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Hypermedia navigation: Differences between spatial cognitive styles

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ABSTRACT

Recently, many studies have investigated the role of individual and cognitive differences during Web navigation and Web searching. Despite this interest, no works have considered the role may assume individual differences in real-environment navigation during Web navigation. The aim of this work is to investigate the effect of different spatial cognitive styles: Landmark style (LS), Route style (RS) and Survey style (SS), on Web searching behaviour. In real-environment navigation, having a specific style determines the type of information individuals selected to navigate and orient themselves. We hypothesize that LS individuals are less proficient during Web exploration due to their analytical analysis of the environmental features. Vice versa SS individuals will show high performance on Web exploration for their holistic analysis of the World. We asked 30 College Students (10 LS, 10 RS, 10 SS) to solve three Web information tasks. The spatial cognitive style of participants was assessed through the Spatial Cognitive Style Test, and they were also asked to fill in a questionnaire about their internet and computer use. An ad hoc key-logger program for browsers was used to collect Web behaviour measures. In particular, the measures considered were: search engine tools used (e.g. back button), pages visited and revisited, time spent on information searching, and mouse cursor movements. The results showed significant differences between the spatial cognitive styles: LS seems to use a trial and error strategy in order to obtain the relevant information. Differences also emerged in the distribution of mouse cursor movements during Web navigation.

1. Introduction

Most people in the Western world now have a computer with Internet access at home and many of them use the computer and search engines daily both at home and at work. Within this population, different age groups and habits can be identified: teenagers and young adults of the 21st century, who were born and grew up with computers and the Internet, are defined by Prensky as "Native Digital"; conversely, older people, who began to use computers for work and other necessities, are called "Digital Immigrant" (Prensky, 2001). Human interaction with computer technology has changed over the past 50 years, so we can consider three waves of computing (Shiode, 2004; Weiser, 1993): a) the first wave goes from 1960 to 1980 and is called the "Mainframe Era", in which there was only one computer shared by many people; b) the second wave is called the "Personal Computing Era", and goes from 1980 to 2000, in which each person has a personal computer; c) the third wave is called "Ubiquitous Computing Era", which goes from 2000 to now, in which individuals have several computers and other devices.

Due to this widespread use of the computer, it seems useful, in the field of computer science, to understand which factors affect computer users' behaviour during computer interaction. With this in mind, some interesting research has focused on Web searching experience. The Literature has tried to identify how internal factors, such as computer expertise or individual characteristics, and external factors, like Web browser features, may influence Web searching behaviour (for a review see Spink & Jansen, 2006). Evaluating the role of these elements can lead to a deeper understanding of which criteria are fundamental in Website design, thus providing the basis for improving contents and search engine efficacy.

One external factor considered is, for example, the impact of display size during Web searching, in terms of usability, in

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particular the smartphone or tablet screen compared to bigger computer displays, and the two different Web interfaces used in these devices during Web navigation. At the dawn of the spread of devices with Web browsing capabilities, the existing Website interfaces were not appropriate for these new tools, and this led to general difficulties during Web searching (e.g. Jones, Marsden, Mohd-Nasir, Boone, & Buchanan, 1999); for this reason, designers and researchers are more and more pushed to improve Web navigation on smaller devices (e.g. Xie, Miao, Song Wen, & Ma, 2005).

With regards to internal factors, a large number of studies have focused on individual differences, one of the most important of which is gender. Many authors explored how gender affects computer skills and Web searching. For example, several studies showed that men are more interested in using computers and Web browsing compared to women (Light, Littleton, Bale, Joiner, & Messer, 2000; Schumacher & Morahan-Martin, 2001). Furthermore, the purposes of men and women during Web browsing appear to be different: women tend to search the Web for relational concerns, like sharing ideas on communities or participating in Webchats; conversely, men are more interested in personal activities and facing a lower cognitive burden to find information (Jackson, Ervin, Gardner, & Schmitt, 2001; Smith & Whitlark, 2001).

Numerous contributions have also discovered links between personality traits and internet usage. People high in Neuroticism (a personality trait of the Big Five characterized by anxiety, fear, moodiness, worry, and loneliness, e.g. Goldberg, 1990; Thompson, 2008), often use the Internet and especially social networks to avoid loneliness and socialize with other people (e.g., Amichai-Hamburger & Vinitzky, 2010), while those high in Extraversion (another personality trait of the Big Five; extraverts tend to be talkative and to show an energetic behavior: Thompson, 2008) tend to make friendships outside the virtual world and use the internet as an instrument to keep in touch (Ross et al., 2009).

Cognitive style (e.g. Riding & Cheema, 1991) describes the way individuals think, perceive and remember information. Different cognitive styles (verbalizer vs. visualizer; wholistic vs. analytic; field dependent vs. independent) have been described and reflect how individuals organize and structure information. Cognitive style emerges as an important factor during Web searching behaviour and information processing. Between the 1940s and 1980s, many researchers developed their own theories and instruments to evaluate cognitive style. Riding and Cheema (1991) grouped the cognitive style into two dimensions: wholistic-analytic (or field dependent-independent) and verbal-imagery (or verbalizer-visualizer). Wholistic or field-dependent cognitive users tend to see a situation as a whole picture (Riding, 1997). They are able to structure and analyse problem solving and learning. Analytic or field-independent cognitive style users see a situation as a collection of parts and focus on one or two aspects of the situation at a time. They are good at seeing similarities, detecting differences, and providing their own structuring in intellectual activity. The verbal-imagery cognitive style describes a person's tendency to elaborate the information using a verbal code or a visual one (Riding & Cheema, 1991). Specifically, verbal (verbalizer) cognitive style users think in terms of words and consider the information they read, see, or listen to, in words or verbal associations. Instead imager (visualizer) cognitive style users think in terms of mental pictures: when they read, see, or listen to something, they consider it in pictures. Only a limited number of studies have been conducted to explore cognitive styles among different information and web users (Kinley et al., 2014). For example, Palmquist and Kim (2000) found that field-dependent cognitive style and lower Web searching expertise are related: users take more time and actions than required to find information. More recently, Kinley and Tjondronegoro (2010) found that verbal users tend to navigate on the Internet in a nonstructural mode, that is sporadic way – for example they often reformulate queries and scan several pages quickly; conversely, imagery users (who represent knowledge in mental pictures) seem to have a more linear and structural navigational behaviour – for example, they read all pages and spend more time on searching for information. Kinley, Tjondronegoro, Partridge, and Edwards (2014) showed that wholistic and verbalizer users followed a top-down search approach while searching for information on the web: that is, they first search for general information and then gradually for specific information. On the other hand, analytic and imager users preferred a bottom-up approach while performing web searches, searching for specific information by using a lot of search terms in their successive queries. Moreover, participants' search queries were categorized into New, Add, Remove, Replace, and Repeat. A significant difference was found between wholistic and analytic users: wholistic subjects were found to use more new and repeat queries than analytic subjects. Moreover, verbalizers executed a higher number of Add, Remove and Replace query reformulations than visualizer cognitive style users. Cognitive style is also a key factor in the development of hypermedia learning systems, because of the individual differences in information processing (Lee, Cheng, Rai, & Depickere, 2005; Liu & Reed, 1995; Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002), even though some studies do not attribute the same importance to this factor (Calcaterra, Antonietti, & Underwood, 2005). Obviously, Internet expertise emerges as a significant element that affects Web searching behaviour. In Lazonder, Biemans, and Wopereis (2000), Internet expertise is associated with better performance during Web searching, and in fact expert users find a greater amount of correct information in a shorter time compared to novice users. Moreover, users with a high level of expertise utilize complex queries and advanced search operators - e.g. Boolean operators - usually not used by average and novice users (e.g. Hölscher & Strube, 2000). An interesting effect related to Web searching experience is spatial disorientation during navigation, which means that users are unable to locate their position in hypermedia during Web interaction (Thüring, Hanneman & Haake, 1995). Herder and Juvina (2004) discovered two Web navigational styles associated with the perception of disorientation: 1) "Flimsy navigation style" reflects a low Internet expertise and is related to users' perceived disorientation, with a high rate of homepages and a lower number of pages visited; 2) "Laborious navigational style", in which users employ a trial and error strategy and open many links to see if they are useful, or otherwise return to previous pages, often using the back button, and follow other links. This navigation style is also related to a low score in mental rotation tasks (Juvina & van Oostendorp, 2004).

Despite the importance of individual and cognitive differences, few studies have considered the potential contribute of spatial and environmental navigation skills on Web searching behaviour. Nevertheless, spatial abilities, in particular spatial orientation, seem to affect performance during information retrieval tasks in Internet (e.g. Pak, Rogers, & Fisk, 2006): search an information using Web implies orienting oneself in a virtual environment that requires a series of abilities also involved during real environment navigation, when individuals have to orient in a real physical space, such as a city, to find a target and to reach a destination: (a) orientation to determine self-location (Web location) and estimated target location (information which I need to try); (b) initial route choice in selecting routes (link) from origin to target location; (c) route monitoring, that is, checking the route taken by estimating self-location and target location (checking if the information is relevant or not for reaching the goal) as well as checking/monitoring and confirming the route choice; and (d) recognition of the target (i.e., reach the information I need) (Golledge, 1999; Lawton & Kallai,