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EFFECTS OF COGNITIVELY DESIGNED HOME PAGES WITH READER'S PRIOR KNOWLEDGE ON THE WEB

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ABSTRACT

The purpose of our ongoing efforts is to investigate the influence of web page design based on text-structure and user's prior knowledge for information retrieval on the basis of navigation accuracy, speed, quality and memorization. We hypothesized that cognitively designed web home page may help low prior knowledge students to organize their representation of text contents of web page. Two types of web pages are classified, differing in structure of home pages (cognitive vs. non-cognitive home page) with two kinds of users (high knowledge vs. low knowledge). In all conditions, subjects were allowed 30 minutes to navigate freely. After first navigation session, they were asked to draw a site map. Then subjects filled out the questionnaire for reading comprehension, accuracy and quality in second navigation followed by drawing a site map viewed. The cognitively designed home page helped both (low prior knowledge) LK students and (high prior knowledge) HK students. We compare the effects of comprehension accuracy, comprehension speed, quality of comprehension and navigation quality of cognitively and non-cognitively designed home page with reader's level of prior knowledge. The findings suggest that the cognitively designed home page is appropriate for both HK and LK subjects, probably because this way of designing aids a clear and broad insight into the organizational structure of the whole web site. The results are interpreted to support our hypotheses.

KEYWORDS

Cognitive design; Navigation; World Wide Web; Comprehension; Prior knowledge.

1. INTRODUCTION

From the last decade, the recent advancements in information technology have made it possible that we can use World Wide Web as an important tool for information and communication. Today, people are using it for business, education, shopping, research, pleasure, etc. The rising popularity of Internet use has stimulated concerns regarding the ways in which one can retrieve the required information. We believe that the information retrieval process using World Wide Web is a significant proportion of the time spent for getting the required information, its comprehension and also some extent to the memorization. A number of studies are published concerning the effects of contents representation of the hypertext structure with user's prior knowledge (Calisir and Gurel, 2003; Potelle and Rouet, 2003; Mcdonald and Stevenson, 1998). Here, we

consider the effect of user's prior knowledge while taking the cognitive home page design as the second factor. Much research is available concerning the cognitive web study (Dalal et al. 2000; Thüring et al. 1995; Gupta and K. Gramopadhye, 1995; Conklin, 1987) dealing with cognitive guidelines. In our research, we will limit our study to text-based pages.

The objective of our study is to examine the impact of home page design and users navigation process with their previous knowledge. We begin with hypotheses of our experiment which are followed by a description of experimental design and methodology. Then, we present the results and data analysis. Finally, we discuss the results and present our conclusion and future perspectives.

2. HYPOTHESES

Media cognition embodies the study of how people construct mental representation. A mental model is a mapping of the properties of the task demanded to its presentation in the mind of the user. We use comprehension and memorization as a series of processes through which subjects integrates his/her prior knowledge of the domain to construct a mental model. A cognitively designed home page can be used to form the mental model of the user. (Dalal et al. 2000). While considering the process of mental representation in navigation, the most common obstacle is that the user becomes disoriented within the hypertext, "lost in hyperspace" the term commonly used. Here we will not go into details of these terms. For details please see (Otter and Johnson, 2000, Thüring et al. 1995; Conklin, 1987). These researchers indicate that many of the web designers are not following the cognitive guidelines which can help the user to navigate effectively for information retrieval. They suggest coherency, structuredness, clarity and legibility to facilitate navigation.

We use the hierarchal structure of the cognitive home page with headings and subheadings having the major advantage of structured and organized information which can improve the user's efficiency and orientation (McDonald and Stevenson, 1998). For non-cognitive home page we break the sequence of headings and subheadings to remove coherency in the document.

Based on the above theory, we lead to fix the following hypotheses.

H1: High prior knowledge students have better comprehension than low prior knowledge students.

H2: Cognitively designed home page lead to better navigation accuracy, speed, quality for information retrieval than non-cognitively designed home pages.

H3: Cognitively designed representations lead to better memorization than non-cognitively designed home pages.

H4: Cognitively designed representations may help more low prior knowledge students organize their information as compare to high prior knowledge students.

3. RESEARCH METHOD

3.1 Design

The hypotheses were tested with the help of an empirical study. One week prior to the experiment, a pre-pilot study was conducted for the preparation.

The experiment used a balanced 2*2 between subject design (Page design * Prior knowledge) the factors are as follows:

1. Page design: Cognitively designed and non-cognitively designed pages (as shown in Fig. 1).
2. Prior knowledge: High prior knowledge and low prior knowledge subjects.

Table 1. The resulting home pages

	Cognitive page	Non-cognitive page
High prior knowledge (HK)	Cognitive page with HK	Non-cognitive page with HK
Low prior knowledge (LK)	Cognitive page with LK	Non-cognitive page with LK

Figure 1: Representation of cognitive and non-cognitive home page

Cognitive home page	Non-cognitive home page
<p>LA FRANCE GEOGRAPHIE PHYSIQUE La Carte de la France Un Relief Diversifié Les Hautes Montagnes Alpes Pyrénées Des Climats Tempérés Statistiques Météorologiques Statistiques Météorologiques du Paris Statistiques Météorologiques du Marseille Statistiques Météorologiques du Lyon Hydrographie ECONOMIE Agriculture Une Agriculture de Plus en Plus Performante Vers de Nouvelles Exigences d'agriculture Industrie Les Industrie Traditionnelles Les Industries de Pointe Les Transports Un Réseau Routier Performant Rail: l'arme du TGV LA SOCIETE Une Société Plus Riche et Moins Inégalitaire Langages Deux Articles de l'ordonnance de Villers-Cotterêts Les Modes de Vie La Famille Française Les Français au Travail L'apprentissage du Temps Libre GEOGRAPHIE ADMINISTRATIF Les Régions La Capitale Climat de la Capitale La 2ème Plus Grande Ville Climat du 2ème Plus Grande Ville La 3ème Plus Grande Ville Climat du 3ème Plus Grande Ville DOM TOM LA POPULATION Densités de Conforts Contrastes La Fin de l'élan Démographique Une Vieille Terre d'immigration La Population Active</p>	<p>LA FRANCE Des Climats Tempérés Un Réseau Routier Performant Géographie Physique Un Relief Diversifié La Carte de la France Les Hautes Montagnes La Population DOM TOM Hydrographie Statistiques Météorologiques Alpes La Fin de l'élan Démographique Les Industries de Pointe Pyrénées Une Agriculture de Plus en Plus Performante Statistiques Météorologiques du Lyon Densités de Conforts Contrastes Statistiques Météorologiques du Paris Une Vieille Terre d'immigration Economie La Fin de l'élan Démographique Agriculture La Population Active Les Régions Les Industrie Traditionnelles Vers de Nouvelles Exigences d'agriculture Statistiques Météorologiques du Marseille Les Transports Rail: l'arme du TGV Géographie Administratif L'apprentissage du Temps Libre La Capitale Les Français au Travail Industrie Climat de la Capitale La Famille Française Climat de la 2ème Plus Grande Ville La 3ème Plus Grande Ville La Société Les Modes de Vie Climat de la 3ème Plus Grande Ville Une Société Plus Riche et Moins Inégalitaire Langages La 2ème Plus Grande Ville Deux Articles de l'ordonnance de Villers-Cotterêts</p>

3.2 Measures

The dependant variables are the navigation accuracy, speed, quality, and memorization. Navigation accuracy was measured by the number of correct answers to a comprehension test in specific time (80 seconds). Navigation speed was measured by the total time taken to complete the comprehension test and by the time spent on home page, other pages, time spent to get the correct answers. Navigation quality was measured by

the number of hyperlinks used to get the required information, by the number of times home page visited and by the number of times other pages visited. Memorization was measured by drawing the site map by users.

3.3 Participants

A total of 32 students studying in University of Valenciennes, University of Paris 8, University of Lille 3 participated the experiment. The subjects were undergraduate/graduate/postgraduate students. There were 6 women and 26 men with an average age of 30 years. All students were familiar with web browsing with a minimum two years of experience. Half were HK and half were LK subjects.

3.4 Material

Two types of web pages were distinguished, differing in structure of home page only (cognitively designed web page vs. non-cognitively designed web page). Four home pages were created with two types dealing with general information about France and about European Nuclear Research Center which were written from various sources. The text about France deals with issue of geography like physical geography, population, economy, administrative distribution and society whereas the text about the European Nuclear Research Center deals with information about the researchers who work there, which type of research is carried out and why we need advancement in sciences and what is the need of this organization. The only difference between web sites was in the design of the home page.

3.5 Procedure

The experiment was carried out individually and was divided into three phases: a pre-experimental phase, an experimental phase, and a post-experimental phase.

3.5.1 Pre-experimental Phase

Subjects were given instructions about the nature of the experiment and to fill out a short questionnaire to evaluate their knowledge level and familiarization with web browsing. Detailed verbal explanation was delivered by the same researcher to avoid any difference in explanation throughout the experiment.

3.5.2 Experimental Phase

Subjects were assigned to one of the web site according to their evaluation. They were allowed to navigate freely for 30 minutes. They were asked to understand rather than just memorize the information presented. They were asked to draw a site map at the end of first navigation session. Then, subjects were given a questionnaire containing 30 questions. To answer the questions, subjects were required to click the appropriate hyperlink on the home page and navigate to the lower level page. We recorded the time for each navigational behavior using a program on visual basic. Then subjects were asked to draw a site map once again at the end. Here we measured navigation accuracy, speed, quality and recall of site map as described earlier.

3.5.3 Post-Experimental Phase

After the experimental phase, the participants were finally asked to draw the site map once again. The goal of this task is to analyze the representation of home page and to further explain the recall. The subjects were also asked to fill out the questionnaire concerning some basic usability problems that were indicated by the 10 the survey of Graphics, Visualization and usability center (GUV) with the World Wide Web. These included finding a page already visited, difficulty in position determining on the web, not being able to find the page, difficulty in organizing the information and pages, where to go next, where was I before, etc... We found significant difference in reported usability problems while navigating through a cognitively designed home page as compared to non-cognitively designed home page. The subject felt disoriented in non-cognitive home pages and they reported more problems in navigation as compared to the subjects of cognitive home pages. The time spent by non-cognitive home page subject was significantly higher than cognitively designed home subjects because the subjects found it difficult to access the right page quickly via non-cognitive home

page. They were bound to spend more time on home page before selecting a suitable link. Thus the home page containing structured and organized information can help subjects to make easy choice. Relationship between headings and sub-headings is equally important. Clear and well structured pages are likely easy to comprehend.

Memorization or recall was accessed by the reported level of understanding of the information with the help of site maps drawn after each navigation session.

4. RESULTS

To test the hypotheses, MANOVA and ANOVA were done as appropriate after verifying test assumptions. A multivariate analysis of variance indicated strong support for the hypothesis of cognitively designed home page leads to better navigation than non-cognitively designed home page ($p < 0.02$, Wilks' $\lambda = 0.44$). The overall effect size (η^2) at 0.352 is strong enough. The hypothesis that high prior knowledge students have better memorization and comprehension was not found significant while treating the navigation characteristics.

When we analyzed univariate analysis of variance, individual ANOVAs do not show a significant interaction between the cognitively designed pages and the user prior knowledge. When we look at the design of web page, the main effect of the design of web page is statistically significant for each of three measures of navigation: navigation accuracy ($p < 0.01$, $F = 6.59$), navigation speed ($p < 0.004$, $F = 5.62$), and navigation quality ($p < 0.0001$; $F = 8.05$). In terms of knowledge, the main effect of the prior knowledge is statistically significant for the measure of memorization at the level of recall of titles of the site map only.

Table 2. Means of navigation measures for page design and prior knowledge

Depending variables		Page design		Prior Knowledge		F
		Cognitive	Non-cognitive	High	Low	
Correct answers in 80 seconds	Mean	8.65	5.46	NS	NS	6.59
	Std. Dev.	0.87	0.87			
Total time spent	Mean	66.37	89.68	NS	NS	14.32
	Std. Dev.	4.35	4.35			
Time spent on home page	Mean	11.63	20.18	NS	NS	13.13
	Std. Dev.	1.67	1.67			
Time spent on other pages	Mean	54.73	69.05	NS	NS	7.82
	Std. Dev.	3.73	3.73			
Time for correct answers	Mean	42.39	64.75	NS	NS	7.06
	Std. Dev.	5.95	5.95			
Number of hyperlinks visited	Mean	131.93	177.13	NS	NS	11.87
	Std. Dev.	9.27	9.27			
Number of times home page visited	Mean	51.81	70.81	NS	NS	9.55
	Std. Dev.	4.34	4.34			
Number of times other pages visited	Mean	54.73	69.5	NS	NS	7.81
	Std. Dev.	3.73	3.73			
Recall of headings and subheadings of site map after free navigation	Mean	NS	NS	18.18	12.93	15.84
	Std. Dev.			0.93	0.93	
Recall of headings and subheadings of site map after second navigation	Mean	NS	NS	22.87	16.81	18.62
	Std. Dev.			0.99	0.99	

4.1 Discussion

The empirical results offer strong support for 2 out of 4 from our hypotheses and indicate that cognitively designed home pages can help in fast, more accurate and qualitative navigation as compared to non-cognitively designed home pages. Both high prior knowledge and low prior knowledge students can take advantage of cognitive representation. On the contrary, we did not find significant effect of high knowledge students over low knowledge students in navigation characteristics. Was this result caused by other factors? We are not sure about it and in the current phase, we can only speculate about it and will continue to enquire as explained in future perspectives.

5. CONCLUSION & FUTURE PERSPECTIVES

Our study suggests the significant importance of web page that is the necessity of the cognitively designed home pages over non-cognitively designed home pages both for high prior knowledge and low prior knowledge students. We use the design of home page only that is quite useful. But we think that all other pages should be designed while considering the cognitive measures including clarity, classification of different pieces of information in categories, legibility, and precise and structured information.

Future research will be considered by exploring the structure of site map recall by the subjects after each navigation session in order to study whether they memorize different pieces of information as presented or they recall just only the headings and sub heading without considering their hierarchy. An issue of future research is to study the first navigation session to manipulate total time taken, time per page, navigation order, pages visited and not visited, and navigation via home page. Perhaps we can get some clue about the influence of high prior knowledge students vs. low prior knowledge students. Our study enhances the use of cognitive style web page to help low knowledge and high knowledge subjects.

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