

# Cognitive Styles and Students' Interaction with an Instructional Web-site: Tracing Users through Eye-gaze

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## Abstract

*Users' psychological and physiological differences have been sought by researchers. Cognitive style –one of these differences- is related to a person's approach of getting, organizing, and processing information. It is indicated in the literature that cognitive style has the potential to affect the users' interaction patterns in computer-based interfaces. This study was conducted to reveal the interaction patterns of users with different cognitive styles by using eye-tracking method. Results indicated that users' fixation durations and places might vary among different cognitive style groups, but no statistically significant difference was found.*

## 1. Introduction

User analysis is an important aspect of user-centered systems design. Users' physiological and psychological characteristics are important for designers. Dillon and Watson (1996) suggest that HCI community cannot indicate exactly how to design interface considering user differences.

Cognitive style is one of the user differences studied by HCI researchers. It refers to an individual's consistent and characteristic approach to organising and processing information, and is one of the most stable user characteristics overtime (Witkin & Goodenough, 1981). Dillon and Watson (1996) consider the cognitive style as information-processing equivalent of personality for any individual.

Field-dependency is one of the most popular cognitive style constructs introduced by Witkin et al. (1977). They stated that field-dependent (FD) people have global perceptions, while the field-independents (FI) tend to think analytically. Indeed, FD people perceive objects as a whole and accomplish a task more holistically, whereas FI focus on individual

components of the object and tend to be more serialistic.

There are many studies which are conducted to explore the effects of users' cognitive style on their interaction with an interface. Some visual and navigational aspects, and content representation and organization are among the common interface issues studied by researchers in the HCI field through the cognitive style perspective (Chen, Magulas & Macredie, 2004; Huang, 2005; Parkinson & Redmond, 2002).

Ford, Miller, and Moss (2001) examined the role of individual differences in Internet searching. Gender and cognitive style were found to be important in terms of internet search behavior, in that male performed better than female, and imager cognitive style performed better than verbalizer. A study (Parkinson & Redmond, 2002) about the cognitive style effects on learner performance for different computer media revealed that FI users performed better in Internet treatment than in the CD-ROM and text treatments. So, it could be suggested that users with different cognitive styles may prefer to use different kind of media. Chen and Macredie (2004) aimed to explore the relationships between the learners' cognitive styles and their perceptions and attitudes toward the features of a Web-based instructional program. Results indicated that cognitive styles influence students' reactions to nonlinear interaction, independent learning, navigation tools and the difficulties and problems they face with. In another study, conducted by Chen, Magoulas and Macredie (2004), findings suggest that cognitive style is important in terms of the users' reactions to the organization of the information, e.g. the subject categories, presentation of the results, and screen layout. Besides the cognitive style effects, computer competency of the users were suggested as important factors affecting users on a web interface (Palmquist & Kim, 2000; Yecan, 2005). Palmquist and Kim (2000) concluded that cognitive style significantly affected the search performance of novice searchers; however there

was not important difference between the cognitive style groups who were experts in using computers.

## 2. Purpose of the Study

The literature indicated that there are some differences between cognitive style groups in terms of interaction with Web site. Many aspects of the interaction such as navigation, content presentation, organization, search behavior, and perceptions on interface were examined by the researchers. In this study, to reveal the interaction between a web site and users with different cognitive styles, eye-tracking method was used. The following research questions were posed at the beginning of the study;

1. Is there any difference between FD and FI users in terms of fixation places in an instructional web site?
2. Is there any difference between FD and FI users in terms of fixation durations in specific places of an instructional website?

## 3. Method

The very general purpose of this study is to discover the effects of cognitive style on interaction with a computer-based interface through eye-tracking method. Data were collected and analyzed quantitatively based on the research questions.

### 3.1. Context and Participants

An instructional web site, explaining how to conduct CPR (Cardiopulmonary resuscitation), was developed by the researcher. The site was consisted of a tree-type menu on the left side, and content explanations on the main frame. The content explanation part was divided into five chunks presenting each one on a separate page to provide small chunks of information. In addition, there was one more page which is explaining the whole content on a single page. Besides this organization, content was supported by visuals – some images and a movie clip.

Participants of the study were undergraduate students. In terms of eliminating the computer competency level effects, subjects were selected among the juniors studying at the department of Computer Education & Instructional Technology.

### 3.2. Procedure

Cognitive style test, GEFT, was administered to select the participants. After the test was administered, basic statistical analyses were conducted and students were divided into three groups including FDs, FIs, and neutrals ( $M=14.82$ ,  $SD=2.87$ ). The selection criterion was based on the GEFT scores and gender of the

participants. Bottom and top scorers of males and females were selected. There were four males and females for each cognitive style group.

After the subjects were selected and notified about the study, they were participated to eye-tracking sessions in which they were notified to study the content (CPR) of the web site. Their aim was to study the content on the web site. They were notified that they will take a test about the subject at the end of the session.

Quantitative data were collected through a Tobii eye-tracker device. Data on fixation places and durations of the users were generated by the help of ClearView software. Descriptive and inferential statistics were applied. Independent t-tests were conducted to reveal the differences if any between the cognitive style groups in terms of their fixation places and fixation durations.

## 4. Findings

Users' fixation durations on each page or frame of the web site were analyzed. Before the analysis, areas of interests (AOI) were determined by using the ClearView program of the eye tracking device. Each separate page and frame (11 in total) of the web site was determined as an AOI. Ten main areas of interest were the 'main menu'; 'introduction to content' frame; separate pages of content including 'part1', 'part2', 'part3', and 'part4'; 'warning about the procedure' frame; video frame; and the tree-type menu frame that showed the steps of the procedural content.

For further analysis, the mean differences between cognitive style groups were examined for each of area of interest. Independent t-test analyses were conducted to reveal the mean differences between the cognitive style groups in terms of fixation durations for each frame. Although the results didn't indicate any statistically significant difference for any AOI, FD users seemed to have better means than FIs for all frames except the video and whole content pages.

After analyzing the data according to the fixations on pages, further analysis was conducted by focusing on smaller parts of the web site. To have more detailed results, AOIs were determined again as images and text chunks on the pages.

Means of text and image fixations of FD and FI groups were compared. Independent samples t-test was conducted, but no significant difference were found between the cognitive style groups neither for text ( $p=.253$ ,  $df=14$ ) nor the image fixations ( $p=.306$ ,  $df=14$ ).

For further analyses, each cognitive style group was compared within the group in terms of image and text fixation means, in order to see whether there is a significant mean difference for both groups in terms of

text and image fixations. Results didn't indicate any significant difference ( $p=.820$ ,  $df=14$  for FD users, and  $p=.117$ ,  $df=14$  for FI users) in terms of fixation places.

## 5. Conclusion and Discussion

Findings of the study revealed that although there are some differences between the cognitive style groups in terms of their fixation places and durations, they didn't indicate conventionally statistical significance.

The first research question searched for differences between the cognitive style groups in terms of fixation places. Findings didn't show that any frame or page is preferred by a group indicating a statistical significance. Namely, both groups equally focused on the menus. Similarly, each group focused on small-chunk and large-chunk content presentations, and video page equal to the other group. On the other hand, descriptive data showed that, FD users usually had a better mean in average fixation durations, namely they spent more time than FIs. This situation might be an evidence for FD users' performance problems in hypermedia (Leader & Klein, 1996; Palmquist & Kim, 2000; Chen, 2002).

Another issue examined in the study was the fixation durations on specific places of cognitive style groups. To answer this question, specific places were determined on the web site, and participants were traced during their study. Comparisons were made between the text fixations and image fixations of the users. Actually, there was no significant difference between the FD and FI participants in terms of text fixation means. As similar, the image fixation means were not statistically different among the cognitive style groups.

Further analyses indicated that FD participants' fixation means on images and texts were not statistically different, similar to the findings of FI users. However, descriptive data indicated that FI users' image fixation means were higher than their text fixation means. As stated by Witkin and Goodenough (1981) and Saracho (1997), FI people tend to be more self-paced, so an image would be enough for them to understand a concept, instead of reading textual explanations.

Since the findings usually revealed that there are some differences among the cognitive style groups but they are not statistically significant, it could be suggested that the research should be extended by increasing the sample size to provide variance. Furthermore, experimental research with different user interfaces could be conducted. Users' performances could be assessed for different interface designs by experimental studies.

In terms of data source triangulation, think-aloud procedures could be added to cognitive style studies, so that users' affective reactions could be gathered besides the statistical data of eye-gaze or time and achievement scores. Moreover, the participants of this study were selected among the experienced computer users. Effects of cognitive style on using hypermedia might be more observable for less experienced computer users. Further research could examine this issue.

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