thinking style. To define cognitive style in greater detail, it is useful to look at part of the psychology to which cognitive styles belong. As the name implies, cognitive styles belong to the field of cognition. Preece, Rogers, and Sharp (2002) describe cognition as the thing that goes on in our heads when we carry out our everyday activities, like thinking, remembering, learning, daydreaming, decision making, seeing, reading, writing and talking. The following definition of cognitive styles flows logically from the description

of cognition: “cognitive style is an individual’s preferred and habitual approach to organizing and representing information” (Riding & Rayner, 1998, p.8). This definition will be used in this study.

Cognitive styles can be discerned from learning styles. Sometimes the terms seem to be used interchangeably, but a distinction can be made. Namely, cognitive styles operate across a range of cognitive activities, including learning. The term ‘learning style’ is used as cognitive style causing information processing taking place specifically in a learning context (Ford & Chen, 2001).

2.4.3 Origins of cognitive style

Opinions differ about the origins of style, whether it is genetically determined (nature) or environmentally influenced (nurture). No longitudinal studies of the effect of age have been undertaken, probably due to the difficulty of assessing the cognitive style of very young children (Riding & Rayner, 1998).

Renzulli and Dai (2001, p.38) state that “styles are stable but undergoing change.” Research by Riding, Rayner and Banner (as cited in Riding, 2001) seems to show the opposite. They explored the relation between style and home background. Pupils were rated in terms of parental support. This study showed no significant effect of the home background on the style. This leaves open that style is innate or learned at an early age.

2.4.4 Different types of cognitive styles

A lot of different dimensions of cognitive styles exist, for example leveling – sharpening, impulsivity – reflectiveness, converging – diverging, holist – serialist, and field-dependency – field-independency (Riding & Rayner, 1998). This wide range of style labels is mainly due to work of various researchers between the 1940s and the 1980s. Researchers all observed style dimensions, but because they worked quite isolated from each other, they all gave their own labels to the styles they were studying, and they all developed their own instruments for assessment (Riding, 1997). As a reaction to the multitude of developed styles, Riding and Cheema (as cited in Riding & Rayner, 1998) introduced two general style dimensions into which the different style labels could be grouped. The two dimensions are the wholist-analytic dimension and the verbal-imagery dimension. The wholist-analytic dimension describes whether an individual tends to organize information in wholes or parts. And the verbal-imagery dimension describes whether an individual tends to represent information during thinking verbally or in mental pictures.

The cognitive style that will be used in this study belongs to the wholist-analytic dimension, namely field dependency. Reasons for choosing field dependency will be discussed in Section 2.4.6.

2.4.5 Description of field dependency

Field dependency (introduced by Witkin) is an individual’s tendency to discern and to isolate elements embedded in complex contexts (Calcaterra, Antonietti & Underwood, 2005). The field dependent individual is likely to be dominated or influenced by the prevailing field. The field independent individual is less susceptible for influences of the

field, and experiences items as separate from their backgrounds (Kim, 2001). Table 2.1 presents a number of characteristics of field dependent and field independent individuals.

Table 2.1
Differences between field dependent individuals and field independent individuals (Chen & Macredie, 2002, p.4)

Field dependent individuals	Field independent individuals
• find it difficult to restructure new information and forge links with prior knowledge	• are able to reorganize information to provide a context for prior knowledge
• show a greater social orientation	• are influenced less by social reinforcement
• experience surroundings in a relatively global fashion, passively conforming to the influence of the prevailing field or context	• experience surroundings analytically, with objects experienced as being discrete from their backgrounds
• demonstrate fewer proportional reasoning skills	• demonstrate greater proportional reasoning skills
• prefer working in groups	• prefer working alone
• struggle with individual elements	• are good with problems that require taking elements out of their whole context
• are externally directed	• are internally directed
• are influenced by salient feature	• are individualistic
• accept ideas as presented	• accept ideas strengthened through analysis

Several instruments have been developed to measure field dependency, for example the Group Embedded Figures Test (GEFT), the Cognitive Style Analysis (CSA) and the Extended Cognitive Style Analysis for the Wholistic/Analytic Dimension (E-CSA-WA). The GEFT and the CSA have been used several times in research on field dependency and navigation behavior. The E-CSA-WA is a relatively new test that has not been used in combination with navigation behavior.

2.4.6 Reasons for choosing field dependency

The dimension of field dependency has very often been applied in research. It has been investigated in a wide range of human activity (Ford et al., 2002). The relation between field dependency and navigation behavior in hypermedia environments has been investigated several times, as well. (See for example the review paper of Chen and Macredie (2002) on cognitive styles and hypermedia navigation and studies by Ford and Chen (2000), and Kim (2001).) This is not very surprising, considering the fact that the characteristics of field dependency fit well with navigating in a hypermedia environment. Namely, field dependency is about the tendency to discern and isolate elements embedded in complex contexts; navigating through a complex context as a hypermedia environment implies discerning and isolating elements. The fit between navigation

behavior and field dependency, and the available research on these subjects, make field dependency an appropriate cognitive style for the first research question of this study.

No research is available about the relation between cognitive styles and users' mental models of the information in a hypermedia environment. In spite of that, field dependency may be related to the mental models that individuals form of the information in a hypermedia environment. After all, field independent individuals demonstrate greater proportional reasoning skills, and they are better with problems that require taking elements out of their context, than field dependent individuals (Chen & Macredie, 2002). These characteristics seem relevant for creating a mental model of an information structure, for which a certain amount of organizing information elements is required.

2.4.7 Factors related to field dependency, when measuring with CSA or E-CSA-WA

Riding and Rayner (1998) state that the construct of cognitive style appears to be valid, as assessed by the CSA. They state that evidence comes from a range of studies and from a variety of contexts. It implies that field dependency is independent from other variables, like intelligence, personality measures, and gender. A study with a relatively new cognitive style test confirms these findings: Peterson et al. (in press) found that field dependency, measured with the E-CSA-WA cognitive style test, appeared to be independent from ability and personality.

There do not appear to be any factors related to field dependency, when using the CSA or E-CSA-WA. In spite of this, two factors will be mentioned in the design of the study, namely gender and type of educational program. These factors are quite easy to administer. Other factors, such as intelligence, personality or ability will not be included in the design of the study, because they are too complicated to measure. The limited time and means available for this study do not permit such elaborate assessments.

2.5 Hypotheses about field dependency and navigation behavior

Sections 2.1 to 2.4 have discussed the terms that are important in the first research question: *What is the relation between users' cognitive styles and users' navigation behavior in a hypermedia environment?* In this section, the hypotheses belonging to the first research question of this study will be discussed. The hypotheses are based on the characteristics of field dependency (see Section 2.4.5), and on studies that have been investigating the relation between field dependency and navigation behavior.

Chen and Macredie (2002) give in their review paper 'Cognitive Styles and Hypermedia Navigation: Development of a Learning Model' an overview of research on hypermedia learning in combination with field dependency. The 30 studies that are discussed were published between 1989 and 2001. Chen and Macredie developed a model on the basis of the analysis of these 30 studies (see figure 2.3).

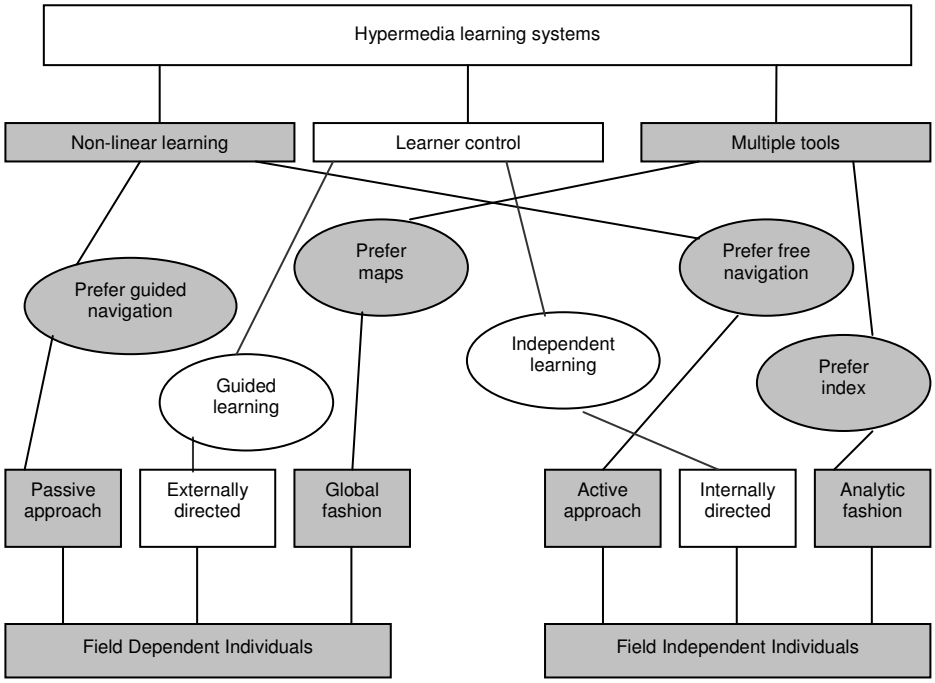

Figure 2.3 Model based on analysis of 30 studies on navigation and field dependency (Chen & Macredie, 2002, p.12)

This model will be used to structure the hypotheses about field dependency and navigation behavior in this study. Only the gray parts will be used, with a focus on the passive/active approach and the global/analytic fashion. Other elements of the model are less relevant for this study, because they focus too much on learning aspects and on the design side of hypermedia environments.

2.5.1 Passive approach versus active approach

First of all, the passive approach of field dependent individuals and the active approach of field independent individuals will be discussed. Chen and Macredie (2002) relate approach to the way individuals prefer moving through the hypermedia environment. They state on the basis of several studies that field dependent individuals seem to prefer a fixed path to follow in a linear environment. In contrast, field independent individuals are relatively capable of determining their path through a non-linear hypermedia environment. Chen and Macredie state that this may be due to the fact that field independents tend to be more capable of imposing their own structure on the information. However, field dependents tend to rely more on the external cues provided.

Regarding the passive versus the active approach, it can be expected that field dependent individuals will use the linear navigation possibilities of the hypermedia environment more often than field independent individuals. Although a web site is characterized by nonlinearity, a form of linear navigation can be distinguished. Namely, web site users can follow links that bring them one step back or one step forward, and omit jumping through the information. Buttons that provide the possibility of moving one

step back or one step forward, are back and forward buttons of the browser and next and previous buttons on the web pages themselves.

A small-scale study by Kim (1997) supports the assumption that field dependents use the 'linear-navigation-buttons' more often than field independents. Kim investigated how students navigated while searching information on the World Wide Web. This study indicated, among other things, that field dependent students preferred to use the back/forward buttons. However, a study by Ford and Chen (2000) contradicts the assumption. They asked 65 postgraduate students to construct a homepage, by means of a hypermedia-based tutorial. They found, among other things, that field independent individuals used the back/forward buttons more often than field dependents when consulting the tutorial.

In this study it will be assumed that back/forward buttons and next/previous buttons provide the possibility to show linear navigation behavior, and that field dependent individuals are more likely to use these buttons than field independents. This will be assumed in spite of the fact that the results of the study by Ford and Chen (2000) seem to prove the contrary. Two hypotheses have been formulated:

- *Hypothesis 1. Field Dependents use the back/forward buttons of the browser more often than Field Independents*
- *Hypothesis2. Field Dependents press more often on the next/previous buttons than Field Independents*

A study by Reed et al. (2000) investigated whether 18 graduate students with different levels of computer experience and with different cognitive styles (including field dependency), showed different navigation behavior in a hypercard program. Navigation behavior was operationalized by the number of linear and non-linear steps, and the percentage of non-linear steps. They found in addition to different effects based on experience levels, that field dependent individuals took more linear steps and more nonlinear steps than field-independent and field-mixed participants. (Field mixed individuals are individuals with average scores on field dependency.) The explanation Reed et al. (2000, p.626) give for this finding is: "field dependents tend to accept the existing structure more than field-independents. Apparently, it does not matter what form this structure takes: linear or non-linear."

Comparable results have been found in a study by Kim (2001). In this study 48 undergraduate students had to execute two search tasks on a university web site. The results of the study indicate that field dependents with little experience in online database search spent a longer time and visited more nodes than the field independent novices. For the field dependent and field independent with a high level of search experience, this difference did not occur. However, Ellis, Ford, and Wood (1993) found that field independents accessed a larger number of information nodes than field dependents. They investigated two hypertext packages, among an unknown number of participants. The participants had to answer a set of questions, demanding different types of understanding.

In this study, the assumption of Reed et al. (2000) will be tested, despite the results of the study by Ellis, Ford and Wood (1993). The results of the study by Ellis, Ford and Wood

may be a little bit outdated, because hypermedia systems have become much more elaborate than hypertext systems.

Separating the linear and non-linear steps is too labor-intensive for this study. Therefore, the total number of steps (clicks) will be registered. This leads to the following hypothesis:

- *Hypothesis 3. Field Dependents need more clicks to find the intended information than Field Independents*

The fact that field dependents tend to passively accept the existing structure can be shown in another aspect of navigation behavior as well. Namely, 'passively conforming to the influence of the prevailing field or context' (Chen & Macredie, 2002, p. 4), may have an effect on the extent to which one accepts the information that is given, when interacting with the hypermedia environment.

The Writing Studio provides interactive options, like the possibility to send an email or save writings. Considering the passive approach that is supposed to belong to field dependents, it can be expected that field dependents need less confirmation of the results of their actions than field independents, because field dependents are likely to accept the information as given more readily than field independents. This leads to the following hypothesis:

- *Hypothesis 4. Field Independents check their actions more often than Field Dependents*

2.5.2 Global approach versus analytic approach

The second aspect from the model of Chen and Macredie (2002) that will be used in this section is the distinction between the global approach of field dependents and the analytic approach of field independents. Chen and Macredie deduce from different studies that field dependents prefer other kinds of navigation tools than field independents. Field independents tend to prefer the navigation tools that can be applied to locate specific information, like indexes, and search engines. Field dependents tend to prefer tools that give them an overview of the environment, like maps.

The Writing Studio does not contain tools like a search engine, an index or a map. Despite this lack of tools, it may still be possible to see the preference of the field dependents and the field independents. Namely, it is possible that users notice the missing tools. A search engine is perhaps the tool that is most missed. Therefore, the following hypothesis has been formulated:

- *Hypothesis 5. Field Independents refer more often to a search engine than Field Dependents*

Navigation tools, as mentioned above, are not the only way in which specific information can be located. The main navigation bar may be a tool to locate specific information, as well. This bar is always on the top of the page (it is a part of the 'global navigation', see

Section 2.2.2), and allows users to switch their paths with one click on this navigation bar. It can be expected that field independent individuals adopt an analytical approach and therefore use the main navigation bar more often than field dependent individuals. Conversely, field dependent individuals are likely to adopt a less analytical approach and click more often on hyperlinks on the pages themselves (that is, local and contextual navigation), than field independents.

A study by Kim (2001) found that field dependent novices used embedded links more often than field independent novices and experienced field dependents and field independents. This result supports a part of the assumption made in this study. Namely, embedded links are part of contextual navigation. The following hypotheses have been formulated:

- *Hypothesis 6. Field Independents click more often on the main navigation bar than Field Dependents*
- *Hypothesis 7. Field Dependents use local and contextual navigation more often than Field Independents*

2.5.3 Effectiveness of navigation behavior

The effectiveness of users' navigation behavior is not mentioned in figure 2.3. Nevertheless, it is an aspect worth mentioning. After all, to what extent did the global or analytical and the passive or active approach have any effect?

Chen and Macredie (2002) mention several studies that show differences between field dependents and field independents, with regard to the effectiveness of their behavior. The studies they mention have mixed results. Some studies show differences in performance between the two cognitive style-groups; the field independents were often more successful than the field dependent individuals. But other studies do not show any differences in learning outcomes.

Regarding the characteristics of field dependent and field independent individuals, it can be expected that field independent individuals are better able to analyze information in a complex environment (see table 2.1), like a hypermedia environment. It is likely that field independents are more successful in finding the intended information. In contrast, field dependents are likely to need more help to fulfill tasks in a hypermedia environment than field independents. The need for help can be displayed by the use of the help function, and by the consultation of examples. Ford and Chen (2000) found that field dependent users preferred to learn by using examples, whereas field independent users preferred detailed descriptions of HTML commands. The following hypotheses have been formulated:

- *Hypothesis 8. Field Independents complete more tasks than Field Dependents*
- *Hypothesis 9. Field Dependents use the help function more often than Field Independents*
- *Hypothesis 10. Field Dependents consult examples more often than Field Independents*

As mentioned above, it can be expected that field dependent individuals experience more difficulties in fulfilling tasks. Several studies show that field dependents feel disoriented more often than field independents. For example, Wang, Hawk, and Tenopir (2000) examined users' interaction with the Internet. They found that field dependents might find it more difficult to navigate on the Web and might get confused more easy than field independent participants. In a study by Kim (2001) it was found that field dependents tended to get disoriented more easily than field independents. Kim regarded the use of the homepage as a sign of being disoriented: "the frequent use of the Home button implies that the searcher has gotten lost in the process of the search and needs to return to the starting point to get his or her bearings" (p.251). In Kim's study it was found that field dependent novices used the home button significantly more than field independent novices or experienced field(in)dependents.

In this study, the number of visits to the homepage will be measured, as well. To determine whether the homepage has been used as a starting point, the clicks on hyperlinks on the homepage have to be registered. This leads to the following hypothesis:

- *Hypothesis 11. Field Dependents click more often on links on the homepage than Field Independents*

2.6 Explorative research on field dependency and mental model

In the previous sections, hypermedia environment, navigation behavior and cognitive styles have been discussed, as the hypotheses belonging to the first research question. The second research question is: *Is there a relation between users' cognitive styles and users' mental models of the information in a hypermedia environment; and if so, what is that relation?* The concepts 'hypermedia environment' and 'cognitive style' have been discussed already. The concept 'mental model' will be discussed in this section. For the second research question, no hypotheses will be formulated, because it concerns an explorative question.

The basis for the concept 'mental model' can be found in the schema theory of Bartlett. The schema theory of Bartlett (as cited in Benjafield, 1997) belongs to the field of cognition, just like cognitive styles (see Section 2.4.2). A schema is a simplified representation of a real situation. Bartlett calls this simplification 'rationalization', which means that "a person attempts to make a memory as coherent and sensible as possible" (p.73). Bartlett states that schemata are flexible and that they guide a person's behavior. Bartlett gives the following example to illustrate this: to make a proper stroke in a game such like tennis, one must adjust his or her posture and movements to fit the current situation. One must not repeat the stroke one has made before, because it is not likely that the movement of the ball is exactly the same.

A mental model is a schema about objects. It can be described as an internal representation of objects in the world and the relations between those objects (Benjafield, 1997; Thatcher & Greyling, 1998). A mental model is set up by two kinds of knowledge: knowledge of how to use the object and knowledge about how the object works. Mental models are not static: the more experience users have with something, the more their mental models develop (Preece et al., 2002).

In this study, it will be investigated whether users' mental models are related to users' cognitive styles. Participants with different cognitive styles will be asked to create a mental model of a specific hypermedia environment, the Writing Studio. Although the participants never visited the Writing Studio before, it is very likely that they do have mental models of web sites. After all, probably they use the Internet frequently.

As mentioned before, experience can develop users' mental models. Therefore, in this study the experience users have with online writing centers, and the experience users have with visiting web sites will be taken into account.

Now, all relevant concepts of the two research questions have been discussed, as well as a number of hypotheses about field dependency and navigation behavior. The next chapter will discuss how the study has been set up, in order to answer the two research questions.

3. Design of the study

This chapter discusses the design of the study. To get an answer on the research questions, three methods have been used: a Cognitive Style Test (Section 3.3), the Thinking Aloud Method (Section 3.4), and a Card Sorting Method (Section 3.5). But before the different methods will be discussed, Section 3.1 gives an overview of the study, and Section 3.2 describes the participants.

3.1 Overview of the study

The study presented in this master's thesis consisted of two stages. (The schematics of these stages are represented in figure 3.1.) The first stage consisted of a Cognitive Style Test. The second stage of the study consisted of the Thinking Aloud Method and the Card Sorting Method.

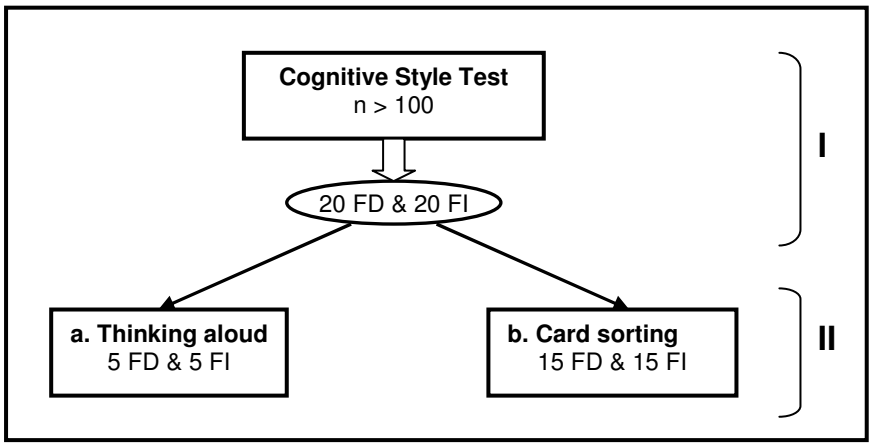

Figure 3.1 Schematics of the study (FD = Field Dependent individuals, FI = Field Independent individuals)

For the Cognitive Style Test was aimed at a number of at least one hundred participants, because for the second stage of the study two groups of participants were needed whose scores on the Cognitive Style Test differed considerably. To get two distinct groups, the more participants in the Cognitive Style Test, the better. But due to the limited time and means of this study, an amount of around one hundred seemed to be reasonable. Section 3.2 describes the participants of the Cognitive Style Test.

The twenty participants with the highest scores on the Cognitive Style Test (FI) and the twenty participants with the lowest scores on the Cognitive Style Test (FD) were selected for participation in the second stage of the study. The second stage of the study consisted of two parts: the Thinking Aloud Method (a), to answer the research question about cognitive styles and navigation behavior, and the Card Sorting Method (b), to answer the second research question about cognitive style and mental models. In both methods, the focus was on the difference between field dependent and field independent individuals.

Ten students participated in the Thinking Aloud Method. The choice for 2x5 participants was based on Nielsen (2000). He states that five participants are sufficient for discovering more than 75% of the problems that can occur during using a web site. In this study, it has been assumed that if five participants are sufficient for discovering most of the usability problems, five participants will be sufficient for discovering different navigation behaviors, as well. Two groups of five participants were used in this study.

In the Card Sorting Method, thirty students participated. The choice for 2x15 participants for the card sorting study was based on a study of Tullis and Wood (2004) and the comments on this study of Nielsen (2004). The study of Tullis and Wood indicates that thirty participants are needed to reach a correlation of 0.95 between the results of thirty participants and the ultimate results (of a group of 168 participants). Nielsen states that a correlation of 0.90 is a 'comfortable place to stop', for which fifteen users are needed.

3.2 Participants

This section describes the participants of Stage I of the study. Forty of these participants participated in Stage II as well.

Participants for the Cognitive Style Test were selected from the student population of the University of Twente, because students belong to the target population of the Writing Studio. The test was promoted during lectures, with an advertisement in the university newspaper and posters on the campus, and via personal contacts of the researcher. As a reward for participation, the results of the test and possible selection for further research were offered. Students who take courses at third, fourth and/or fifth year level at the University of Twente could participate. Students who take 'pre-master' courses could participate, as well. (Pre-master courses are introductory courses that are required for some students before being admissible to enroll in a master program). The criterion of the level of courses was chosen for two reasons:

- It is not desirable that a language barrier influences the results of the Cognitive Style Test, the Thinking Aloud Method or the Card Sorting Method. It can be expected that students who are following courses on third, fourth and/or fifth-year level understand the English that is being used in the Writing Studio. After all, it is likely that they have been reading English books and articles for several years already.
- It is not desirable that computer experience or Internet experience influences the navigation behavior. By choosing students who have been taking courses at college or university for several years, the influence of computer and internet experience can be controlled, because it can be expected that they have comparable (high) experience using computers and using the internet. After all, they had to use computers for making assignments, they had to consult the Internet for handing in their assignments, for finding information, for e-mailing, and so forth.

3.3 Cognitive Style Test: E-CSA-WA

In order to determine the degree of field dependency of the participants, the Extended Cognitive Styles Analysis – Wholistic-Analytic test (E-CSA-WA) was used. This test is Stage I of the study. First, in Section 3.3.1 it will be explained why the E-CSA-WA was chosen. Next, it will be described what the procedure of the test is (Section 3.3.2), and how the data has been analyzed (Section 3.3.3).

3.3.1 Motivation for using the E-CSA-WA

The E-CSA-WA was chosen, because this test is based on a test that has widely been applied in cognitive style studies: Riding's Cognitive Styles Analysis (CSA) (Peterson, Deary & Austin, 2003a; Reza Rezaei & Katz, 2004). Riding's CSA is a computerized test that measures two dimensions of cognitive style, namely the wholistic-analytic cognitive style dimension (WA) and the verbaliser-imager dimension (VI). The WA-part of the CSA can be used to measure field dependency, because "the Cognitive Styles Analysis measures what the authors refer to as wholist/analytic dimension, noting that this is equivalent to field dependence/ independence" (Riding & Sadler-Smith, as cited in Ford, 2000).

Peterson, Deary and Austin (2003a; 2003b) found that, despite some empirical evidence for the validity of the CSA, the test re-test reliability was not very strong. In order to increase the reliability of the WA dimension of the CSA, they extended the test with new items, which resulted in the E-CSA-WA. Their extensions did improve the test's reliability (Peterson et al. 2003a).

Another reason for choosing the E-CSA-WA is the fact that the test is computerized. Consequently, the test is easy to administer.

3.3.2 Pretest and procedure

The E-CSA-WA has been pre-tested with two co-workers of the University of Twente. The E-CSA-WA is an existing, computerized test. Therefore, adapting the test is not possible. The pre-test was used to examine whether the English instructions were clear to Dutch participants and how much time was required to complete the test. The comprehensibility of the questionnaire was taken into account, as well.

The test was administered as prescribed in the Administration Guide of the E-CSA-WA (Peterson, 2003). Each participant was tested individually, in a quiet room. Before the test started, each participant received short instructions on paper (see Appendix A). No information was given about the way in which cognitive style was measured. When a participant asked for the meaning of cognitive style, only superficial information was given (e.g. 'a cognitive style is a thinking style').

The E-CSA-WA took approximately 15 minutes to complete. The participants had to answer eighty questions, by pressing on 1 (yes) or 2 (no) on the number pad of a keyboard. There were forty questions about shapes being identical (an example is given in figure 3.2) and forty questions about a single shape being part of a complex figure (an example is given in figure 3.3).

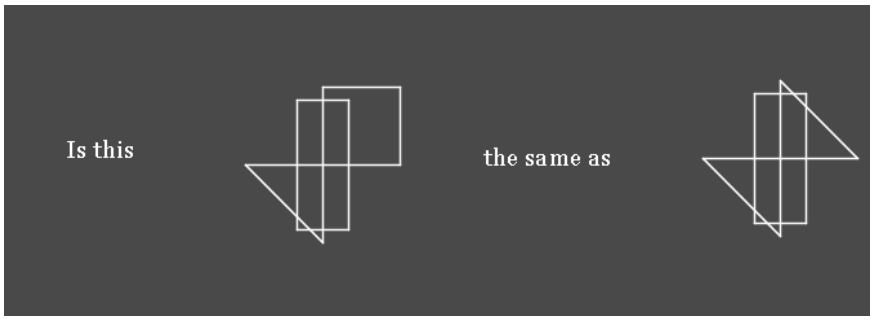

Figure 3.2 Example of a wholistic item in the E-CSA-WA

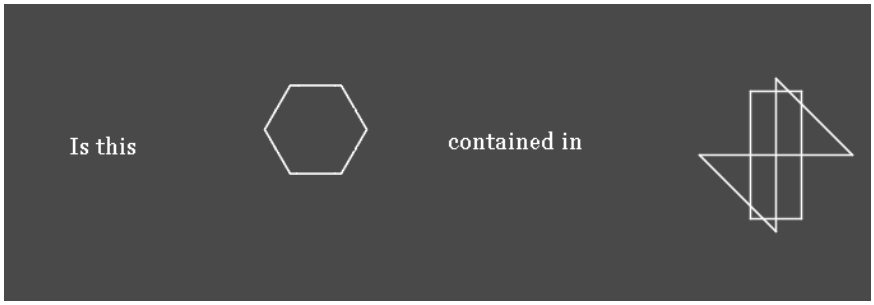

Figure 3.3 Example of an analytic item in the E-CSA-WA

After completion of the test, the participants were asked to fill in a short questionnaire (see Appendix B). First of all, the questionnaire checked the factors that have been taken into account in the selection of the participants: whether the participant indeed followed courses on third, fourth and/or fifth year level at the University of Twente, how much experience the participant had using computers and visiting web sites, and whether the participant thought that the English of the test influenced his/her results negatively. Secondly, the questionnaire contained questions about gender, and about the study program in which the participant took most of his or her courses. These questions were included to check the assumption that gender and ability are independent of cognitive style (see Section 2.4.7). Namely, students with a technical study program will use geometrical figures more often than students with a non-technical study program will. This may be reflected in ability. Finally, questions were included about whether the participant was a pre-master student, and whether the participant was willing to participate in further research.

3.3.3 Data analysis

The WA Ratio of a participant indicates his or her wholistic-analytic style preference. This ratio was assessed, by computing the ratio of the median reaction times for both task types. Wholistic (or 'field dependent') participants are expected to respond faster to the questions about comparing the similarity. Analytic (or 'field independent') participants are assumed to respond faster to the questions about whether one object is embedded within a larger object (Peterson et al., 2003a). Ratios that are closer to 0 would indicate a tendency towards a wholistic preference and scores that are closer toward 2 (or above) indicate a tendency for an analytic preference. When a participant makes more than 8 mistakes (10%), the results of the participant will be excluded.

The twenty participants with the highest scores and the twenty participants with the lowest scores were selected for further research. For the distribution of participants over the research methods, the height of the WA Ratio was not taken into account. But gender and type of studies were taken into account. Men and women, and students with a technical study program and students with a non-technical study program were distributed over the two research methods, in a way that within both methods, the distribution over the two cognitive style groups was as equally as possible. This was done in order to prevent undesired influences of gender and type of study program.

The statistical software package SPSS version 12.0.1 for Windows was used to analyze the distribution of the WA Ratio and the composition of the two selected groups. First, descriptive data was given, such as the mean and the standard deviation of the WA Ratio. Further, the non-parametric Chi-Square Test was used to determine whether one of the two groups contained significantly more male or female, students with a technical study program or students with a non-technical study program, and pre-masters or non pre-masters. All differences were tested at a level of $\alpha=0.05$, unless otherwise indicated.

3.4 Thinking Aloud Method

This section is about the Thinking Aloud Method, Stage IIa of the study. The Thinking Aloud Method was used in order to answer the first research question, about the relation between cognitive styles and navigation behavior. It has been executed with ten participants (five field dependent individuals and five field dependent individuals). Section 3.4.1 explains why the Thinking Aloud Method is a suitable method for this study. Subsequently, in Section 3.4.2 the tasks that were used will be discussed. Further, Section 3.4.3 and 3.4.4 discuss the procedure of the method, and the way in which the data have been collected and analyzed.

3.4.1 Motivation for using the Thinking Aloud Method

With the Thinking Aloud Method, participants need to verbalize their thoughts while executing tasks. This method is used because the method offers the opportunity to observe users' actual behavior in the hypermedia environment. This is needed to answer the research question. Additionally, the accompanying thoughts can be documented. Because of that, the method enables retrieving clues about misconceptions and confusion, before they manifest as incorrect behaviors (Rubin, 1994). These early clues are useful, because they can give background information for the navigation behavior that has been shown.

An important disadvantage of the Thinking Aloud Method is that verbalizing may feel unnatural and distracting, and may be a tiring activity. The thought process is slowed down, which may lead to fewer problems than normal (Rubin, 1994).

Despite the fact that verbalizing may have some undesirable effects, the Thinking Aloud Method has been used in this study. The value of verbalizing was decisive: it can provide useful information that gives a more detailed picture of navigation behavior than when only observing navigation behavior.

3.4.2 Materials: tasks

The participants had to execute ten tasks (see Appendix C). The test session started with two simple tasks. These tasks were not meant to observe the user's navigation behavior, but they were meant to help the participant to feel at ease, and to help the user to get used to verbalizing thoughts (Barnum, 2002). The first task asked the user's first impressions of the Writing Studio. Clicking was not necessary. Task number two was a 'first' and 'crucial' task (Barnum, 2002), namely, logging in. Logging in is a necessary action for using the system. It is a 'first' task in that, it is the first thing a user needs to do before using the system. It is a 'crucial' task in that, when users do not succeed in this task, they will not be able to use the system properly.

Tasks 3 to 9 were formal search tasks (see Section 2.3.1). For these tasks, scenarios were formulated to help participants to project themselves into the tasks. A scenario is an expanded version of one or more tasks, and provides context for the participant, for example the motivation for carrying out the task (Rubin, 1994). After every task, participants had to return to the homepage of the Writing Studio, so that the starting point is the same for each participant in every task.

In the formulation of the tasks, several aspects were taken into account. First of all, tasks were formulated about subjects that are to some extent recognizable for the participant. Further, tasks were formulated for which the participant needs to consult parts of the Writing Studio with expository information, and tasks were formulated for which the participant needs to use an interactive part within the Writing Studio. An example of a task in which a participant has to use an expository part of the Writing Studio is:

- *You would like to summarize a report. You prefer a summary that mimics the structure of your report. Search in the Writing Studio for a suitable type of summary.*

An example of a task in which a participant has to use an interactive part within the Writing Studio is:

- *You would like to use the Writing Studio for writing a research proposal for a project. You do not know yet what the project is about, but you would like to create a new file in the Writing Studio already. Create a new file that you can use for writing a research proposal and give it a suitable name.*

The participants had to make Task 10, without help of the Writing Studio. They were asked to write down what kind of information the Writing Studio contains. The main navigation bar was given as a guide.

3.4.3 Pretest and procedure

The Thinking Aloud Method was pre-tested with a co-worker and a student of the University of Twente. In this pre-test, the comprehensibility of the instruction and the tasks was checked. Further, it was examined how much time was required and whether the laptop and video recorder worked.

Each participant was tested individually in a room with a laptop, and a video camera. Figure 3.2 shows the diagram of the test room. The researcher used a protocol during

each test session, in order to give each participant the same instructions, and to use the same criteria for intervening and taking notes (see Appendix D). If a participant did not find the intended information after five minutes, and the participant was not near to the intended information, the researcher stopped the task. In this way, it was possible to see participants working on several different tasks.

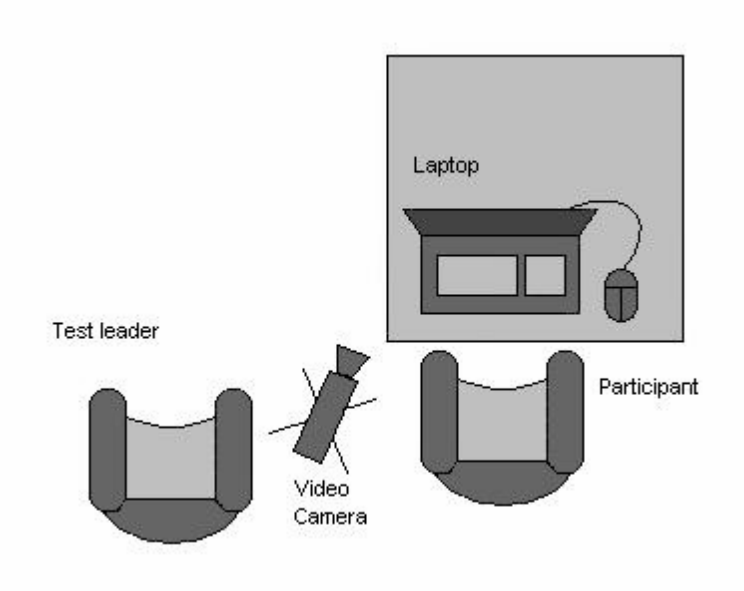

Figure 3.2 Diagram of the test room

After execution of the tasks, participants were asked to fill in a questionnaire (see Appendix E). This questionnaire contained several questions about domain knowledge: questions about whether the participant had ever visited the Writing Studio or another Online Writing Center before, and whether the participant had ever been trained in writing skills. These questions were included, because domain knowledge may influence navigation behavior (see Section 2.3.3). Further, the age of the participant, and participant's opinion about the Writing Studio were asked.

3.4.4 Data collection and data analysis

The video tapes of the thinking aloud sessions were analyzed. First of all, it was registered whether a participant finished a task or not, and whether the given answer was correct or not. Besides, the problems that occurred while executing the tasks were registered. In this study, problems are seen as situations in which the participant verbalized a negative opinion, frustration or confusion. Questions for help might be an indicator of a problem, as well. Therefore, questions for help, and the help that was offered, were registered. Detours were registered as problems, too. Detours imply the steps that have been made outside the most efficient route to the intended information. Further, quantitative data about navigation behavior was registered:

- Number of clicks on main navigation bar
- Number of clicks on local and contextual navigation (on other pages than the homepage), among which:
  - Next/previous buttons
  - Examples
  - Buttons/links in interactive parts of the Writing Studio

- Number of clicks on buttons of the browser
- Number of clicks on homepage
- Number of clicks on help function

Finally, it was registered whether a participant checked his or her answer, and how often a participant referred to a search engine. Time that has been spent on a task was not registered, because many things can influence the time spent, like slow Internet connection, elaborately thinking aloud, and elaborate answers on questions.

The statistical software package SPSS version 12.0.1 for Windows was used to analyze the data of the Thinking Aloud Method. Besides descriptive data of the number of clicks and so forth, the non-parametric Chi-Square Test was used to determine whether the two cognitive style groups completed a significantly different amount of tasks. Further, differences between clicks was tested by Independent Samples T Tests or by Mann-Whitney U, depending on the fact whether the data had a normal distribution. The One-Sample Kolmogorov-Smirnov Test was used to determine whether the data were normally distributed. All differences were tested at a level of $\alpha=0.05$, unless otherwise indicated.

3.5 Card Sorting Method

The second research question of this study is about the possible relation between cognitive styles and users' mental models of the information in a hypermedia environment. To get an answer to this question, the Card Sorting Method is used among fifteen field independent participants and fifteen field dependent participants. This is Stage IIb of the study. Section 3.5.1 discusses the reasons for using the Card Sorting Method, Section 3.5.2 discusses the cards that have been used, and Section 3.5.3 describes how the test was administered and how the data have been analyzed.

3.5.1 Motivation for using the Card Sorting Method

Card sorting is a research method in which participants have to organize cards with information on them. The participants are asked to create groups of cards that they felt 'belonged together.' After that, they have to label the different categories they formed.

It is said that card sorting is a method that discovers users' mental models of an information space (Nielsen, 2004; Nielsen & Sano, 1994; Rosenfeld & Morville, 2002; van der Geest & Loorbach, 2005). This makes the method quite suitable for this study. Other benefits of card sorting can be mentioned. First of all, card sorting is a simple method, and it is relatively cheap. Another benefit of the method is that the method does not directly ask users what they think. Therefore, the risk of socially desirable answers is less than when using a questionnaire, for example (Robertson, 2001). Further, card sorting is especially suitable for large web sites on which it is impossible to reach all the information from the home page (UserSense, n.d.). The Writing Studio is such a large web site.

In the most common version of card sorting, a number of index cards is used. Besides this physical variant, an electronic variant is possible as well, in which participants sort information elements with a computer program. In this study, the version with hard copy

cards was used, because in this variant the researcher is better able to control what is happening, than when participants execute the test at home. Besides, for participants, the hard copy variant seems to be easier to execute than the electronic variant.

Card sorting can be classified in another way, as well: open card sorting and closed card sorting (Rosenfeld & Morville, 2002). In this study, the open variant was used. This implies that the participants are free to choose how many groups they form and what labels they attach to each group. In the closed card sort, the researcher determines the number and the labels of the different groups. The participants have to distribute the information elements over these determined categories. The open card sort was used, because this variant gives the participant more freedom than the closed variant. It was preferable to have as few as possible restrictions, in order distinguish any differences between the two cognitive style groups.

3.5.2 Materials: cards with information elements

For this study, 56 cards were used (in Appendix F the information elements of the cards are listed). Each card contained information originating from the Writing Studio. In the selection of the information elements, several aspects were taken into account. First of all, the information elements were selected from both the parts of the Writing Studio with expository information, and the interactive parts of the Writing Studio (e.g. tutorials and tools). Besides, grouping terms like ‘guide’, ‘tool’ or ‘activity’ were avoided as much as possible, because these kind of terms can guide the sorting of the cards (Robertson, 2001). Further, information elements were chosen of familiar subjects, like business writing, to prevent that participants do not know what the content of the cards means. Some examples of information elements derived from expository parts of the Writing Studio, are:

- *The heading of a memo consists of four distinct information fields and should begin two spaces below the title*

- *An annotated bibliography contains bibliographical information on a text as well as a short summary that describes some of the main points of the text*

Some examples of information elements derived from interactive parts of the Writing Studio are:

- *Questions that guide a writer through a process of determining a suitable behavior pattern of a story's main character. For example: What is X’s primary language and dialect? Does X speak more than one language? Does X have an accent?*

- *Option to create a file in which writing products can be saved*

The cards contained descriptions of the content of several web pages. To prevent many cards beginning with ‘information about…’, in most cases more specific information about the subject was given. On these cards, the main subject of the web page was mentioned clearly. For example, the following information element was derived from a web page about complaint letters.

- *The objective of a complaint letter is to provide detailed information regarding the error or defect and to serve as a legal document recording the writer's claim and the corrective action or adjustment being requested*

The following information element was derived from a web page about business email:

- *The beginning and close of a business email can be written informally*

3.5.3 Pretest, procedure and data analysis

The Card Sorting Method was pre-tested with two co-workers of the University of Twente. In this pre-test the comprehensibility of the instruction and the information elements was checked. Further, it was examined how much time participants required.

Each card sort session was executed individually, and took one hour at most. First, the participant was asked to fill in a questionnaire. This is the same questionnaire as mentioned in section about the Thinking Aloud Method (see Section 3.4.3 and Appendix E). Only the last question, 'Please give your opinion about the Writing Studio in a few words or sentences' was not posed, because the participants did not work with the Writing Studio. During each test session, the researcher used a protocol, in order to give each participant the same instructions (see Appendix G).

The sortings were analyzed with cluster analysis (average linkage), a statistical technique to detect patterns in sets of orderings. The EZCalc package of the EZSort tool was used to create the typical tree diagrams that result from cluster analysis (Dong, Martin & Waldo, n.d.).

The next three chapters will discuss the results of the three research methods. First, the results of the E-CSA-WA will be discussed in Chapter 4. After that, Chapter 5 discusses the results of the Thinking Aloud Method, and Chapter 6 gives an overview of the card sorting results.

4. Results of E-CSA-WA

This chapter describes the results of the study's first stage, namely, the Cognitive Style Test. Section 4.1 discusses the 115 students, who participated in the test. Subsequently, Section 4.2 discusses the two groups that are selected for the Stage II of the study.

4.1 Participants of Stage I

Totally, 123 students of the University of Twente participated in the Cognitive Style Test. The results of eight participants have been excluded from the sample, because these results would probably affect the internal validity of the study. There were several reasons for excluding the eight participants. For example, they made many mistakes, they experienced difficulties with English, or the test was interrupted.

The sample of 115 participants, consisted of 90 males and 25 females. Further, for 54 of the participants, the majority of their courses were in non-technical fields ('Behavioral Sciences' or 'Business, Public Administration and Technology'), and for 61 of the participants, the majority of their courses were at technical fields ('Electrical Engineering, Mathematics and Computer Science', 'Engineering Technology' or 'science and technology'). About a third of the participants was a pre-master student (n=35). Considering the frequency participants use computers and visit web sites, and the number of years they have used computers and visited web sites, it can be said that all participants were experienced users of computers, and experienced visitors of web sites.

4.2 Results E-CSA-WA: selection of 40 participants for Stage II

The WA Ratio is the most important score of the E-CSA-WA. Ratios that are closer to 0 would indicate a tendency towards a field dependent preference and scores that are closer to 2 (or above) indicate a tendency for a field independent preference. (More information about the E-CSA-WA can be found in section 3.3)

The results of the E-CSA-WA were quite surprising. Because cognitive style is said to be independent of intelligence, gender, and so on, it was expected that the sample for this study would include both field dependent and field independent participants. However, the contrary is the case. The mean WA Ratio was 1.498 (SD=0.381), with a minimum of 0.931 and a maximum of 2.795. This implies that the sample of this study hardly contains participants with a field dependent score. (Scores below 0.97 indicate a preference for a field dependent style (Peterson, personal communication, January 6, 2005). The sample of this study only contains two scores below 0.97.)

Due to the distribution of the WA Ratios in this study, it is not possible to select a group of 20 participants with clearly field dependent scores and a group of 20 participants with clearly field independent scores. After all, nearly all scores come into the field

independent side of the continuum. Consequently, the results of the study discussed in this master's thesis will be limited to individuals with a field independent cognitive style.

The 20 participants with the highest WA Ratios and the 20 participants with the lowest WA Ratios were selected for further research. The group with the lowest scores is a group with a 'low field independent' style. The group with the highest scores is a group with a 'high field independent style.' For better readability, the groups will subsequently be referred to in this report as 'low analytics' and 'high analytics.' The group 'low analytics' has scores of 1.163 and lower. The group 'high analytics' concerns all participants with a score of 1.837 and higher. The distance between the two groups is 1.77 standard deviation.

Table 4.1 shows the composition of the two cognitive style groups, regarding gender, the study program in which participants take most of their courses, and whether the participant is a pre-masters student or not. (The total number of participants of the various student types is altogether fewer than 40. This is due to the fact that two participants did not complete this question.) The non-parametric Chi-Square Test shows that the differences in gender, study program and student type between the two cognitive style groups are not significant.

Table 4.1
Composition of group 'low analytics' and group 'high analytics' regarding gender, study program, and student type

		Low analytics (N=20)	High analytics (N=20)
Gender	Male	14	15
	Female	6	5
Study program	Technical	13	10
	Non-technical	7	10
Student type	Pre-master	5	6
	Non-pre-master	13	14

The two cognitive style groups will be divided over the two research methods of Stage II: five low analytics and five high analytics will participate in the Thinking Aloud Method, and fifteen low analytics and fifteen high analytics will participate in the Card Sorting Method. For the distribution of participants over the research methods, the height of the WA Ratio was not taken into account. But men and women, and students with a technical study program and students with a non-technical study program were distributed over the two research methods, in a way that within both methods the distribution over the two cognitive style groups was as equally as possible.

5. Results of Thinking Aloud Method

This chapter discusses the results of the Thinking Aloud Method, in order to give answer to the first research question: *What is the relation between users' cognitive styles and users' navigation behavior in a hypermedia environment?* First, a short description of the ten participants will be given in Section 5.1. Subsequently, Section 5.2 discusses the results that belong to the hypotheses about the search engine and checking behavior. Next, Section 5.3 discusses the hypotheses about the number of clicks in different navigation categories. The results of Tasks 1, 2 and 10 will not be discussed, because they do not contribute to the answering of the research questions.

5.1 Participants of Thinking Aloud Method

As mentioned in Chapter 4, the differences between the cognitive style groups are not as large as expected, because nearly all participants appeared to have a field independent cognitive style. As a result, in the Thinking Aloud Method five high analytics will be compared to five low analytics.

The average age of the ten participants was 23.2 years, with a minimum of 21 and a maximum of 25 years. None of the participants had ever visited an online writing center before. But participants did have experience with writing skills. All ten participants stated that their writing skills had been evaluated at one time or another at or outside the University of Twente. In addition, two participants stated that they had taken writing classes at the University of Twente. One of these participants has also taken writing classes outside the University of Twente. So, writing training was not unknown for any of the participants. Further, it appeared that no professional writers were among the participants. Because no large differences appeared concerning domain knowledge, domain knowledge will not be treated separately in the following analysis.

It is said that study program and gender are not related to navigation behavior. Nevertheless, students with a technical study program and students with a non-technical study program, and males and females have been distributed equally over the two cognitive style groups. Both cognitive style groups for the Thinking Aloud Method consisted of two students who take most of their courses in a technical program, and three students who take most of their courses in a non-technical program. Further, each group consists of three males, and two females. This has been done to prevent unexpected results due to the study program or gender of the participants.

5.2 Results about checking behavior and search engine: hypotheses 4 and 5

Two hypotheses were not about the number of clicks in the hypermedia environment, namely hypothesis 4 about how often participants checked their actions and hypothesis 5

about the number of times participants referred to a search engine. The results belonging to these two hypotheses will be discussed in this section. Due to the unexpected results of the Cognitive Style Test, in the formulation of the hypotheses 'field dependents' is replaced by 'low analytics' and 'field independents' is replaced by 'high analytics.'

5.2.1 Checking behavior

In the tasks for which participants needed the interactive parts of the Writing Studio, it was registered whether participants checked their actions. This implies checking whether a portfolio has been created (Task 4), whether a reference is added in the Bibliography Builder (Task 5), and whether the e-mail was sent (Task 7). Only checking through extra clicks was registered. This implies that the task in which the participant had to send an email was not taken into account. Namely, for checking whether the email was sent, no extra clicks were required. As a result, it was not visible for the researcher whether the participant checked his or her action during this task.

In Task 4, participants had to create a portfolio. All ten participants were able to complete this task. Most of the participants checked whether the new project portfolio had, in fact, been created: four low analytics and three high analytics. In Task 5, participants had to use the Bibliography Builder in order to make a reference. Only one low analytic and two high analytics did use the Bibliography Builder. All three of them checked their input; they said they missed a confirmation. So, both cognitive style groups checked their actions in Tasks 4 and 5 five times.

Based on the results about checking behavior, hypothesis 4 *High analytics check their actions more often than low analytics* has to be rejected.

5.2.2 Search engine

It was registered how often participants referred to a search engine. All navigation tasks (Tasks 3 to 9) of all participants (n=10) were taken into account.

Low analytics referred more often to a search engine than high analytics. Three low analytics mentioned altogether five times that they missed a search engine, and two high analytics mentioned altogether three times that they missed a search engine in the Writing Studio. The tasks for which a search engine was missed were: Task 3 about a suitable type of summary, Task 5 about making a reference, Task 6 about the signs to mark the ending of a press release, and Task 8 about writing a haiku.

Based on the results of this study, hypothesis 5 *High analytics refer more often to a search engine than low analytics* has to be rejected.

5.3 Results about clicks in different navigation categories: hypotheses 1 to 3, and 6 to 11

This section discusses the results belonging to hypotheses 1 to 3, and 6 to 11. These hypotheses are about the number of clicks that high and low analytics need in different navigation categories. The results will be discussed in three groups. In Section 5.3.1, the results that belong to Tasks 3 to 9 will be discussed altogether. Next, the results of tasks

that required the use of interactive parts, and the results of tasks that required the use of expository information, will be discussed in Section 5.3.2 and Section 5.3.3. Finally, based on the results of the different tasks groups, the hypotheses will be discussed in Section 5.3.4.

Within each task group, the results will be discussed as follows. First, the effectiveness of the navigation behavior will be discussed: how many participants were able to complete the tasks? Then, the navigation behavior of the participants who completed the tasks will be discussed in greater detail. A comparison will be made between the average number of clicks high analytics needed and the average number of clicks low analytics needed, and the clicks will be distributed over different navigation categories, namely:

- main navigation bar
- local and contextual navigation
    - next/previous
    - examples
    - tools (= clicks on links or buttons in interactive parts of the Writing Studio)
- back/forward
- homepage
- help function

All differences are tested at a level of α=0.05, unless otherwise indicated. Further, all the statistical tests are two-sided. Although several hypotheses can be logically deducted from theories about field dependency, convincing empirical evidence is lacking in most of the cases. In some cases, results of different studies are contradictory; in other cases, the available 'evidence' is relatively small. To be on the safe side, two-sided testing was chosen.

5.3.1 Results for all tasks

In this section, the results of the Tasks 3 to 9 will be discussed altogether.

All ten participants were asked to complete seven tasks (Tasks 3 to 9). So each cognitive style group could complete 35 tasks. High analytics completed more tasks than low analytics (29 versus 26). The non-parametric Chi-Square Test shows that the difference is not significant: $X^2(1, N=70)=0.764$, $p=0.382$.

A low analytic participant needed on average more clicks per task ($M=12.15$, $SD=6.67$, $n=26$) than a high analytic participant ($M=9.10$, $SD=4.86$, $n=29$). The Independent Samples T Test shows that this is a non-significant difference $t(53)=1.920$, $p=0.061$ at a level of α=0.05. But, at a level of α=0.10, the difference between low and high analytics is significant.

To get more insight into the clicks of low and high analytics, a division of clicks over different navigation categories is given in table 5.1. As can be seen, low analytics needed more clicks in almost all navigation categories. Only in the category 'Tools', high analytics clicked more often. But no differences between the number of clicks of low analytics and the number of clicks of high analytics appeared to be significant (at a level of α=0.05).

Table 5.1

Average number of clicks in different navigation categories per completed task, by high analytics and low analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	2.38	2.14	26	1.52	1.35	29
Local & contextual navigation	7.46	4.49	26	5.69	3.21	29
- Next/previous	0.23	0.82	26	0.14	0.44	29
- Examples	0.69	1.01	26	0.28	0.46	29
- Tools	1.77	3.05	26	1.86	2.95	29
Back/forward	1.38	1.96	26	1.31	1.85	29
Homepage	0.92	1.29	26	0.59	0.73	29
Help function	0.00	0.00	26	0.00	0.00	29

It is remarkable that the help function of the Writing Studio was not used by any of the participants. One high analytic and one low analytic noticed the help function. One said: "What does this question mark stand for?" The other only read the explanation that appears when hovering the mouse over the help button (see figure 5.1).

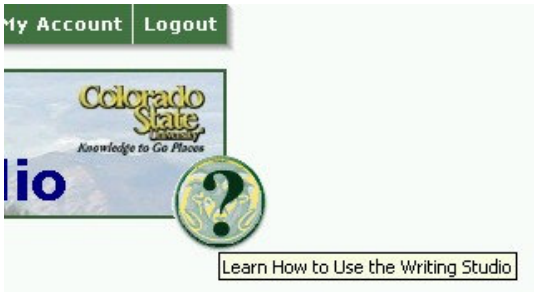

Figure 5.1 Help button with text that appears when hovering over the button

5.3.2 Results for 'interactive tasks'

To get more insight in the differences between the navigation behavior of high and low analytics, the tasks are divided into two groups. The first group is the group of 'interactive tasks.' 'Interactive tasks' is the label for tasks that required use of an interactive part of the Writing Studio. Table 5.2 gives an overview of these tasks. First the results of the three interactive tasks will be discussed altogether. Subsequently, Task 4 will be discussed in more detail.

Table 5.2

Interactive tasks

Task category	Task nr	Task subject
Interactive tasks	4	Portfolio
	5	Reference
	7	Feedback

High analytics succeeded more often in completing interactive tasks than low analytics. High analytics completed interactive tasks 12 times, low analytics 10 times. The non-parametric Chi-Square Test shows that the difference between high and low analytics is not significant: $X^2(1, n=30)=0.682$, $p=0.409$.

The number of clicks that were needed to complete the interactive tasks was for high analytics (*M*=11.25, *SD*=6.137, *n*=12), a little bit larger than for low analytics (*M*=10.30, *SD*=7.675, *n*=10). The difference appeared to be non-significant (*t*(20)=-0.323, *p*=0.750).

In table 5.3, the clicks of high and low analytics are divided into different navigation categories. Whereas in table 5.1 low analytics clicked more often in nearly all navigation categories, in table 5.3 the differences have various directions. In the interactive tasks, high analytic participants needed more clicks than low analytic participants in the categories 'Local & contextual navigation', 'Next/previous', 'Tools', and 'Back/forward.' When looking at the three interactive tasks, none of the differences between high and low analytics appeared to be significant.

Table 5.3

Average number of clicks in different navigation categories per completed interactive task, by high analytics and low analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	2.10	2.23	10	2.00	1.41	12
Local & contextual navigation	6.30	5.50	10	7.00	4.18	12
- Next/previous	0.00	0.00	10	0.08	0.29	12
- Examples	0.00	0.00	10	0.00	0.00	12
- Tools	3.40	3.89	10	4.50	3.03	12
Back/forward	1.10	1.52	10	1.75	2.30	12
Homepage	0.80	1.32	10	0.50	0.80	12

To give an example of navigation during an interactive task, Task 4 will be discussed separately. This task was the first interactive task of the test, and is illustrative for the group of interactive tasks. Detailed information about the interactive Tasks 5 and 7 can be found in Appendix H.

In Task 4, participants were asked to create a new portfolio in order to organize future writings about a research proposal. All ten participants succeeded in creating a new portfolio, in spite of the fact that four participants (one low analytic and three high analytics) experienced difficulties with the meaning of 'project portfolio.' "Do I have to create a new project? Or do you have to create a new portfolio within that project?" "This is a portfolio; I do not think it is the same as a file." The high success rate can be due to the fact that a portfolio can be created through a variety of paths.

The high analytics needed on average more clicks than low analytics (see table 5.4). The results are somewhat influenced by the participants who needed the most clicks to complete the task: two high analytics (11 and 14 clicks) and one low analytic (11 clicks). The high number of clicks is due to the fact that they created a portfolio via a path that was not very logical, namely via: 'Freewriting', 'My bibliography & notes', and 'My work at a glance.' All these three pages are interactive parts of the Writing Studio, for which it is necessary to select or create a portfolio in advance. Because no portfolio was selected at the moment the participants had to execute a task, a page with the options to create or select a portfolio was displayed. At the other hand, two low analytics and one high analytic were able to complete Task 4 in the shortest possible route: three clicks.

Table 5.4

Average number of clicks for Task 4 by low analytics and high analytics

	Low analytic (n=5)			High analytic (n=5)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	5,20	3,35	5	7,60	4,72	5

In order to get more insight in the differences between high and low analytics, the clicks in the different navigation categories are presented in table 5.5.

Table 5.5

Average number of clicks in different navigation categories for Task 4, by low and high analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	1.20	1.30	5	1.60	1.51	5
Local & contextual navigation	2.20	0.45	5	4.20	3.19	5
- Next/previous	0.00	0.00	5	0.00	0.00	5
- Examples	0.00	0.00	5	0.00	0.00	5
- Tools	2.20	0.45	5	3.60	2.19	5
Back/forward	0.80	1.79	5	1.20	1.64	5
Homepage	1.00	1.73	5	0.60	0.89	5

The differences in the number of clicks in 'Local & contextual navigation' and 'Tools' are mainly due to the use of tools of the two high analytic participants who created a portfolio via 'Freewriting' and 'My bibliography & notes.'

Low analytics clicked more often on the homepage than high analytics. The results of the three interactive tasks altogether show the same. This is quite unexpected. After all, it seems that high analytics experience more difficulties in completing interactive tasks than low analytics. It was expected that more disorientation would lead to more homepage visits. Apparently, this is not applicable for interactive tasks.

5.3.3 Results for 'expository tasks'

The second group of tasks is the group 'expository tasks.' Expository tasks are tasks that required use of expository information of the Writing Studio. Table 5.6 gives an overview of these tasks. First, the results of the group of expository tasks will be discussed. Subsequently, expository Task 3 will be discussed in more detail.

Table 5.6

Expository tasks

Task category	Task nr	Task subject
Expository tasks	3	Summary
	6	Press release
	8	Haiku
	9	Refusal letter

High analytics were a little bit more successful than low analytics in completing expository tasks. Namely, high analytics completed expository tasks 17 times; low analytics 16 times. The difference is not significant: $X^2(1, n=40) = 0.173$, $p=0.677$.

Whereas the difference in the average number of clicks for the interactive tasks, appeared to be non-significant, for the expository tasks, the difference between high and low analytics is significant. Low analytics needed obviously more clicks to complete the expository tasks (M=13.30, SD=5.919, n=16) than high analytics (M=7.59, SD=3.083, n=17). The difference between low analytics and high analytics appeared to be significant (t(22.28)=3.453, p=0.002).

To get more insight into the possible reasons for this significant difference, the clicks have been divided over different navigation categories (see table 5.7). As can be seen, low analytics clicked in each navigation category more often than high analytics. In several navigation categories, the differences are significant: 'Main navigation bar' (U=70.50, p=0.014), 'Local and contextual navigation' (t(31)=3.321, p=0.002), and 'Examples' (U=86, p=0.044). At a level of α=0.10, one category can be added to the list of significant differences, namely the number clicks on links and buttons in tools was for low analytics significantly higher than for the high analytics (U=110.50, p=0.066).

Table 5.7
Average number of clicks in different navigation categories per completed expository task, by high analytics and low analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar*	2.56	2.13	16	1.18	1.24	17
Local & contextual navigation*	8.19	3.75	16	4.76	1.95	17
- Next/previous	0.38	1.03	16	0.18	0.53	17
- Examples*	1.13	1.09	16	0.47	0.51	17
- Tools**	0.75	1.88	16	0.00	0.00	17
Back/forward	1.56	2.22	16	1.00	1.46	17
Homepage	1.00	1.32	16	0.65	0.70	17

* significant with α=0.05, ** significant with α=0.10

Expository Task 3 will be discussed separately. This was the first expository task of the test. The results of this task are illustrative for the group of expository tasks. The other expository tasks (Tasks 6, 8, and 9) are described in Appendix I.

In Task 3, participants were asked to search for a type of summary that mimics the structure of the document being summarized, namely the outline summary. All ten participants completed the task. This can be due to the fact that 'Writing Summaries' is visible after only one click in the main navigation bar. No deep 'digging' is needed.

It is remarkable that only four participants (three high analytics and one low analytic) found exactly the right type of summary. Most of the incorrect answers were close to the right type of summary, namely the keypoint summary (3x), and the main point summary (1x). This may be due to some confusion that occurred about terms in the navigation bar on the Writing Summaries page. Some participants misunderstood the word 'outline', namely as 'structure' or 'scheme.' The word 'objectivity' has been misinterpreted, as well. Two participants regarded 'objectivity' as a type of summary, and therefore, as a possible answer. Another incorrect answer was the descriptive abstract. The participant found the abstract in the CSU Writing Guides through the Engineering Room, and was very surprised about the place where he found the abstract. "An abstract is something very general; why on earth do they put it under engineering?!" Further, a

participant stopped her search too early: she was satisfied with the general page about summaries. This can be due to the fact that the Internet connection was very slow at that moment. After she waited for a while, she was probably happy that she finally found relevant information.

The shortest path to the outline summary consists of three clicks. Both cognitive style groups needed more clicks than the ideal number of three (see table 5.8).

Table 5.8
Average number of clicks for Task 3 by low analytics and high analytics

	Low analytic (n=5)			High analytic (n=5)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	17.40	7.06	5	9.40	4.04	5

The high number of clicks could be expected, because the participants never visited the Writing Studio before, and Task 3 was the first task in which they had to use the Writing Studio. Difficulties with starting the search task may have led to extra clicks. One participant phrased it as follows: “In fact, I have no idea where I have to look for a summary.” Other participants tried several distinct paths before they found any relevant information. It is remarkable that several participants start their searching with clicking on Writing Activities: “I’d like to do something, namely writing a summary. Therefore, I would expect it at Writing Activities.”

As can be seen in table 5.8, low analytics clicked on average more often to complete Task 3, than high analytics. The standard deviations of the groups are quite large, which indicates diversity within the two cognitive style groups, regarding the number of clicks. The box plot in figure 5.2 shows the spread within the two groups. One participant who found the Writing Summaries page by accident after relatively few clicks caused the distribution in the low analytic group.

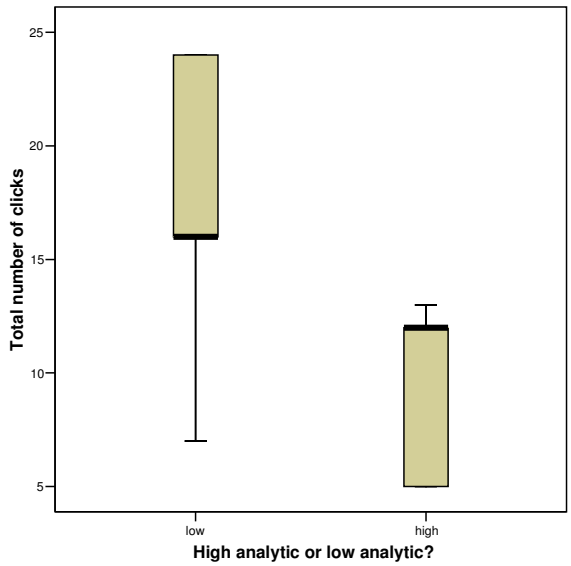

Figure 5.2 Box plot about total number of clicks for Task 3 by low analytics and high analytics

To get more insight into the difference between the high analytics and the low analytics, the number of clicks in different navigation categories is given in table 5.9.

Table 5.9
Average number of clicks in different navigation categories for Task 3, by low and high analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	2.80	1.64	5	2.20	1.64	5
Local & contextual navigation	10.40	4.51	5	5.00	3.39	5
- Next/previous	0.00	0.00	5	0.40	0.89	5
- Examples	1.40	1.52	5	0.00	0.00	5
Back/forward	2.40	3.29	5	1.40	2.19	5
Homepage	1.80	1.92	5	0.80	0.84	5

The difference in clicks on 'Local & contextual navigation' is remarkable: low analytics clicked more often on 'Local & contextual navigation' than high analytics. This may be partly due to the fact that two low analytics used interactive parts of the Writing Studio, whereas high analytics did not. One low analytic tried to create a project portfolio; another watched the movie about outline summaries. Another reason for the number of clicks of the low analytics may be the fact that a low analytic looked for a type of summary in the CSU Writing Guides. These Guides are quite elaborate and much clicking is needed to find relevant information.

Another remarkable difference between high and low analytics is the use of examples. Four low analytics used examples, to determine which type of summary they had to choose. One of them made an elaborate comparison between the original version of a text and the summary of the text, in order to distinguish whether the type of summary was right. High analytics did not use examples. The use of examples can be an indication for the difficulties users experience when searching information.

5.3.4 Discussion of hypotheses 1 to 3, and 6 to 11

Based on the results that are described in Sections 5.3.1 to 5.3.3, in this section, the hypotheses about clicks in different navigation categories will be discussed. Due to the results of the Cognitive Style Test, 'field dependents' is replaced by 'low analytics' and 'field independents' is replaced by 'high analytics.'

- *Hypothesis 1: Low analytics use the back/forward buttons of the browser more often than high analytics*
- *Hypothesis 2: Low analytics press more often on the next/previous buttons than high analytics*

There were no significant differences between high and low analytics, regarding the use of back/forward buttons and next/previous buttons. Therefore, hypotheses 1 and 2 have to be rejected. Although the differences were not significant, when looking at the results of all tasks, and when looking at the results belonging to the group of expository tasks, the nature of the difference was as expected. Namely, low analytics used the back/forward buttons and the next/previous buttons more often than high analytics. For the group of interactive tasks the relation was just the reverse: high analytics used the back/forward and next/previous buttons more often than low analytics.

- *Hypothesis 3: Low analytics need more clicks to find the intended information than high analytics*

The results of this study show that low analytics needed significantly more clicks to find the intended information than high analytics. This significant difference occurred when looking at the required number of clicks for the seven tasks altogether (at a level of α=0.10), and when looking at the number of clicks needed for the group of expository tasks (at a level of α=0.05). Therefore, when looking at all tasks and when looking at expository tasks, hypothesis 3 can be confirmed. It is remarkable that the relation between high and low analytics is reversed in the interactive tasks, although this difference was not significant.

- *Hypothesis 6: High analytics click more often on the main navigation bar than low analytics*

In expository tasks, low analytics clicked significantly more often on the main navigation bar than high analytics. However, the direction of the difference is not the same as the direction that is presented in hypothesis 6. Therefore, hypothesis 6 has to be rejected.

When looking at the results of the tasks altogether and when looking at the group of interactive tasks, it appeared that low analytics used the main navigation bar more often than high analytics, as well. These differences were not significant.

- *Hypothesis 7: Low analytics use local and contextual navigation more often than high analytics*

Hypothesis 7 can be confirmed for the group of expository tasks, because low analytics clicked significantly more often on local and contextual navigation than high analytics did. When looking at the results of all tasks the same relation is found, but this relation is not significant. For the use of local and contextual navigation in the interactive tasks, the result was just the reverse: high analytics used local and contextual navigation more often than low analytics do. The difference for the interactive tasks is not significant.

- *Hypothesis 8: High analytics complete more tasks than low analytics*

There were no significant differences between high and low analytics, regarding the number of completed tasks. Therefore, hypothesis 8 has to be rejected. Although the differences are not significant, the results show that for interactive tasks as well as for expository tasks high analytics were more successful than low analytics.

- *Hypothesis 9: Low analytics use the help function more often than high analytics*

Hypothesis 9 has to be rejected, because there was no participant that used the help function.

- *Hypothesis 10: Low analytics consult examples more often than high analytics*

In expository tasks, low analytics consulted significantly more often examples than high analytics. Therefore, for expository tasks, hypothesis 10 can be confirmed. Participants did not use examples during the execution of the interactive tasks.

- *Hypothesis 11: Low analytics click more often on links on the homepage than high analytics*

There were no significant differences between high and low analytics, regarding the number of clicks on the homepage. Therefore, hypothesis 11 has to be rejected. Nevertheless, it is worth mentioning that the relation between the two groups appeared to be as expected: low analytics clicked in both task groups more often on links on the homepage than high analytics did.

This chapter discussed the results of the Thinking Aloud Method. A distinction was made between interactive and expository tasks. Significant differences between the navigation behavior of high and low analytics occurred in the expository tasks. The next chapter discusses the results of the Card Sorting Method.

6. Results of Card Sorting Method

This chapter discusses the results of the Card Sorting Method, in order to give an answer to the second research question: *Is there a relation between users' cognitive styles and users' mental models of the information in a hypermedia environment; and if so, what is that relation?* In the Card Sorting Method, there were no participants with a field dependent cognitive style, just like in the Thinking Aloud Method. Therefore, the difference between the two cognitive style groups was relatively small. As a result, the differences that did occur between the mental models of the cognitive style groups are quite special. Fifteen low analytics and fifteen high analytics participated. In Section 6.1, a description of the thirty participants will be given. In Section 6.2, the mental models of both cognitive style groups will be compared.

6.1 Participants of Card Sorting Method

The mean age of the 30 participants is 23.3 years; the youngest participant is 20 years old and the oldest is 39. One participant had seen the Writing Studio before; this participant followed the introductory course of the Academic Writing for pre-master students, in which the Writing Studio is used. In that introductory course, the Writing Studio was shown to the students. The participant had not visited the Writing Studio himself. The other participants had never visited any online writing centers before. There did not appear to be significant differences in writing experience between high and low analytics (see Appendix J).

Table 6.1 shows the composition of the two cognitive style groups. As can be seen, the distribution of males and females over the two cognitive style groups is quite proportional. The non-parametric Chi-Square Test shows that the differences between the two cognitive style groups are not significant.

Table 6.1
Composition of the two cognitive style groups, regarding gender and study program

		Low analytics (n=15)	High analytics (n=15)
Gender	Male	11	12
	Female	4	3
Study program	Technical	10	7
	Non-technical	5	8

6.2 Mental models of low analytics and high analytics

The groupings of elements by the thirty participants were analyzed with cluster analysis, using an average linkage algorithm. Cluster analysis is a technique that aims at finding patterns in groupings. The type of algorithm distinguishes how the objects are sorted; average linkage algorithm strikes a balance between single linkage algorithm that

emphasizes similarities, and complete linkage algorithm that emphasizes differences more. The program EZCalc of the package EZSort (IBM, no date) was used to create the typical tree diagrams that result from cluster analyses.

Figure 6.1 and 6.2 show the results of the cluster analysis for both cognitive style groups. On the left sides of the figures, the different information elements that were displayed on the cards can be seen. The first word or words are given, as well as the place in the Writing Studio where the information can be found. The place where the information can be found is mostly abbreviated, and is displayed between brackets. Therefore, elements with the same information between brackets come from the same place in the Writing Studio. (The complete descriptions of the cards can be found in Appendix F.)

On the horizontal axis, the disagreement is shown. This indicates the extent to which participants disagreed about whether information elements belong together. Disagreement close to 0% means that nearly all participants placed the cards into the same pile. This is shown in the diagram, when information elements are connected at the left side of the diagram. When very few or none of the participants placed two information elements into the same pile, the elements are connected at the right side of the diagram, close to 100% disagreement. For example in figure 6.1, the cards with ‘Kent Haruf’ and ‘Nicole Backens’ (at the top of the diagram) were grouped together by all low analytics. But almost all the low analytics sorted the card ‘The appearance’ in a different way.

In the following figures of this chapter, the exact percentages of disagreement will not be shown. But the line for 30% disagreement and the line for 70% disagreement will be represented in each figure.

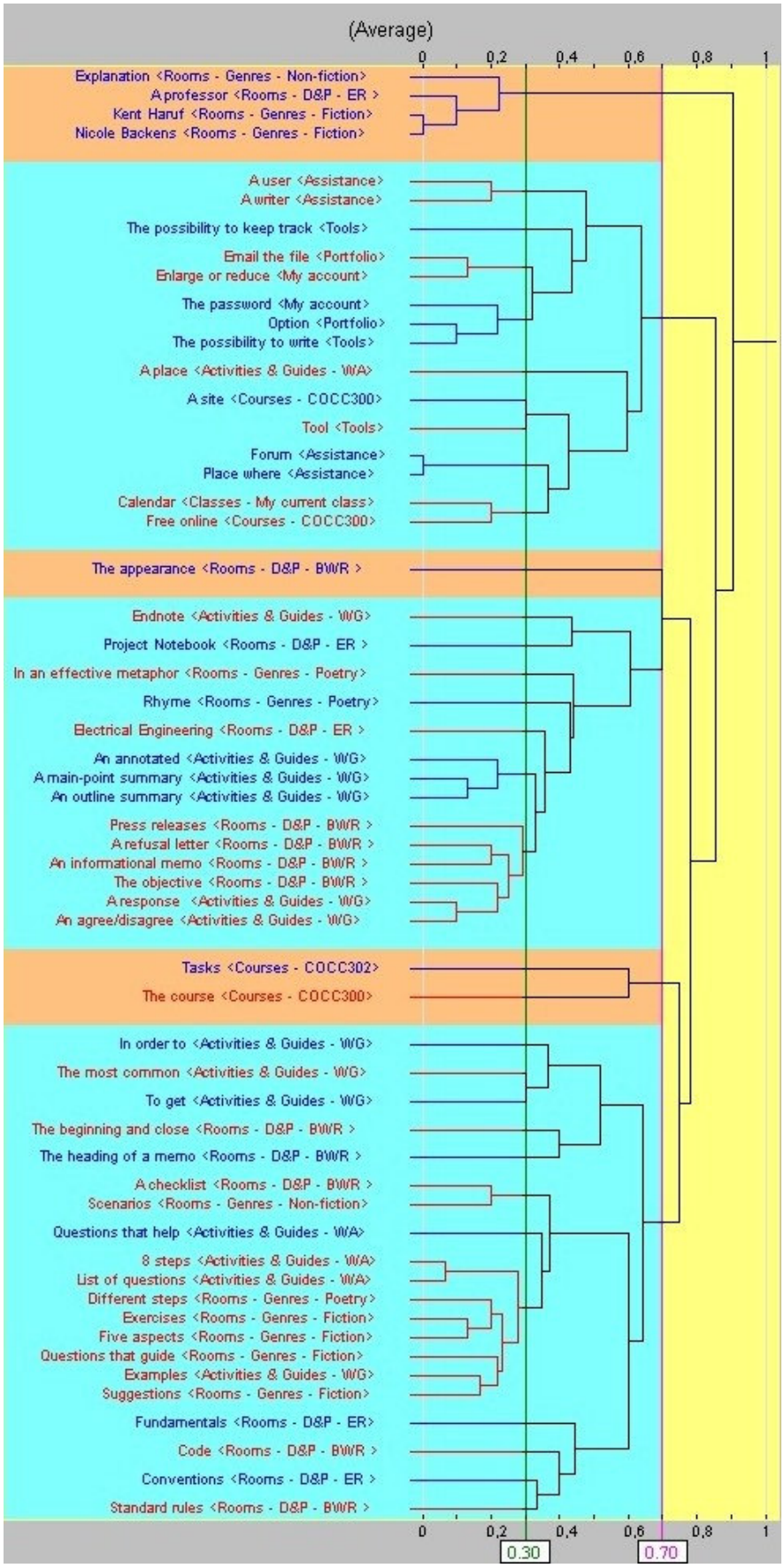

Figure 6.1 Cluster analysis results of low analytics

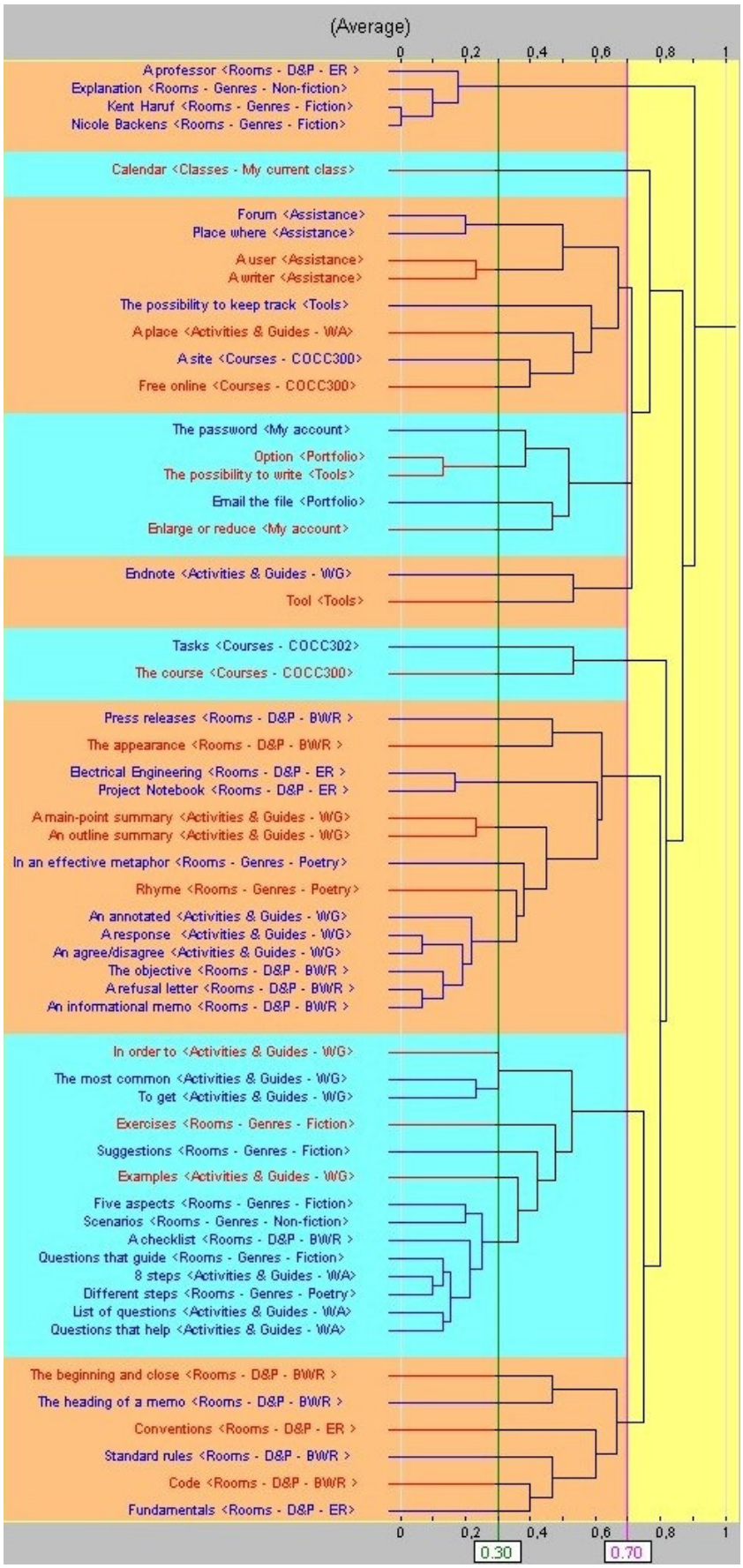

Figure 6.2 Cluster analysis results of high analytics

The tree diagrams of both cognitive style groups seem to be quite similar at first view. But a more detailed look at the graphs, leads to remarkable things. To structure the comparison, the graphs have been divided into four parts. Namely, each graph can roughly be split into four 'branches.' The first 'branch' appears to be about people and their writings, the second about utilities of the Writing Studio, the third about descriptions of writing and writing products, and the fourth about writing as an activity. For each comparison, first the branches of both cognitive style groups will be shown. After that, the branches will be discussed.

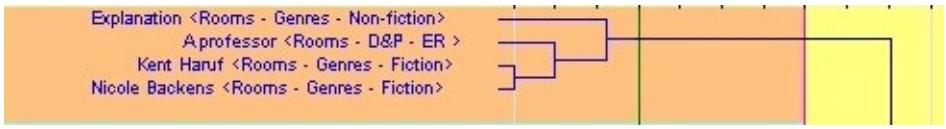

Figure 6.3 Selection of cluster analysis results of low analytics ('persons about writings')

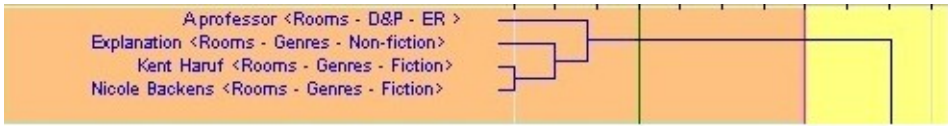

Figure 6.4 Selection of cluster analysis results of high analytics ('persons about writings')

The first parts that have been compared are shown in figure 6.3 and 6.4. As can be seen, high analytics and low analytics nearly made an identical sorting of the four cards: '*Explanation* of literary journalism by John Calderazzo', '*A professor* of Civil Engineering about the importance of writing', '*Kent Haruf* reads one of his fiction writings at a lecture', and '*Nicole Backens* talks about the role of theme in fiction writing.' The cards '*Kent Haruf*' and '*Nicole Backens*' were even sorted together by all 30 participants. The four cards contain information about a person who tells something about writing.

The way these four cards were sorted is quite remarkable. Namely, the cards have different origins in the Writing Studio: the engineering room, the non-fiction writing room, and the fiction writing room. Apparently, the division of information into different genres did not correspond to the participants' mental models. A category of cards with information about persons discussing writing did appear to fit more to participants' mental models. The genre to which the writing product belongs did not seem to be of any relevance in the sortings.

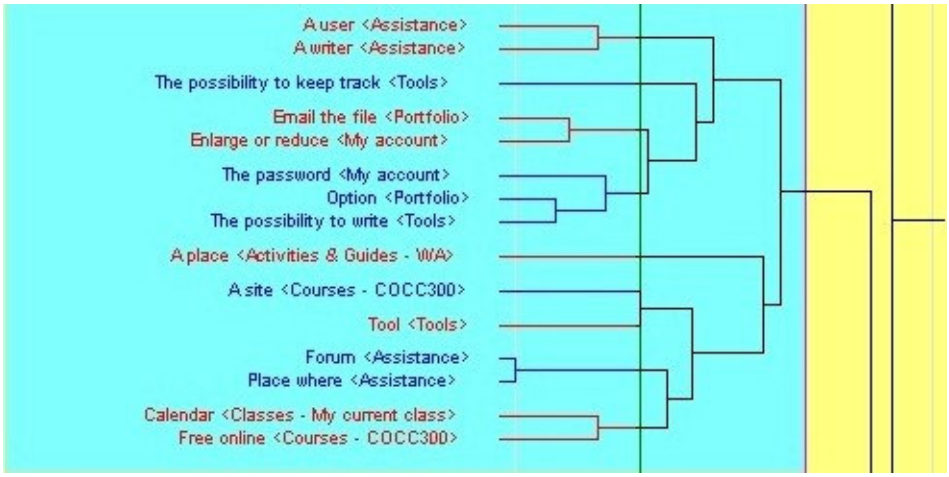

Figure 6.5 Selection of cluster analysis results of low analytics ('utilities of the Writing Studio')

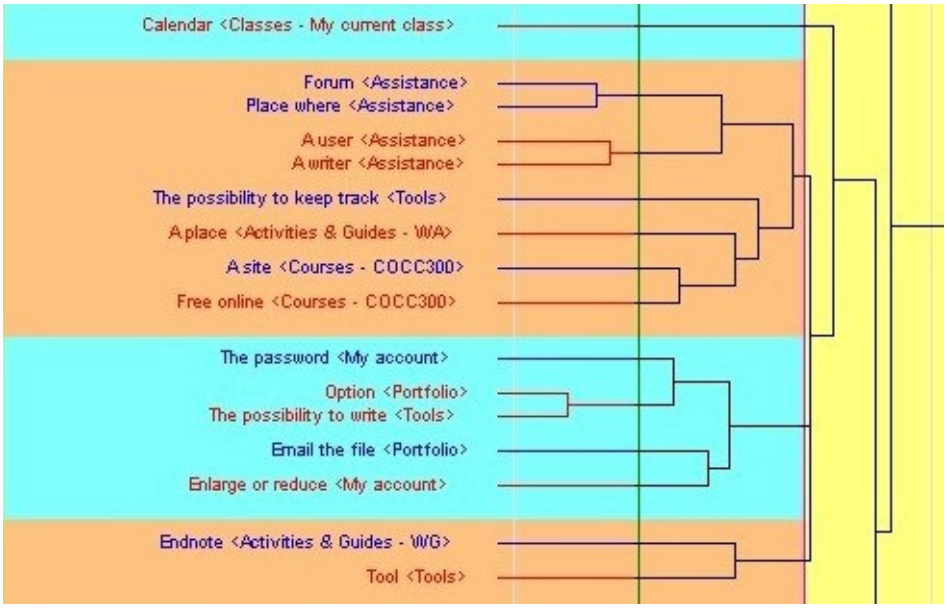

Figure 6.6 Selection of cluster analysis results of high analytics ('utilities of the Writing Studio')

The second parts that have been compared are displayed in figure 6.5 and 6.6. The graphs show that the mental models of both high and low analytics do not correspond to the actual structure of the Writing Studio. Namely, even as in the first branch, the cards have a lot of origins (for example, assistance, tools, portfolio, and my account). But still, there appears to be an organizing principle; most of the cards concern utilities of the Writing Studio. For example: '*A user* of the Writing Studio can send a draft to a Writing Center Consultant', '*Option* to create a file in which writing-products can be saved', and '*Enlarge or reduce* the text size of the information in the Writing Studio.'

The different graphs can be discussed more in detail. First of all, the mental model of the high analytics seems to be more specific than the mental model of the low analytics. Namely, the high analytics (figure 6.6) organized the cards into different groups. They made a distinction between the cards related to assistance and courses, and the cards

related to my account and portfolio. In contrast, the branch of the low analytics (figure 6.5) seems to be a kind of repository.

Further, there was a lot of disagreement among the high analytics about the card *'Calendar* belonging to the Academic Writing Class.' Almost each of the high analytics sorted this card in a different way. The probable reason for this disagreement is that the Calendar-card was the only card that belongs to the category 'classes.' So in fact, the card did not belong to any of the other cards.

Next, the card '*Endnote* is a computer program that helps to organize references' and the card *'Tool* that helps writers to make a list of references' were put together by about half of the high analytic group. Conversely, the low analytics placed the card about Endnote into the third branch, with descriptive information about writing (see figure 6.7). It seems to be, that the high analytics sorted the cards '*Calendar'* and '*Endnote*' more on their content, than low analytics who seem to have sorted on the form in which the information was given.

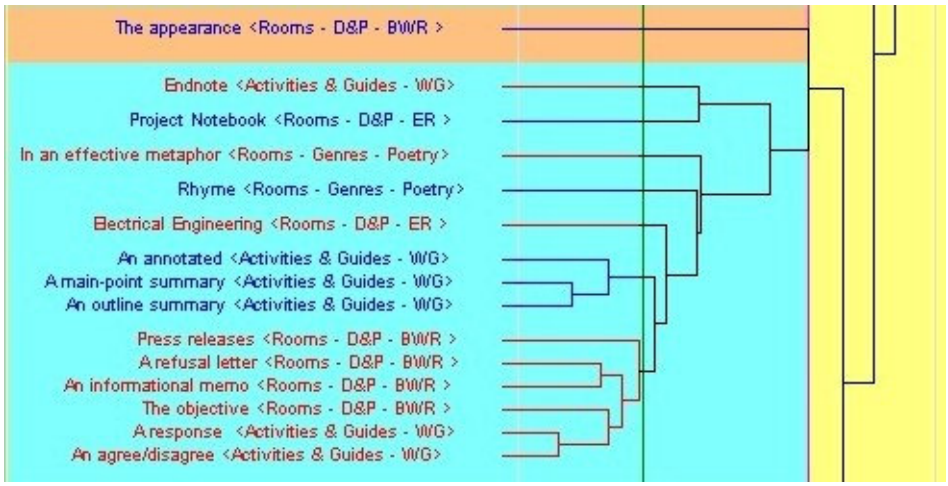

Figure 6.7 Selection of cluster analysis results of low analytics ('descriptions of writing and writing products')

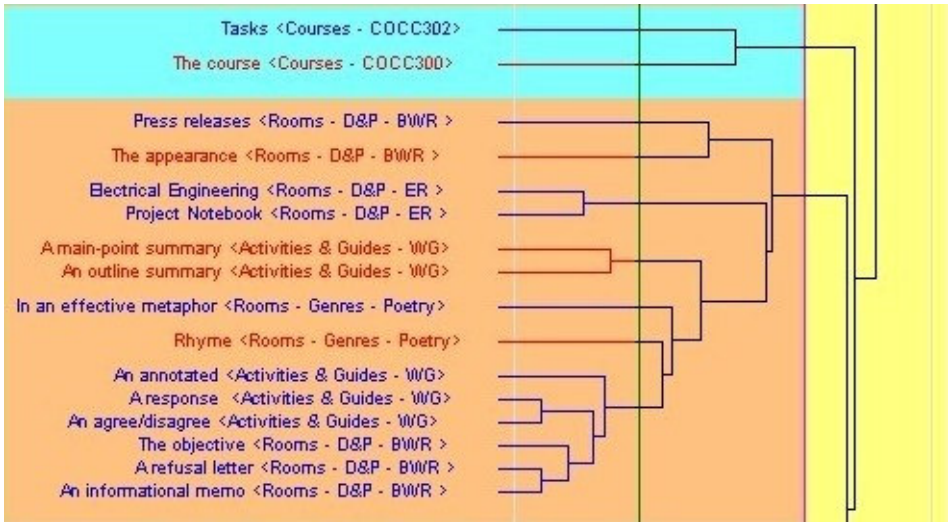

Figure 6.8 Selection of cluster analysis results of high analytics ('descriptions of writing and writing products')

The next two parts of the graphs that have been compared are shown in figure 6.7 and 6.8. It is remarkable that most low analytics (about 10) sorted the card *'The appearance* of what have come to be known as press releases date back to the 1880's' in a different way. This card belongs to the information about press releases in the Business Writing Room, but apparently this was not self-evident to most of the low analytics. A possible reason for this is that the card contains historical information about a writing product, and the other cards do not contain such information. Maybe information about the origin of writing products is not expected in an environment like the Writing Studio. The high analytics were able to sort the card about the history of press releases; they put it near another card of press releases (see figure 6.8).

The high analytics made a distinct group, as well, i.e. *'Tasks* that belong to the course 'Writing Online' and *'The course* Writing Arguments is an intermediate-level college writing course that focuses on argumentation, logic, and critical thinking.' The low analytics formed an identical group, but, as can be seen in figure 6.9, they linked it to the more practical information about writing.

The other cards of the 'third branch' have their origin in different writing rooms and writing guides. The correspondence between most of the cards is that they contain descriptive information about writing. On many of the cards, the information was presented in the form of a definition. This seems to be the organizing principle of this branch. (For example: *'Rhyme* is a key element of many poems' or *'A refusal letter* is a negative response to either an invitation of a job offer.')

Within this branch of descriptive information, high analytics seemed to be more able than low analytics in to organize the cards on the basis of their content. Perhaps the explanation for this is that the high analytics had more knowledge about the different writing genres, although the results of the questionnaire do not indicate that.

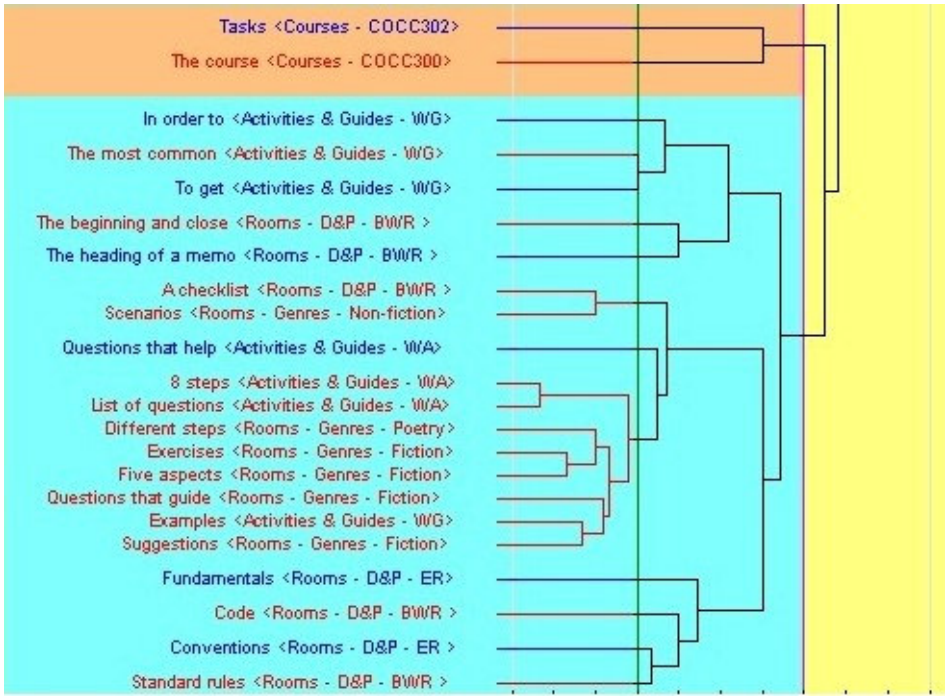

Figure 6.9 Selection of cluster analysis results of low analytics ('writing as an activity')

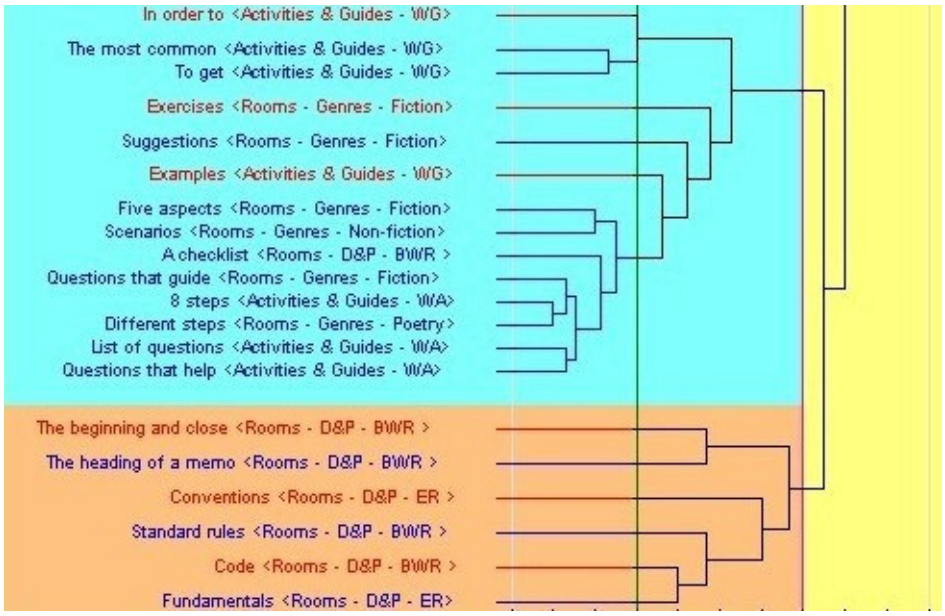

Figure 6.10 Selection of cluster analysis results of high analytics ('writing as an activity')

The last two parts that have been compared are presented in figures 6.9 and 6.10. The cards in these parts of the graphs contain information about 'how to write.' They contain instructions, guides, exercises, and so forth. In this branch, writing is treated as an activity. The origins of the cards are quite diverse: different writing rooms, writing guides and writing activities. So the mental models of the participants do not seem to correspond with the organizing principles that are offered by the Writing Studio.

As mentioned before, the combination of the course cards of the low analytics, are linked to this 'fourth branch.' Apparently, these two cards fit in low analytics' mental models better in the category 'writing as an activity' than in the category of expository information.

The high analytics separated some cards from the group, too, namely the cards. *'The beginning and close* of a business email can be written informally', *'The heading of a memo* consists of four distinct information fields and should begin two spaces below the title*'*, '*Conventions* for the communication of civil engineers', *'Standard rules* for formatting press releases', *'Code* about proper behavior in email communication', and '*Fundamentals* of desktop publishing.' So, a category of cards about rules and obligations appears to be more logical to high analytics' than dividing the cards over a business writing category and an engineering category.

The results of the two cluster analyses have been compared. In general, no major differences occurred between the mental models of the low analytics and the mental models of the high analytics. Roughly, both groups used the same rules to sort the information. But a difference between the two cognitive style groups can be mentioned. High analytics seemed to have a mental model in which there is a more detailed division of information into different genres. This detailed division was not found in low analytics' mental models.

Further, it is remarkable that for both cognitive style groups the mental models did not correspond to the structure as it is presented in the Writing Studio. For example,

participants hardly discriminated between information originating from the rooms and information originating from the activities and guides.

In Chapters 4, 5 and 6 the results of the different research methods are discussed. The next chapter discusses the conclusions of this study. An answer will be given to both research questions.

7. Conclusions

This study aims at getting more insight into users' navigation behavior in hypermedia environments. Therefore, two research questions were formulated. In this chapter answers to both research questions will be given. The conclusion to the first research question will be discussed in Section 7.1. Subsequently, in Section 7.2 a conclusion will be drawn about users' cognitive styles and users' mental models of a hypermedia environment. Section 7.3 compares the answers to both research questions, in order to elicit whether mental model is the intervening factor between cognitive style and navigation behavior.

Before answering the research questions, remarks have to be made about users' cognitive styles. Namely, this study aimed at comparing navigation behaviors and mental models of field dependent individuals and field independent individuals. However, within the group of 115 participants of the Cognitive Style Test there were hardly any field dependent individuals. Due to limited time and means available for this study, it was not possible to administer the Cognitive Style Test among more (or other) participants. Therefore, it was decided to execute Stage II with the 115 mainly field independent participants. This led to a group of 20 high analytics and a group of 20 low analytics, for participation in Stage II of the study. As a result, this study is not able to draw any conclusions upon field dependent individuals.

7.1 Cognitive styles related to navigation behavior in a hypermedia environment

In this section, an answer will be given to the research question: *What is the relation between users' cognitive styles and users' navigation behavior in a hypermedia environment?* This question has been investigated by using the Thinking Aloud Method among five participants with a high analytic cognitive style, and five participants with a low analytic cognitive style.

First of all, task type seems to be an intervening variable between cognitive style and navigation behavior. Namely, differences occurred between tasks for which particular information had to be found, and tasks for which an interactive part of the hypermedia environment had to be used. The 'expository tasks' revealed some significant differences between high and low analytics. For several 'interactive tasks' the relations that were found were the reverse of the relations that were found in the expository tasks. But none of the differences that were found in interactive tasks were significant. This is a remarkable result, because interactive tasks as well as expository tasks can be divided into the same category of task types, namely formal search tasks (see Section 2.3.1). Apparently, there does exist a difference between formal searches in interactive parts and formal searches in expository parts of a hypermedia environment.

Secondly, on several aspects, users' cognitive styles did appear to be related to users' navigation behaviors. This is quite remarkable, because of the small number of participants and the relatively small difference between the two cognitive styles, one would expect that significant differences were not likely to occur. As mentioned before, significant differences between the navigation behavior of high and low analytics only occurred when looking at the results of the expository tasks. An example of a significant difference is that low analytics needed significantly more clicks than high analytics to complete expository tasks. The explanation of Reed et al. (2000) for this would be that field dependents accept the existing structure more than field independents, regardless whether the structure is linear or non-linear. In addition, an explanation might be that the low analytics felt more disoriented in the Writing Studio than high analytics during expository tasks, which was illustrated by their higher number of clicks.

Another significant difference was found in the local and contextual navigation. Low analytics clicked significantly more often on local and contextual navigation than high analytics did. And within the local and contextual navigation, low analytics consulted examples significantly more often than high analytics. These results were as expected. Low analytics were expected to be more influenced by what they see, and to adopt a less analytical navigation approach than high analytics. Further, they were expected to use examples often, because this could indicate a need for help. This supports the assumption that low analytics felt more disoriented in the Writing Studio during expository tasks. Another reason for the higher use of examples can be that low analytics just do not like reading a lot of text and think that examples are more efficient. This latter reason seems to be comparable to a study by Ford and Chen (2000). Ford and Chen showed that field dependents preferred to learn by using examples, whereas field independent users preferred more detailed descriptions when constructing a homepage.

An unexpected significant difference was that low analytics used the main navigation bar significantly more often than high analytics. It was assumed that the main navigation bar was a means by which high analytics could show an analytical navigation approach. It is difficult to determine the reason for this behavior of low analytics. Perhaps a main navigation bar is not a means by which an analytical navigation approach can be shown. Or, just the main navigation bar of the Writing Studio is not suitable for an analytical navigation approach, because in the main navigation bar of the Writing Studio, global and local navigation are integrated in one navigation bar. The navigation bar is folded out when using it (see figure 2.2).

With reference to the relation between users' cognitive styles and navigation behaviors, it can not be said that only the significant differences are relevant in this study. Some non-significant relations are worth mentioning, as well. Perhaps, other studies can investigate these relations in greater depth.

First, it appears to be that interactive parts of a hypermedia environment are easier to use for low analytics than for high analytics. High analytics needed more clicks to complete interactive tasks than low analytics did, and high analytics used the back/forward buttons and the next/previous buttons more often than low analytics did. For expository tasks, the relations are just the reverses. Probably, the interactivity of the application is the factor that explains the different numbers of clicks between high and low analytics. Perhaps, 'passively conforming to the influence of the prevailing field or

context' (Chen & Macredie, 2002, p.4), is an advantage for low analytics in interactive parts of a hypermedia environment: they just follow the pre-determined path.

Another non-significant relation between high and low analytics that is worth mentioning is the use of the homepage. For both task types, low analytics clicked more often on the homepage than high analytics. For expository tasks this seems to be logical; it seems that low analytics felt more disoriented than high analytics during the execution of expository tasks. As a result, they returned to the starting point more often than high analytics did. But for interactive tasks, it seems that high analytics experienced more difficulties in finding their way. However, in interactive tasks, low analytics clicked more often on links on the homepage as well. It is difficult to give an explanation for this on the basis of the results of this study.

7.2 Cognitive styles related to users' mental models of a hypermedia environment

Besides cognitive style, user's mental model can be related to navigation behavior, as well. But what determines user's mental model? The second research question of this study aimed at investigating whether cognitive style is related to user's mental model of the hypermedia environment. The second research question was: *Is there a relation between users' cognitive styles and users' mental models of the information in a hypermedia environment; and if so, what is that relation?* This question has been investigated by using the Card Sorting Method, among fifteen high analytics and fifteen low analytics. This section draws conclusions from the results of the Card Sorting Method, in order to answer the second research question.

In a broad view, no major differences occurred between low analytics' mental model of the Writing Studio and high analytics' mental model of the Writing Studio, as demonstrated in their orderings of information elements; so cognitive style did not appear to be related to mental model. Both cognitive style groups seemed to use the same principles for creating their mental models. These principles to organize information differed from the principles that were used in the Writing Studio. The information in the Writing Studio is mainly classified by type of writing, for example, business writing and writing for engineers. In contrast, both cognitive style groups seemed to prefer organizing by the form in which the information was presented, for example, a group of descriptive information about writing, and a group with guidelines and exercises in order to practice writing. As a result, both mental models did not correspond with the actual information structure of the Writing Studio.

But with a closer look at both mental models, it does seem that cognitive style is related to mental model. Namely, within the global framework, high analytics appear to have a more specific image of the information in the hypermedia environment than low analytics have. In some cases, the high analytics were able to sort the information on the basis of writing genre. Perhaps the global approach of low analytics is related to thinking in essentials, and the analytical approach of high analytics is related to a keener eye for detail. A logical reason for the difference between high and low analytics would be that high analytics have more knowledge about writing and writing genres. But the data of this study do not seem to support this explanation. Namely, there did not appear to be much

difference between the writing experience of low analytics and the writing experience of high analytics.

The results of the Card Sorting Method are remarkable. First of all, because the mental models did not correspond to the actual structure, and secondly, because cognitive style only seems to be related to mental model at quite a detailed level. It is difficult to give an explanation for these results. Because of the fact that both cognitive style groups tended to organize the information elements on the basis of the form of the information instead of content, the results may be an artifact of the sorting task. If that is true, then it is questionable whether the results of the Card Sorting Method are valid. This will be discussed in more detail in Chapter 8.

7.3 Mental model: an intervening factor between cognitive style and navigation behavior?

In this study, it was suggested that user's mental model of the hypermedia environment was an intervening variable between user's cognitive style and user's navigation behavior (see figure 1.2). Although the relation between mental model and navigation behavior has not been investigated directly, comparing the results of the two research questions might give an indication about whether or not mental model seems to be an intervening variable.

As mentioned in Section 7.2, the relation between cognitive style and mental model is not very clear. In a broad view, cognitive style does not seem to be related to mental model; at a more detailed level both concepts did seem to be related. The suggestion was made that the mental models are artifacts of the Card Sorting Method. Due to fact that a relation between cognitive style and mental model has not been established, the following comparison of the results of the two research questions has to be read with caution.

The mental models of both cognitive style groups did not correspond with the actual hypermedia environment. But this did not appear to be a barrier for completing tasks. Low analytics, as well as high analytics were able to complete most of the tasks. Apparently, both cognitive style groups have the ability to adapt quickly to an environment that does not correspond to their mental models. This would imply that mental models do not influence navigation behavior.

Nevertheless, high analytics' mental model was more detailed than low analytics' mental model, and high analytics' navigation behavior was more efficient than low analytics' behavior. At this point, the possibility is left open that mental model can be an intervening variable between cognitive style and navigation behavior.

In summary, based on the results of this study, there is no convincing evidence that supports the assumption that user's mental model is an intervening variable between user's cognitive style and user's navigation behavior.

8. Reflection on study

During this study, a lot of choices were made. Retrospectively, not all choices were optimal. Therefore, a critical reflection can not be avoided in this master's thesis. In Section 8.1, limitations of the study will be discussed. To conclude this thesis, Section 8.2 gives recommendations for further research.

8.1 Limitations

First of all, nearly all participants appeared to have an analytic (or 'field independent') cognitive style. Due to the outcomes of the Cognitive Style Test, a distinction could only be made between high analytics and low analytics. The availability of wholistic (or 'field dependent') participants could have led to more distinct cognitive style groups resulting in more significant differences between the two groups.

The analytic scores may be due to the university population. After all, 'analytical thinking' is one of the competencies students learn at university. Analytical thinking may be distinct from spatial ability and intelligence.

Secondly, the number of participants in the Thinking Aloud Method was quite small to compare two groups on the basis of quantitative data. The number of participants was based on recommendations about usability studies. Retrospectively, that was not correct, because measuring navigation behavior is quite different from determining the usability of a web site. Further, the navigation behavior was not measured in a particularly elaborate manner. For example, a distinction within 'local and contextual navigation' could have been made. More participants and a more elaborate measure of navigation behavior could have led to more (specific) data about navigation behavior.

Third, domain knowledge was measured too briefly. The questionnaire only asked for experience with (evaluation of) writing skills. But this does not say much about the level of expertise of the participants. Some additional questions that measured participants' knowledge about writing would have been valuable. More data about domain knowledge could have given more insight into navigation behavior and into the mental models of both cognitive style groups.

8.2 Recommendations for further research

Obviously, when conducting a study that is comparable to the study presented in this master's thesis, the limitations that were mentioned in Section 8.1 are important points for attention. This indicates the need to use participants of a non-university population, more participants, and a more elaborate measure of domain knowledge and navigation behavior.

Furthermore, recommendations about further research can be made based on the results of this study. First of all, further research on the influence of task type is relevant.

In this study a difference was found between two task types, that both belonged to the category of formal search tasks. Further research could elicit whether a more distinct division in task types can be made.

Secondly, it is recommended to use another measure to find users' mental models of a hypermedia environment, for example, closed card sorting. Perhaps a closed card sort can create a more realistic situation, and therefore a more realistic mental model than open card sort. In a closed card sort, participants see several categories, under which they have to place information. This is comparable to a visit of a web site: the user of the web site sees the main navigation bar and forms an image of the types of information belonging to each button of the navigation bar. In this study, open card sort was used. The organization of the cards on the basis of the form of the information suggests that participants were relying too much on the information of the cards. Closed card sort would force the participants to think about the information on a more global level.

Finally, it would be interesting to focus on users' attitudes when investigating navigation behavior. Often, the relation between a specific factor and navigation efficiency or navigation effectiveness is measured. In such studies, as much as in this study, efficiency and effectiveness are regarded to be preferable above inefficiency and ineffectiveness. But perhaps users with inefficient navigation paths do not mind that they have to search for a while. Perhaps they are just as satisfied as users who choose the most efficient route.

How do people navigate in a hypermedia environment? What is it that makes them navigate in a particular way? This study showed that cognitive style is an important factor that determines how people find their way on a web site. It is useful for web designers to have insights into characteristics of their target populations such as cognitive styles, because these kinds of insights will contribute to better web design. Considering the growth of applications on the Internet, and the growing number of Internet users, it can not be said that there is enough knowledge about users' needs and preferences. Therefore, research on navigation behavior in hypermedia environments will remain worthwhile.

References

Bachiochi, D., Berstene, M., Chouinard, E., Conlan, N., Danchak, M., Furey, T., Neligon, C., & Way, D. (1997). Usability studies and designing navigational aids for the World Wide Web. *Computer Networks and ISDN Systems, 29*, 1489-1496.

Barab, S.A., Bowdish, B.E., & Lawless, K.A. (1997). Hypermedia Navigation: Profiles of Hypermedia Users. *Educational Technology Research & Development, 45*(3), 23-41.

Barnum, C.M. (2002). *Usability Testing and Research*. New York: Longman.

Benjafield, J.G. (1997). *Cognition*. New Jersey: Prentice-Hall, Inc.

Biggs, J. (2001). Enhancing Learning: A Matter of Style or Approach? In R.J. Sternberg, & L.-f. Zhang (eds.) *Perspectives on thinking, learning, and cognitive styles.* (pp.73-102). Mahwah, NY: Lawrence Erlbaum.

Calcaterra, A., Antonietti, A., & Underwood, J. (2005). Cognitive style, hypermedia navigation, and learning. *Computers & Education, 44*, 441-457.

Centraal Bureau voor de Statistiek. (2005). *ICT en media gebruik naar persoons- en huishoudkenmerken.* Available: http://statline.cbs.nl/StatWeb/start.asp?LA=nl&DM=SLNL&lp=Search/Search [2005, April 19].

Chen, S.Y., & Macredie, R.D. (2002). Cognitive Styles and Hypermedia Navigation: Development of a Learning Model. *Journal of the American Society for Information Science and Technology, 53*(1), 3-15.

Chen, S.Y., Fan, J.-P., & Macredie, R.D. (in press). Navigation in hypermedia systems: experts vs. novices. To appear in *Computers in Human Behavior.*

Danielson, D.R. (2002). Web navigation and the behavioral effects of constantly visible site maps. *Interacting with Computers, 14*, 601-618.

Dong, J., Martin, S., & Waldo, P. (no date) *A User Input and Analysis Tool for Information Architecture. IBM Ease of Use.* Available: http://www-3.ibm.com/ibm/easy/eou_ext.nsf/publish/410/$File/EZSortPaper.pdf [2004, October 22].

Ellis, D., Ford, N., & Wood, F. (1993). Hypertext and learning styles. *The Electronic Library, 11*(1), 13-18.

Farkas, D.K., & Farkas, J.B. (2002). *Principles of Web Design*. New York: Longman.

Ford, N. (2000). Cognitive Styles and Virtual Environments. *Journal of the American Society for Information Science, 51*(6), 543-557.

Ford, N., & Chen, S.Y. (2000). Individual Differences, Hypermedia Navigation, and Learning: An Empirical Study. *Journal of Educational Multimedia and Hypermedia, 9*(4), 281-311.

Ford, N., & Chen, S.Y. (2001). Matching/mismatching revisited: an empirical study of learning and teaching styles. *British Journal of Educational Technology, 32*(1), 5-22.

Ford, N., Wilson, T.D., Foster, A., Ellis, D., & Spink, A. (2002) Information Seeking and Mediated Searching. Part 4. Cognitive Styles in Information Seeking. *Journal of the American Society for Information Science and Technology, 53*(9), 728-735.

Garret, J.J. (2003). *The elements of user experience*. Indianapolis: New Riders Publishing.

Herder, E., & Juvina, I. (2004). *Discovery of Individual User Navigation Styles.* Proceedings of 3rd International Conference on Adaptive Hypermedia and Adaptive Web-based Systems, Eindhoven, The Netherlands.

IBM. (no date). *EZSort (beta release).* Available: http://www-3.ibm.com/ibm/easy/eou_ext.nsf/publish/410 [2004, October 18].

Kim, K.S. (1997). *Effects of cognitive and problem-solving styles on information-seeking behavior in the WWW: A case study.* Available: http://www.edb.utexas.edu/mmresearch/Students97/Kim/ [2005, April 27].

Kim, K.S. (2001). Information seeking on the Web: Effects of user and task variables. *Library & Information Science Research, 23*, 233-255.

Kim MacGregor, S. (1999). Hypermadia Navigation Profiles: Cognitive Characteristics and Information Processing Strategies. *Journal of Educational Computing Research, 20*92), 189-206.

McDonald, S., & Stevenson, R.J. (1998). Effects of Text Structure and Prior Knowledge of the Learner on Navigation in Hypertext. *Human Factors, 40*(1), 18-27.

Nielsen, J. (2000). *Why you only need to test with 5 persons.* Available: http://www.useit.com/alertbox/20000319.html [2005, April 25]

Nielsen, J. (2004). *Card sorting: How many users to test.* Available: http://www.useit.com/alertbox/20040719.html [2004, September 24].

Nielsen, J., & Sano, D. (1994) *1994 Design of SunWeb – Sun Microsystems' Intranet.* Available: http://www.useit.com/papers/sunweb/ [2005, February 9].

Palmquist, M. (2005). The Writing Studio: Rethinking Instructional Metaphors for Web-based Writing Environments. In L. Van Waes, C.M. Neuwirth, & M. Leijten (eds.) *Writing and Digital Media*. London: Elsevierre.

Peterson, E.R. (2003). *Administration Guide for the Verbal Imagery Cognitive Styles Test & the Extended Cognitive Style Analysis-Wholistic Analytic Test.* University of Edinburgh.

Peterson, E.R., Deary, I.J., & Austin, E.J. (2003a). The Reliability of the Cognitive Styles Analysis Test. *Personality and Individual Differences, 34*, 881-891.

Peterson, E.R., Deary, I.J., & Austin, E.J. (2003b). On the Assessment of Cognitive Style: Four Red Herrings. *Personality and Individual Differences, 34,* 889-904.

Peterson, E.R., Deary, I.J., & Austin, E.J. (in press). Are intelligence and personality related to verbal-imagery and wholistic-analytic cognitive styles? To appear in *Personality and Individual Differences*.

Preece, J., Rogers, Y., & Sharp, H. (2002). *Interaction design: beyond human-computer interaction.* New York: Wiley.

Reed, W.M., Oughton, J.M., Ayersman, D.J., Ervin Jr., J.R., & Giessler, S.F. (2000). Computer experience, learning style, and hypermedia navigation. *Computers in Human Behavior, 16*, 609-628.

Renzulli, J.S., & Dai, D.Y. (2001). Abilities, Interests, and Styles as Aptitudes for Learning: A Person-Centered Interaction Perspective. In R.J. Sternberg, & L.-f. Zhang (eds.) *Perspectives on thinking, learning, and cognitive styles.* (pp.23-46). Mahwah, NY: Lawrence Erlbaum.

Reza Rezaei, A., & Katz, K., (2004). Evaluation of the reliability and validity of the cognitive styles analysis. *Personality and Individual Differences, 36*, 1317-1327.

Riding, R.J. (1997). On the nature of cognitive style. *Educational Psychology, 17*(1-2), 29-50.

Riding, R.J. (2001). The Nature and Effects of Cognitive Styles. In R.J. Sternberg, & L.-f. Zhang (eds.) *Perspectives on thinking, learning, and cognitive styles.* (pp.47-72). Mahwah, NY: Lawrence Erlbaum.

Riding, R.J., & Rayner, S.G. (1998). *Cognitive Styles and Learning Strategies. Understanding Style differences in Learning Behaviour.* London: David Fulton Publishers.

Robertson, J. (2001). *Information design using card sorting.* Sidney: Step Two Designs Pty ltd. Available: http://www.steptwo.com.au/papers/cardsorting/pdf/cardsorting.pdf [2005, April, 25].

Rosenfeld, L., & Morville, R. (2002). *Information Architecture for the World Wide Web.* 2nd ed. Beijing, hina: O'Reilly.

Rubin, J. (1994). *Handbook of Usability Testing. How to plan, design, and conduct effective tests*. New York: Wiley.

Smith, P.A. (1996). Towards a practical measure of hypertext usability. *Interacting with Computers, 8*(4), 365-381.

Thatcher, A., & Greyling, M. (1998). Mental models of the Internet. *International Journal of Industrial Ergonomics, 22,* 299-305.

Tullis, T., & Wood, L. (2004). *How many users are enough for a card-sorting study?* Paper presented at the Usability Professionals Association conference, Minneapolis, MN.

UserSense, (no date). *Card Sorting, goedkoop en eenvouding.* Available: http://www.usersense.com/archives/00000040.html [2004, October 19].

van der Geest, T, & Loorbach, N. (2005). Testing the Visual Consistency of Web Sites. *Technical Communication, 52*(1), 27-36.

Wang, P., Hawk, W.B., & Tenopir, C. (2000). Users' interaction with World Wide Web resources: an exploratory study using a holistic approach. *Information Processing and Management, 36*, 229-251.

Appendices

Appendix A. Participant Instructions Cognitive Style Test

This appendix belongs to Section 3.3.2

- This analysis is simple to do.
  It is not a test of intelligence or ability.
  It assesses information about your cognitive style.
  The task will be presented on a computer and you will need to respond by pressing one of two number pad keys (YES or NO).
  Work at your own rate.
  It is important that you work through continuously without interruption.
  At the end of the tasks a screen will display your results.
  Please note down the **W/A ratio**.

- Before the test starts, please fill in the fields on the screen of your computer **EXCEPT 'Identification No' and 'Name.'**
  Press OK.

Appendix B. Questionnaire Cognitive Style Test

This appendix belongs to Section 3.3.2

Participant nr
Room nr
Date

What is your gender?	☐ Male ☐ Female
At which faculty do you take most of your courses?	☐ BBT ☐ CTW ☐ EWI ☐ GW ☐ TNW
Do you follow courses at 3rd, 4th, and/or 5th year level at the University of Twente?	☐ Yes ☐ No
Are you a pre-master student?	☐ Yes ☐ No
In which year did you start using computers?	____
In which year did you start visiting Web Sites?	____
How often do you use a computer?	☐ 5 - 7 days a week ☐ 2 - 4 days a week ☐ 2 - 4 days a month ☐ 1 day a month or less
How often do you visit Web Sites?	☐ 5 - 7 days a week ☐ 2 - 4 days a week ☐ 2 - 4 days a month ☐ 1 day a month or less
The Cognitive Style Test was in English. Do you think this influenced your results negatively?	☐ Yes ☐ Somewhat ☐ No

Forty participants will be selected to participate in further research. The selection will be made on the basis of the scores on the Cognitive Style Test.

- *It will take place in January/February 2005*
- *Participating will take about 1 hour*
- *You will be rewarded with €10*

If you are selected for the next session, are you willing to participate?	☐ Yes ☐ No

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Appendix C. Tasks Thinking Aloud Method *(in Dutch)*

This appendix belongs to Section 3.4.2

De pagina die nu staat weergegeven op je computerscherm, is de startpagina van de Writing Studio. Je kunt de Writing Studio zien als een grote gereedschapskist, met daarin verschillende soorten gereedschap die schrijvers kunnen helpen bij het schrijven van allerlei schrijfproducten. Dit gereedschap bestaat zowel uit tekstuele informatie als uit praktische hulpmiddelen.

Vergeet niet om hardop te denken, tijdens het uitvoeren van de opdrachten!

Opdracht 1

Voor deze opdracht hoef je nog geen handelingen te verrichten. Kijk naar het scherm en beantwoord de volgende twee vragen.

- Wat is je eerste indruk van de Writing Studio?
- Noem 3 concrete dingen die je in de Writing Studio verwacht te vinden.

Geef het aan als je opdracht 1 hebt afgerond.

Opdracht 2

Om optimaal gebruik te kunnen maken van de Writing Studio moet je ingelogd zijn.

- Log in met behulp van de volgende gegevens:
  Emailadres:
  Password:

Geef het aan als je opdracht 2 hebt afgerond.

Opdracht 3

Je wilt een samenvatting schrijven van een verslag. Je wilt dat de structuur van je verslag terug komt in de samenvatting.

- Zoek in de Writing Studio welk type samenvatting het meest geschikt is voor jouw situatie

Geef het aan als je opdracht 3 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 4

De Writing Studio biedt je de mogelijkheid om je schrijfproducten te ordenen. Dit betekent dat je per schrijfproject een apart dossier kunt bijhouden.

Je hebt al één dossier aangemaakt in de Writing Studio, namelijk voor een kort verhaal dat je aan het schrijven bent. Je wilt de Writing Studio ook gaan gebruiken voor het schrijven van een onderzoeksvoorstel voor een project binnen je studie. Je weet nog niet goed wat het project inhoudt en hoe het onderzoeksvoorstel eruit moet zien, maar je wilt wel alvast een nieuw dossier aanmaken in de Writing Studio.

- Maak een nieuw dossier aan dat je kunt gebruiken voor het schrijven van het onderzoeksvoorstel en geef het een passende titel.

Geef het aan als je opdracht 4 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 5

Je onderzoeksvoorstel is inmiddels af en ook al nagekeken door je docent. Je docent wijst je erop dat een goede literatuurlijst ontbreekt. Om voor een voldoende in aanmerking te komen, moet je alsnog een literatuurlijst aan het voorstel toevoegen. De literatuurlijst moet voldoen aan de normen van APA.

- Maak van onderstaand boek een referentie die voldoet aan de APA-normen. Doe dit met behulp van de Writing Studio. (Schrijf de referentie op het antwoordformulier):

  Auteur: J.J. Garret
  Titel boek: The elements of user experience
  Jaar: 2003
  Uitgever: New Riders Publishing
  Plaats: Indianapolis
  Geraadpleegde paginanummers: 5-10

Geef het aan als je opdracht 5 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 6

Stel je voor, je werkt bij een multinational op de communicatieafdeling. Je hebt de taak gekregen een persbericht op te stellen over een actuele kwestie. Daarom wil je weten hoe een persbericht eruit moet zien.

- Zoek in de Writing Studio naar informatie over persberichten. Als je geschikte informatie hebt gevonden, geef dan aan met welke tekens je het einde van een persbericht kunt markeren.

Geef het aan als je opdracht 6 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 7

Je bent bezig met het schrijven van een kort verhaal, wat je hebt opgeslagen in een dossier. Je vraagt je af of jouw verhaal geschikt is voor jonge lezers van 12 tot 15 jaar. Je kent iemand die al eens eerder voor deze doelgroep heeft geschreven, namelijk Thea van der Geest. Toevallig weet je van haar dat zij ook een geregistreerde gebruiker is van de Writing Studio.

- Stuur je dossier met je korte verhaal op naar Thea van der Geest en vraag haar of je verhaal geschikt is voor jongeren van 12 tot 15 jaar oud.

Geef het aan als je opdracht 7 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 8

Vanwege je interesse in de dichtkunst, lijkt het je leuk om een keer een ‘haiku’ te schrijven. Je wilt graag weten hoe je het best kunt beginnen met het schrijven van een haiku.

- Zoek in de Writing Studio naar informatie over haiku’s. Als je geschikte informatie hebt gevonden, noem dan een manier waarop je kunt beginnen met het schrijven van een haiku.

Geef het aan als je opdracht 8 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 9

Je bent op zoek naar een afstudeerplek in het buitenland. Met twee bedrijven heb je telefonisch contact gehad, een bedrijf in Canada en een bedrijf in de Verenigde Staten. Je ontvangt positieve berichten: beide bedrijven bieden je een afstudeerplek aan. Jouw voorkeur gaat uit naar Canada.

Je wilt het bedrijf in de VS per brief laten weten dat je hun aanbod afslaat. Je vindt het belangrijk je contacten goed te onderhouden, en wilt daarom een nette brief schrijven.

- Ga na of de Writing Studio een voorbeeld van een dergelijke brief bevat.

Geef het aan als je opdracht 9 hebt afgerond. Ga terug naar de startpagina van de Writing Studio en sluit (indien van toepassing) alle overige schermen.

Opdracht 10

Maak op het antwoordformulier een schets van de structuur van de Writing Studio. Hierbij mag je de site niet gebruiken.

Als hulp staat de menubalk weergegeven op het antwoordformulier. Schrijf onder de menubalk de belangrijkste webpagina's. Je kunt met lijnen eventueel verbindingen leggen tussen verschillende pagina's van de website. Schrijf bij de onbekende onderdelen wat je er verwacht te vinden.

Geef het aan als je opdracht 10 hebt afgerond.
Je ontvangt nu een korte vragenlijst.

Appendix D. Protocol Thinking Aloud Method *(in Dutch)*

This appendix belongs to Section 3.4.3

Ik wil graag beginnen met het onderzoek. Allereerst wil ik je bedanken dat je mee wilt werken aan dit vervolgonderzoek. Ook dit onderzoek maakt deel uit van mijn afstudeerproject voor TCW.

In dit vervolgonderzoek wordt een website getest, namelijk de Writing Studio van de Colorado State University. Het betreft een educatieve website die bedoeld is om mensen te helpen bij het schrijven van allerlei schrijfproducten. Het doel van dit onderzoek is het verbeteren van deze website. Ik zal straks dus niet *jouw* kwaliteiten testen, maar de kwaliteiten van de *site*. Voel je daarom niet ongemakkelijk als je straks tegen problemen aanloopt. Deze problemen hebben immers betrekking op de *site* en niet op jou.

Straks krijg je 10 opdrachten, die je moet uitvoeren met behulp van de website. Het is de bedoeling dat je tijdens het uitvoeren van de opdrachten hardop denkt. Terwijl je de opdachten maakt, maak ik aantekeningen van wat er gebeurt. Er worden ook opnames gemaakt met de videocamera. De camera neemt op wat er op het scherm gebeurt; jij zult niet herkenbaar in het beeld komen. Verder wordt ook je stem opgenomen en worden je muiskliks en toetsaanslagen opgeslagen. Al deze gegevens worden uitsluitend gebruikt voor onderzoek; in rapportages zullen je gegevens anoniem worden verwerkt.

Nadat je de opdrachten hebt afgerond, krijg je nog een korte vragenlijst. In totaal zal het onderzoek ongeveer een uur duren. Deelname aan dit onderzoek is vrijwillig, dus mocht je tijdens het onderzoek willen stoppen, dan kan dat zonder consequenties.

Er geldt een aantal regels voor het uitvoeren van de opdrachten. Die regels heb ik op papier gezet. Lees ze rustig door; ondertussen zal ik de videocamera instellen.

> overhandigen ‘deelname aan onderzoek Writing Studio’
DOORLEZEN INSTRUCTIES OPDRACHTEN

> instellen videocamera

Is tot zover alles duidelijk? Heb je nog vragen? Als alles duidelijk is en je met het onderzoek akkoord gaat, wil je dan onderaan het formulier je handtekening zetten?

> overhandigen pen
TEKENEN VOOR AKKOORD
> Opspelden dasspeldmicrofoon
> Microfoon & opnameapparatuur aanzetten
> overhandigen opdrachten, antwoordformulier en pen

Dan mag je nu beginnen met het uitvoeren van de opdrachten.

Noteren tijdens de uitvoering van de opdrachten:

- waar hulp geboden?
- aard van de hulp
- oplossingen die door de proefpersoon zelf worden aangedragen/uitgevoerd

Vragen na afloop van elke opdracht

1. (als er niet hardop is gedacht)
   Kun je in je eigen woorden kort zeggen wat je geprobeerd hebt te doen?
2. Wat was het lastigste probleem met de site dat je tegenkwam bij deze opdracht?
3. Welk onderdeel van de site was de handigste hulp bij deze opdracht?

Ingrijpen als:

- Neem nooit de bediening van de muis of het toetsenbord over
- Als de pp **niet hardop denkt**:
  Kun je me vertellen wat je aan het doen bent en wat je daarbij denkt?
- Als een het een pp **niet lukt om in te loggen** in het systeem (opdracht 2):
  Ga naar de homepagina van de Writing Studio.
  Vul bij e-mail het aangegeven emailadres in.
  Vul bij password het aangegeven password in.
  Druk op Login/Enter.
- Als een pp om **hulp vraagt zonder dat hij echt in de problemen** is:
  Ik probeer zo goed mogelijk te weten te komen hoe jij met de site werkt en of de site daarbij problemen geeft. Ik kan je daarom helaas niet helpen met het uitvoeren van de opdrachten, want dan kan ik niet meer zien hoe jij het doet.
- Als een pp **vastloopt** en ook na herhaaldelijk proberen het probleem niet kan oplossen:
  Wat ben je nu aan het doen?
  Gebeurt er wat je verwacht?
  (Geen waarom-vragen of suggestieve vragen)
- Als een pp verbaal of non-verbaal aangeeft echt **gefrustreerd** te raken over een onderdeel van de site
  Wat bent je nu aan het doen?
  'Gebeurt er wat je verwacht?
  (Geen waarom-vragen of suggestieve vragen)
- Als de pp **beschreven heeft wat hij probeert te doen**:
  geef een aanwijzing waarmee de gewenste actie kan worden uitgevoerd, ook al is die actie niet handig of zinnig
- Als de pp **na 5 minuten** de opdracht nog niet op de pagina is, waarop de gewenste info staat weergegeven:
  Ik weet nu genoeg over dit onderdeel van de site. Ik wil je nog een paar vragen stellen, voordat we doorgaan naar de volgende opdracht. (Ga naar de homepagina van de WS)

> Opdrachten en antwoordformulier innemen

Dankjewel. Dan wil ik je nu vragen om deze vragenlijst in te vullen. Dit mag in het Nederlands.

> vragenlijst overhandigen
VRAGENLIJST INVULLEN

> videocamera uitzetten
> microfoon uitzetten

Dankjewel. Het experiment is nu afgerond. Hartelijk bedankt voor je medewerking! Je krijgt de beloofde vergoeding van €10,- Zou je onderaan het formulier willen tekenen voor ontvangst?

> overhandigen formulier
FORMULIER TEKENEN

Dankjewel voor je deelname! Ik wil je vragen om tot 10 februari niet met anderen over dit onderzoek te praten. Dat zou namelijk de resultaten kunnen beïnvloeden.

Appendix E. Questionnaire Stage II

This appendix belongs to Section 3.4.3 & Section 3.5.3

Participant number	Date	Thinking Aloud

1. What is your age?

____

2. Have you ever visited the Writing Studio of the Colorado State University (before your participation in this study)?

- ❑ No, never
- ❑ Yes, a few times
- ❑ Yes, frequently

3. Have you ever visited an Online Writing Center (before your participation in this study)?

- ❑ No, never
- ❑ Yes, a few times
- ❑ Yes, frequently

4. Have you ever taken any classes to improve your writing skills at the University of Twente?

- ❑ No
- ❑ Yes, namely (please mention the names of the classes):

____
____

5. Have you ever taken any classes to improve your writing skills *outside* the University of Twente?

- ❑ No
- ❑ Yes, namely (please mention the names of the classes):

____
____

6. How often have your writing skills been evaluated during your studies at the University of Twente?

- ❑ Never
- ❑ Rarely
- ❑ Some times
- ❑ Frequently

7. How often have your writing skills been evaluated *outside* the University of Twente?

- ❑ Never
- ❑ Rarely
- ❑ Some times
- ❑ Frequently

Please give your opinion about the Writing Studio in a few words or sentences:

Appendix F. Content of cards

This appendix belongs to Section 3.5.2 & Section 6.2

1. 8 steps that guide the writer through a 'looping-process.' Looping is a form of freewriting in which one writes for a set amount of time and then reads what one has written
2. A checklist, consisting of questions to help with reviewing and revising writing-products. For example: Does your document begin with an appropriate opening or introduction? Does it end with a logical conclusion?
3. A main-point summary provides the central point of a source. It should identify the title, author, and main point or argument.
4. A place to do some freewriting. Freewriting is like brainstorming, except that one tries to write phrases and sentences instead of a list
5. A professor of civil engineering about the importance of writing
6. A refusal letter is a negative response to either an invitation or a job offer
7. A response is a written statement of a writer's reaction to and thinking about a document
8. A site which provides grammar rules and style guidelines to help writers write more clearly
9. A user of the Writing Studio can send a draft to a Writing Center Consultant
10. A writer can ask an instructor to comment on a writing product
11. An agree/disagree response provides a clear statement of the point with which the writer is agreeing or disagreeing and an explanation of it
12. An annotated bibliography contains bibliographical information on a text as well as a short summary that describes some of the main points of the text
13. An informational memo is an in-house communication addressed to one or more individuals
14. An outline summary mimics the structure of the text being summarized. It includes the main points, reasons, and evidence in the same order they appear in the original text.
15. Calendar belonging to the Academic Writing class
16. Code about proper behavior in email communication
17. Conventions for the communication of civil engineers
18. Different steps to write a sonnet
19. 'Electrical engineering lab reports' present data, discuss results, and provide conclusions. Some lab reports also describe the experiment and the procedures followed.
20. Email the file in which writing-products are saved
21. Endnote is a computer program that helps to organize references
22. Enlarge or reduce the text size of the information in the Writing Studio
23. Examples of interview questions to ask a person who is familiar with the issue you are writing about
24. Exercises to practice writing a plot of a story
25. Explanation of 'literary journalism' by John Calderazzo

26. Five aspects of place and setting. These aspects give the opportunity to think about a story's place and setting from different points of view
27. Forum for users of the Writing Studio
28. Free online English dictionary, thesaurus and reference guide, crossword puzzles and other word games, online translator, and Word of the Day
29. Fundamentals of desktop publishing (Desktop publishing is the process of laying out and designing pages with a desktop computer)
30. In an effective metaphor, the thing being compared to something else takes on the characteristics of the something else in such a way that something new, different, or significant is revealed about the first thing
31. In order to write good summaries, it is recommendable to take notes when reading sources. Some tips for effective note taking are given.
32. Kent Haruf reads one of his fiction writings at a lecture
33. List of questions to guide a writer through a brainstorming session
34. Nicole Backens talks about the role of theme in fiction writing
35. Option to create a file in which writing products can be saved
36. Place where writers can chat with each other
37. Press releases are used to cover a wide range of topics. Among them are education and human resources, teaching and research, the economy, politics, health and the environment
38. Project notebook: scientists and engineers use project notebooks to record data as they collect it, to brainstorm explanations of data, to record details of experimental apparatus, and to make progress notes
39. Questions that guide a writer through a process of determining a suitable behavior pattern of a story's main character. For example: What is X's primary language and dialect? Does X speak more than one language? Does X have an accent?
40. Questions that help a writer to analyze the target population of a particular writing product
41. Rhyme is a key element of many poems
42. Scenarios that help writers to generate ideas to write about. For example: 'write about an experience that changed your view of the world'
43. Standard rules for formatting press releases
44. Suggestions for revising a story, when the writer knows what is wrong, but does not know how to fix it
45. Tasks that belong to the course 'Writing Online.' For example: 'write a critical analysis of an internet discussion forum of approximately 1500 words or six printed pages'
46. The appearance of what have come to be known as 'press releases' date back to the 1880's
47. The beginning and close of a business email can be written informally
48. The course 'Writing Arguments' is an intermediate-level college writing course that focuses on argumentation, logic, and critical thinking
49. The heading of a memo consists of four distinct information fields and should begin two spaces below the title
50. The most common strategies used in critical reading include asking questions about an issue before reading sources that address that issue, skimming sources, reading to understand, reading to question, highlighting, and making notes on print copies of

sources.

51. The objective of a complaint letter is to provide detailed information regarding the error or defect and to serve as a legal document recording the writer's claim and the corrective action or adjustment being requested
52. The password of the user account can be changed
53. The possibility to keep track of writing activities, by creating a to-do-list
54. The possibility to write and save drafts
55. To get a clear overview of the sources a writer wants to use, it is helpful to group the sources. Criteria for grouping can be: sources with similar purposes for writing, similar values and beliefs, or similar backgrounds.
56. Tool that helps writers to make a list of references

Appendix G. Protocol Card Sorting Method

This appendix belongs to Section 3.5.3

I'd like to start with the experiment. First of all, thank you for participating. This experiment is part of my graduation project for Communication Studies, as well. When you finished the experiment, I can tell you more about this graduation project, if you like.
Before we start the experiment, I'd like to ask you to fill in this questionnaire.

> give questionnaire and pen
FILL IN THE QUESTIONNAIRE

Thank you. Now, I will explain you how this experiment works. I will read the instructions. This may sound a bit unnatural, but in this way, I know for sure that every participant gets the same instructions. During this experiment, you are working with these 56 cards.

> show cards

All these cards are parts of a website: the Writing Studio of the Colorado State University. The Writing Studio is an educational website, and can be seen as a big toolbox, which contains many tools to help writers with their writing. The site is suitable for almost *all* kinds of writers (including students, for example) and for almost *all* kinds of writing products.

My question to you is to sort all these cards in a way that is useful and meaningful to you. You have to combine the cards of which you think they belong together. The sorting has to be based on the content of the cards, so not on, for example, the length of the sentences. The result of your sorting will be a number of piles (or rows) with cards in it that belong together.
When you've sorted the cards, I will ask you to label the piles. I will ask you whether there are connections between the piles, as well. And after that, I will ask you some questions about the piles you formed.

There are some rules for the sorting task.
- The size of the piles is up to you, but:
    a. You are not allowed to make 56 piles of 1 card each.
    b. You are not allowed to make 1 pile of 56 cards.

The data of this experiment will be used confidentially.

Is everything clear to you? Do you have any questions about the test? If you agree with the procedure and you are willing to participate, please sign on this form.

> give form
SIGN FORM *(participant has chance to say 'no')*

Now you can start sorting the cards. Take as much time as you need.

> give the cards
SORT THE CARDS

Thank you. Then I'd like to ask you to label each group. Please choose a label that shows why the cards of the group belong together. Please write down the label on a post-it, and stick it to the group to which it belongs.

> give pen and post-its
LABEL THE CARDS

Thank you. Then I'd like to ask you some questions. I'd like to know the reasons for labeling the piles in this way. You are allowed to consult the cards in the piles, but you are not allowed to change the piles.

QUESTIONS *(Why do you think these cards belong together?)*
> attach paperclips to the groups

Then I'd like to ask you whether you think there are connections between the piles. If yes, group the different piles and give the combination of piles a new name.

COMBINE PILES/ROWS
QUESTIONS *(Why do you think these piles belong together?)*

The experiment is finished now. You will receive 10 euro. Please sign on this form for receipt.

> Give 10 euro and form
SIGN FORM

Thanks for participating! Do you have any questions about the experiment? I'd like to ask you not to talk about this research with others. That might influence the results the study. The last test day is on February 9, so after that date you can freely talk about it.

Appendix H. Interactive tasks 5 and 7

This appendix belongs to Section 5.3.2

Task 5: making a reference

In Task 5, participants had to make a reference that meets the APA standards.

Effectiveness of navigation behavior

Six participants were able to make a reference in accordance with the APA standards: three low analytics and three high analytics. Different parts of the Writing Studio were used to find relevant information: three participants (two high analytics and one low analytic) used the tool 'My Bibliography & Notes.' Three participants (two low analytics and one high analytic) used expository information of the CSU Writing Guides. The navigation behavior between the participants who used the Bibliography Builder and the participants who used the CSU Writing Guides is quite different, and therefore, hard to compare. That is why these groups will be discussed separately.

Four participants did not finish Task 5. Two of these participants were close to the Bibliography Builder, but did not use it. One visited the tool twice, but did not recognize it as a tool to make references with. The other did not click on the link to the tool, due to the word 'my' in 'My Bibliography & Notes'; she thought she did not need something personal to create a reference. The other two participants who did not succeed seemed to think that the reference had to be inserted into the portfolio. In fact, this is true. But the two participants were unable to locate the Bibliography Builder: one of them repeatedly tried the link 'Update Portfolio.'

Characterization of navigation behavior (Bibliography Builder)

The shortest, and most logical, way to make a reference is using the Bibliography Builder. Five clicks are needed to create a reference with the Bibliography Builder; the typing and clicking to fill in the content of the reference has been left out of consideration. The Bibliography Builder can be found after one click in the main navigation bar on 'My Working Bibliography & Notes.'

The number of clicks is represented in table H.1. The low analytic participant used less clicks than the two high analytics. The low analytic used only four clicks. This is less than the five clicks that were actually needed. This is due to the fact that he directly chose the right path to the Bibliography Builder, but that he did not click to select a citation style.

Table H.1

Average number of clicks for Task 5 by low analytics and high analytics (Bibliography Builder)

	Low analytic (n=1)			High analytic (n=2)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	4,00	-	1	9,50	2,12	2

To get more insight in the differences between the navigation behavior of high and low analytics, table H.2 shows the number of clicks in the different navigation categories. The high analytics clicked more often on links or buttons in tools. This is due to a participant who expected to find information about the APA style in the Bibliography Builder. He did not immediately discover that the Bibliography Builder was a tool. This resulted in extra clicks in the Bibliography Builder. Further, the high analytics clicked more often on the main navigation bar. This is due to one high analytic, who first tried the 'writing guides' and the 'Working with sources room', before he found the Bibliography Builder.

Table H.2
Average number of clicks in different navigation categories for Task 5 (Bibliography Builder), by low analytics and high analytics

	Low analytic (n=1)			High analytic (n=2)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	1.00	-	1	2.50	0.71	2
Local & contextual navigation	3.00	-	1	7.00	2.83	2
- Next/previous	0.00	-	1	0.00	0.00	2
- Examples	0.00	-	1	0.00	0.00	2
- Tools	3.00	-	1	6.00	4.24	2
Back/forward	0.00	-	1	0.00	0.00	2
Homepage	0.00	-	1	0.00	0.00	2

The participants who used the Bibliography Builder experienced some problems with filling in the different fields of the Bibliography Builder. For example, selecting the right citation style was a problem, the meanings of several fields were unclear, and no confirmation was given of their input. The participants said they missed a confirmation, and therefore, all three of them checked their input.

Characterization of navigation behavior: CSU Writing Guides
The most efficient route to information about APA in the CSU Writing Guides consists of eight clicks. The starting point of this route is the guide 'Writing Annotated Bibliographies.' The high analytic participant needed 9 clicks, the two low analytics needed 16 clicks on average (see table H.3).

Table H.3
Average number of clicks for Task 5 by low analytics and high analytics (CSU Writing Guides)

	Low analytic (n=2)			High analytic (n=1)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	16,00	1,41	2	9,00	-	1

Table H.4 gives an overview of the clicks in different navigation categories for low and high analytics who used the CSU Writing Guides. Low analytics needed on average more clicks than high analytics, which was mainly a result of the high number of clicks in 'Local and contextual navigation.' The high analytic participant directly chose the right path; the two low analytic participants first searched on other parts of the Writing Studio before finding a way to enter the CSU Writing Guides.

Table H.4

Average number of clicks in different navigation categories for Task 5 (CSU Writing Guides), by low analytics and high analytics

	Low analytic (n=2)			High analytic (n=1)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	3.50	3.54	2	1.00	-	1
Local & contextual navigation	10.50	2.12	2	1.00	-	1
- Next/previous	0.00	0.00	2	1.00	-	1
- Examples	0.00	0.00	2	0.00	-	1
- Tools	0.00	0.00	2	0.00	-	1
Back/forward	1.50	2.12	2	0.00	-	1
Homepage	0.50	0.71	2	0.00	-	1

Task 7: sending a portfolio to a registered user of the Writing Studio

Task 7 is a task that requires the use of an interactive part of the Writing Studio. Namely, the participants are asked to send a portfolio to a registered user of the Writing Studio, in order to ask for feedback. The participants only have the name of the registered user.

Effectiveness of navigation behavior

Six participants (four high analytics and two low analytics) completed this task, of whom five completed it correctly. The incorrect answer concerned a general email to the Writing Center, without a portfolio attached. Four participants (three low analytics and one high analytic) were not able to ask the registered user for feedback on their portfolio. Reasons for not finishing this task were not being able to choose the right option under 'Assistance', and not being able to use the local search engine for name search (one participant left the search engine after 6 unsuccessful tries). Some participants mentioned that they missed a search engine close to 'E-mail my portfolio': "Actually, it would be the easiest when a list of addresses was available here." Maybe the participants were misled by the phrase about sending their portfolio. Namely, the option they had to consult is in fact not an option with which a portfolio can be send. It is an option with which a user can make his or her writing product accessible to other registered users. An email requests feedback, and notifies the registered user that he or she has access to some work of a colleague-writer.

A problem that occurred among successful and unsuccessful participants was the use of the search engine, in order to find the name of the registered user. Figure H.1 shows the search engine. Participants experienced difficulties with finding the e-mail address of the registered user. This was because of three reasons: participants did not know the meanings of 'wildcard', 'exact' and 'partial'; the name of the registered user contained a prefix; and for the results of the search, scrolling was necessary.

Figure H.1 Search engine for names and e-mail addresses of Writing Studio's registered users

Characterization of navigation behavior

Six clicks are necessary to ask a registered user for feedback on a portfolio. In this number, the typing is excluded. Table H.5 shows the number of clicks that low analytics and high analytics needed in order to complete the task. Both groups obviously needed more clicks than the number of clicks in the most efficient route, and low analytics needed more clicks than high analytics. The variance within both groups is quite large.

Two high analytics and one low analytic first selected the portfolio they had to send. This takes extra clicks. Further, no participants directly chose the right hyperlink under 'Assistance.' Especially the option 'Chat with other writers' was very popular. This resulted in extra clicks, as well.

Table H.5

Average number of clicks for Task 7 by low analytics and high analytics

	Low analytic (n=2)			High analytic (n=4)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	20,50	6,36	2	17,25	5,74	4

Characterization of navigation behavior

In table H.6, a more detailed description of the navigation behavior of the low analytics and the high analytics is given. Low analytics clicked more often on the 'Main navigation bar', 'Local & contextual navigation', 'Tools', and 'Homepage' than high analytics. High analytics clicked more often on the 'Back/forward' buttons than low analytics.

Table H.6

Average number of clicks in different navigation categories for Task 7, by low and high analytics

	Low analytic (n=2)			High analytic (n=4)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	3,50	3,54	2	2,50	1,73	4
Local & contextual navigation	14,00	4,24	2	10,25	4,50	4
- Next/previous	0,00	0,00	2	0,00	0,00	4
- Examples	0,00	0,00	2	0,00	0,00	4
- Tools	10,00	4,24	2	6,00	2,94	4
Back/forward	2,00	0,00	2	3,75	2,63	4
Homepage	1,00	1,41	2	0,75	0,96	4

Appendix I. Expository tasks 6, 8 and 9

This Appendix belongs to Section 5.3.3

Task 6: finding the right signs to mark the ending of a press release
Task 6 asked the participant to find out what kinds of signs are suitable for marking the ending of a press release.

Effectiveness of navigation behavior
Only three participants completed this task successfully: two high analytics and one low analytic. Seven participants did not complete the task. The reason for this may be that participants experienced difficulties with determining the difference between the 'Business Writing Guides' and the 'Business Writing Room.' Namely, four unsuccessful participants searched in the 'Introduction to Business Writing' (part of the 'Business Writing Guides') for information about press releases, without any result. Two participants did visit 'Business Writing Room' – where the intended information can be found – but left the room again, without having clicked on the right link.

Characterization of navigation behavior
To find suitable signs to mark the ending of a press release, 5 clicks are needed. The high analytics found the answer quite fast; after 6.5 clicks on average (see table I.1). In contrast, the low analytic person used 19 clicks.

Table I.1
Average number of clicks for task 6 by low analytics and high analytics

	Low analytic (n=1)			High analytic (n=2)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	19,00	-	1	6,50	0,71	2

Table I.2 shows how the clicks of low analytic and high analytics are distributed over the different navigation categories. The high number of clicks of the low analytic is mainly due to the number of clicks in 'Local & contextual navigation.' The reason for this is that she first tried the link 'Introduction into Business Writing', which resulted in many clicks in local and contextual navigation. In contrast, the two high analytics chose almost directly the right path.

Table I.2
Average number of clicks in different navigation categories for Task 6, by low analytics and high analytics

	Low analytic (n=1)			High analytic (n=2)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	2,00	-	1	1,00	1,41	2
Local & contextual navigation	14,00	-	1	5,00	0,00	2
- Next/previous	1,00	-	1	0,00	0,00	2
- Examples	0,00	-	1	0,00	0,00	2
Back/forward	1,00	-	1	0,00	0,00	2
Homepage	2,00	-	1	0,50	0,71	2

Task 8: finding how to begin writing a haiku

In Task 8 participants had to search for a way in which one can start writing a haiku.

Effectiveness of navigation behavior

All 10 participants completed this task successfully. This may be due to a learning effect. Participants may have seen the 'poetry writing room' before, so they knew where to look for relevant information.

Characterization of navigation behavior

Information about the beginning of a haiku can be found quite quickly, namely after 3 clicks. High analytics did not need many clicks, on average 5.6 (see table I.3). Low analytics needed 10 clicks on average.

Table I.3

Average number of clicks for Task 8 by low analytics and high analytics

	Low analytic (n=5)			High analytic (n=5)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	10,00	4,85	5	5,60	3,05	5

Table I.4 shows the number of clicks low analytics and high analytics made in the different navigation categories. The higher number of clicks on the main navigation bar and on local and contextual navigation, may be due to the fact that two low analytics and one high analytic did not directly choose the 'Poetry Writing Room', and that two low analytics and one high analytic did not directly choose the right hyperlink in the 'Poetry Writing Room.'

Table I.4

Average number of clicks in different navigation categories for Task 8, by low and high analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	3.40	3.44	5	0.80	0.84	5
Local & contextual navigation	5.60	2.19	5	3.80	1.30	5
- Next/previous	0.00	0.00	5	0.00	0.00	5
- Examples	0.60	0.55	5	0.60	0.55	5
Back/forward	0.20	0.45	5	0.60	1.34	5
Homepage	0.80	0.84	5	0.40	0.55	5

Task 9: finding an example of a refusal letter

In Task 9 participants have to find out whether the Writing Studio contains an example of a refusal letter.

Effectiveness of navigation behavior

Ten participants completed this task, of which nine completed the task correctly. One person (low analytic) chose an application letter instead of a refusal letter. Probably this is due to careless reading. The high success rate for this task is probably because participants did not have to search deep in the hierarchy for information about letters.

Characterization of navigation behavior

Four clicks are needed to find an example of a refusal letter. Low analytics needed more clicks to find intended information than high analytics (see table. I.5). The writing guides of the Writing Studio contain a guide 'Writing Business Letters.' The 'Business Writing Room' contains information about business letters, as well.

Table I.5

Average number of clicks for Task 9 by low analytics and high analytics

	Low analytic (n=5)			High analytic (n=5)		
	M	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Total number of clicks	11,40	3,29	5	8,20	1,48	5

The total number of clicks can be distributed over different navigation categories (see table I.6).

Low analytics clicked, on average, more often on the main navigation bar, on local and contextual navigation, on next/previous buttons, and on back/forward buttons than high analytics. High analytics clicked more often on the homepage than low analytics.

Table I.6

Average number of clicks in different navigation categories for Task 9, by low and high analytics

	Low analytic (n=5)			High analytic (n=5)		
Navigation category	*M*	*SD*	*# tasks*	*M*	*SD*	*# tasks*
Main navigation bar	1.60	0.55	5	0.60	0.55	5
Local & contextual navigation	7.40	1.95	5	5.40	0.55	5
- Next/previous	1.00	1.73	5	0.20	0.45	5
- Examples	1.60	0.89	5	1.00	0.00	5
Back/forward	2.20	1.92	5	1.40	0.89	5
Homepage	0.20	0.45	5	0.80	0.84	5

It is remarkable that in Task 9 the meaning of business writing still was not clear to all participants. "Business letter, I do not know whether that is correct. It seems to be something from a company, not to a company." Apparently, not all participants understood that 'business' means 'commercially' instead of 'company.'

Appendix J. Questions about writing experience – results for participants of the Card Sorting Method

This appendix belongs to Section 6.1

In tables J.1 to J.4 the results of the questions about domain knowledge are presented. These are the results of the participants of the Card Sorting Method. The non-parametric Chi-Square Test, showed that the answers to the questions about writing experience were not significantly related to participant's cognitive style.

Table J.1

Frequency of answers to the question "Have you ever taken any classes to improve your writing skills at the University of Twente?"

	Low analytics (n=15)	High analytics (n=15)
No	13	11
Yes	2	4

Table J.2

Frequency of answers to the question "Have you ever taken any classes to improve your writing skills outside the University of Twente?"

	Low analytics (n=15)	High analytics (n=15)
No	12	13
Yes	3	2

Table J.3

Frequency of answers to the question "How often have your writing skills been evaluated during your studies at the University of Twente?"

	Low analytics (n=15)	High analytics (n=15)
Never	3	5
Rarely	6	5
Some times	2	4
Frequently	4	1

Table J.4

Frequency of answers to the question "How often have your writing skills been evaluated outside the University of Twente?"

	Low analytics (n=15)	High analytics (n=15)
Never	4	6
Rarely	6	4
Some times	4	4
Frequently	1	1