Chapter 1. Introduction

The focus of the PhD project reported here is Web navigation. The idea that inspired this project comes from a study conducted by Van Oostendorp (2002). He started from a practical desideratum: given a website for the general public, how could one make sure it is visited by its intended users and visits are followed by re-visits? In other words, how could one make sure the users' experience with a particular website is satisfactory and therefore the website is perceived as worth re-visiting by its intended users? As the main result of this study, *Interestingness of provided information* and *Ease of navigation* were found to be the main factors determining users' satisfaction. These two factors, as well as users' satisfaction were measured with the aid of questionnaires. Thus, how interesting the content is perceived to be and how easy to use the structure of the website seems to the users determine whether and to what extent users are satisfied with using the website. It is interesting to note as early as now that it was in this study for the first time when *structure-related aspects* (ease of navigation) were found to be complementary to *content-related aspects* (interestingness of provided information). Later on this dichotomy will reoccur and be referred to as *syntax vs. semantics*.

Throughout this report the term "Web navigation" is used as a central metaphor for using the Web (Instone, 2002). While we agree with those who argue that using the Web is much more than navigation, we adhere to the main stream of researchers who see the Web as a world-wide hypertext and navigation as the major part of user experience on the Web (Lazar, 2003). We use the term "Web navigation" in a broad sense referring to users' orientation in an information space, locating information and progressing from one information source to another. Other terms frequently used in this field, such as *surfing*, *foraging*, *browsing*, or *searching,* are considered synonyms with or enclosed in *Web navigation*, unless otherwise specified. Searching in strict sense – as in using a search engine – although an important part of Web use, is not our focus here, and is extensively treated elsewhere (Van Zwol & Van Oostendorp, 2004).

An interesting common connotation of the above metaphors is the suggested challenge involved in using the Web. The Web has brought us not only the opportunity of nonlinear access to information sources but also the challenges of *cognitive overload* and *disorientation* (Conklin, 1987; Edwards & Hardman, 1988).

Since this field of study is relatively new, researchers have to rely on more established domains to provide concepts and methods. In our case, such domains are: human-computer interaction, cognitive science,

human factors, and text comprehension. Since the activity of Web navigation is in itself new, one has to make analogies with activities that have been extensively studied and understood. Throughout this report we will mainly use interaction paradigms such as reading/writing and talking/listening. Within these paradigms, using the Web can be seen as a dialogue: users inform Web applications about their choices and Web applications "reply" with content. There are also specifics of Web navigation that become apparent during these analogies. For example, involving spatial features (syntax) in processing contents (semantics) is recognized as a distinguishing characteristic of Web navigation (Di Blas, Paolini & Speroni, 2004).

Research attempting at modeling cognitive mechanisms involved in Web navigation gains increasing influence in the Human-Computer Interaction community (Kitajima, Blackmon & Polson, 2000; Pirolli & Fu, 2003). Existing theories such as Information Foraging (Pirolli & Card, 1999) and Construction-Integration (Kintsch, 1998) and models such as SNIF-ACT (Pirolli & Fu, 2003) and CoLiDeS (Kitajima, Blackmon & Polson, 2000) have been taken as input for our own research. Based on this input, we have tried to make a step further and propose amendments to the existing models. As we will try to convince the reader in the next sections, the main idea of our model is that not only semantic but also syntactic (spatial) processes must be accounted for in models of Web navigation tasks (Juvina & van Oostendorp, 2004).

The objective of our research was to build a cognitive model that predicts and explains human performance in Web-assisted tasks. We intended to gather facts and descriptive statistics of Web navigation behavior in order to ground our model in reality. These data were expected to help us answer the question: *what are the most important factors determining success in Web-assisted tasks*? An important part of our data was purposely automatically recorded. The reason for this was two-fold: (1) automation allows efficiency in data gathering; and (2) when user data is automatically recorded, dynamic (real-time) adaptations of the Web application can be designed. However, automatically recorded data (referred also as Web-logging data) need to be properly interpreted; therefore, an important part of our work was concerned with answering the question: how can one make sense of behavioral navigation data?

The next intended step was to build a cognitive model that explains the role of the factors that appeared to be important in the previous phase. This model was expected to give insights into how the information space is represented in users' minds, what features are represented or abstracted out, how relevance of information perceived on the screen is judged, how this judgment of relevance can be computationally

modeled, how contextual information is used in judging relevance, and how one can computationally model the involvement of contextual information.

This project has also a more practical objective: improving existing interfaces and tools and providing a better navigation support to users. The full realization of this practical component is, certainly, beyond the scope of a PhD project. However, practical criteria are useful for guiding and testing the theoretical and empirical work. Within this objective we try to answer questions such as: *What type of support is necessary and possible*? *What are the consequences and implications of providing theory-based Web navigation support*? Empirical studies showing the usefulness of such support will be presented, confirming the validity of the proposed model.

Applications of this research are suggested. In particular, using the Web via screen readers by visually impaired persons (VIPs) is treated as a demonstrative case. We have conducted an empirical study in which vision impairment was simulated, in order to investigate *how VIPs can be supported in their Web use.* Participants had to perform Web navigation tasks with the screen of the computer switched off and, instead, with the aid of a screen reader. We also suggest that our work can be applied to other cases where information overload interacts with users' cognitive limitations (mobility, multitasking, etc.) and to other target populations (e.g.,elderly, cognitively impaired).

Summarizing, the research presented here is driven by the following questions:

- What are the most important factors determining success in Web-assisted tasks?
    - How can one measure or estimate these factors in an automatic way?
- What are the explanatory cognitive mechanisms for the identified factors?
    - How can one implement these mechanisms in a (computational) cognitive model?
- What kind of Web navigation support can be conceived based on the knowledge gained from the two previous questions?
    - What impact has this support on users?

The remainder of this thesis is structured as follows:

Chapter 2 presents the field of studying Web navigation from behavioral and cognitive perspectives. It shows previous work and results on this topic and it introduces the necessary concepts for the next sections. It starts with presentation of general facts about Web navigation,

continues with individual differences, goes into details about cognitive processes involved in Web navigation and cognitive models of Web navigation, and it ends with practical constraints and opportunities.

Chapter 3 discusses methodological issues. Since the field is relatively new, there are important problems that one is confronted with, such as: how to collect and analyze navigation data, what and to what extent results can be generalized, where to place ourselves between the paradigms of common user versus individual differences, and how descriptive concepts can be computationally modeled.

In Chapter 4, several empirical studies are presented together with their results. The structure of this chapter follows the same logic as the one in Chapter 2. It starts with facts about Web navigation, how they were measured, recorded and analyzed, and how they can be interpreted. It continues with individual differences and how these were investigated based on correlational analyses. Then it presents how we modeled the main cognitive processes involved in Web navigation and what is the value, both theoretically and practically, of our modeling approach. Subsequently, two experimental studies are presented aimed at testing our model and its relevance. The results of these studies suggest that it is empirically justified and practically attractive to provide model-based navigation support to users of Web applications.

Chapter 5 presents possible extensions and applicability of our research. The case of using the Web via screen readers by VIPs is used for demonstrative purposes. A computational implementation of the model in a cognitive architecture is also proposed and demonstrated.

Chapter 6 summarizes the main contributions of this project to the fields of information science, human-computer interaction and cognitive science. The value and limits of our research reported here are discussed, together with directions for further research.