The Role of Human Factors in Web Personalization Environments

Panagiotis Germanakos, Nikos Tsianos, Zacharias Lekkas, Constantinos Mourlas
Faculty of Communication and Media Studies, National & Kapodistrian University of Athens, 5 Stadiou Str, GR 105-62, Athens, Hellas
{pgerman, ntsianos, mourlas}@media.uoa.gr

George Samaras
Computer Science Department, University of Cyprus, CY-1678 Nicosia, Cyprus
cssamara@cs.ucy.ac.cy

1. Introduction

The explosive growth in the size and use of the World Wide Web as a communication medium as well as the new developments in ICT allowed service providers to meet these challenges developing new ways of interactions through a variety of channels enabling users to become accustomed to new means of service consumption in an "anytime, anywhere and anyhow" manner. However, the nature of most information structures is static and complicated, and users often lose sight of the goal of their inquiry, look for stimulating rather than informative material, or even use the navigational features unwisely. Hence, researchers and practitioners studied adaptivity and personalization to address the comprehension and orientation difficulties presented in such systems, to alleviate such navigational difficulties and satisfy the heterogeneous needs of the users allowing at the same time Web applications of this nature to survive.

There are many approaches to address these issues of personalization but usually, each one is focused upon a specific area, i.e. whether this is profile creation, machine learning and pattern matching, data and Web mining or personalized navigation.

Some noteworthy, mostly commercial, applications in the area of Web personalization that collect information with various techniques and further adapts the services provided, are amongst others the Broadvision's One-To-One, Microsoft's Firefly Passport, the Macromedia's LikeMinds Preference Server, the Apple's WebObjects, etc. Other, more research oriented systems, include ARCHIMIDES (Bogonikolos et al., 1999), Proteus (Anderson et al., 2001), WBI (Magglio & Barret, 2001), BASAR (Thomas & Fischer, 1997), and mPERSONA (Panayiotou & Samaras, 2004). Significant implementations have also been developed in the area of adaptive hypermedia, with regards to the provision of adapted educational content to students using various adaptive hypermedia techniques. Such systems are amongst others, INSPIRE (Papanikolaou et al., 2003), ELM-ART (Weber & Specht, 1997), AHA! (De Bra & Calvi, 1998), Interbook (Brusilovsky et al., 1998), and so on.

2. Background

Once considering adaptation and personalization categories and technologies we refer to Adaptive Hypermedia and Web Personalization respectively, due to the fact that they

both make use of a user profile to achieve their goal and consequently they can together offer the most optimized adapted content result to the user.

2.1 A Constructive Comparison of Adaptive Hypermedia and Web Personalization

In view of the aforementioned statement it would be essential to highlight their similarities and differences and furthermore, to identify their convergence point which is their objective to develop techniques to adapt what is presented to the user, based on the specific user needs identified in the extracted user profiles.

Generally, Adaptive Hypermedia refers to the manipulation of the link or content structure of an application to achieve adaptation and makes use of an explicit user model (Eklund & Sinclair, 2000, Brusilovsky, 2001). Adaptive Hypermedia is a relatively old and well established area of research counting three generations (Brusilovsky & Peylo, 2003). Educational hypermedia and on-line information systems are the most popular, accounting for about two thirds of the research efforts in adaptive hypermedia. Adaptation effects vary from one system to another. These effects are grouped into three major adaptation technologies - adaptive content selection (Brusilovsky & Nejdl, 2004), adaptive presentation (or content-level adaptation) and adaptive navigation support (or link-level adaptation) (Eklund & Sinclair, 2000, Brusilovsky, 2001).

On the other hand, Web personalization refers to the whole process of collecting, classifying and analyzing Web data, and determining based on these the actions that should be performed so that the user is presented with personalized information. Personalization levels have been classified into: Link Personalization, Content Personalization, Context Personalization, and Authorized Personalization (Rossi et al. 2001, Lankhorst, 2002). The technologies that are employed in order to implement the processing phases mentioned above as well as the Web personalization categories are distinguished into: Content-Based Filtering, Rule-based Filtering, Collaborative Filtering, Web Usage Mining, Demographic-based Filtering, Agent technologies, and Cluster Models (Pazzani, 2005, Mobasher et al., 2002).

As inferred from its name, Web personalization refers to Web applications solely, and is a relatively new area of research. One could also argue that the areas of application of these two research areas are different, as Adaptive Hypermedia has found popular use in educational hypermedia and on-line information systems (Brusilovsky, 2001), whereas Web personalization has found popular use in eBusiness services delivery. From this, it could be implied that Web personalization has a more extended scope than Adaptive Hypermedia.

The most evident technical similarities of them are that they both make use of a user model to achieve their goal and they have in common two of the adaptation / personalization techniques: the adaptive-navigation support and the adaptive presentation. Last but not least, it is noteworthy to mention that they both make use of techniques from machine learning, information retrieval and filtering, databases, knowledge representation, data mining, text mining, statistics, and human-computer interaction (Mobasher et al., 2007).

2.2 The User Profile Fundamentals

One of the key technical issues in developing personalization applications is the problem of how to construct accurate and comprehensive profiles of individual users and how

these can be used to identify a user and describe the user behaviour, especially if they are moving (Panayiotou & Samaras, 2004). User profiling can either be *static*, when it contains information that rarely or never changes (e.g. demographic information), or *dynamic*, when the data change frequently. Such information is obtained either *explicitly*, using online registration forms and questionnaires resulting in static user profiles, or *implicitly*, by recording the navigational behaviour and / or the preferences of each user (Germanakos et al., 2007a).

3. The Significance of Human Factors in the Web Personalization Process

But, do the designers and developers attempt to build user-centric Web-based applications, taking into consideration the real users' preferences in order to provide them a really personalized Web-based content? Many times this is not the case. How can a user profile be considered complete, and the preferences derived optimized, if it does not contain parameters related to the user perceptual preference characteristics? *User Perceptual Preference Characteristics* could be defined, as all the critical factors that influence the visual, mental and emotional processes liable of manipulating the newly information received and building upon prior knowledge, that is different for each user or user group. These characteristics, which have been primarily discussed in (Germanakos et al. 2007a), and formulate a three-dimensional approach to the problem of building a user model that determines the visual attention, cognitive and emotional processing taking place throughout the whole process of accepting an object of perception (stimulus) until the comprehensive response to it (Germanakos et al., 2005).

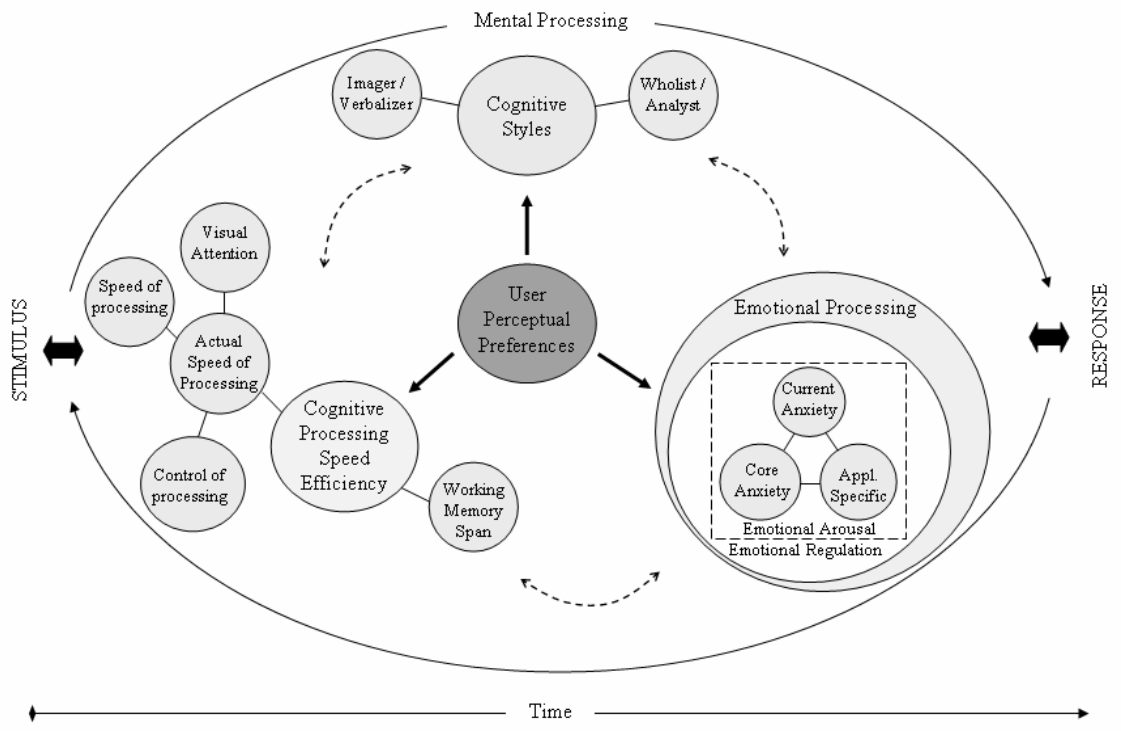

Figure 1. User Perceptual Preference Characteristics – Three-Dimensional Approach

The first dimension investigates users' *cognitive style*, the second their *visual and cognitive processing efficiency*, while the third captures their *emotional processing* during the interaction process with the information space.

3.1 Cognitive Style

Cognitive styles represent an individual's typical or habitual mode of problem solving, thinking, perceiving or remembering, and "are considered to be trait-like, relatively stable characteristics of individuals, whereas learning strategies are more state-driven…" (McKay et al., 2003). Amongst the numerous proposed cognitive style typologies (Cassidy, 2004) has been selected Riding's Cognitive Style Analysis (Riding, 2001), because it is considered that its implications can be mapped on the information space more precisely, since it is consisted of two distinct scales that respond to different aspects of the Web. The imager/verbalizer axis affects the way information is presented, whilst the wholist/analyst dimension is relevant to the structure of the information and the navigational path of the user. Moreover, it is a very inclusive theory that is derived from a number of pre-existing theories that were recapitulated into these two axises.

3.2 Cognitive Processing Efficiency

The cognitive processing parameters (Demetriou & Kazi, 2001) that have been included in the model are:

i. *control of processing* (refers to the processes that identify and register goal-relevant information and block out dominant or appealing but actually irrelevant information),
ii. *speed of processing* (refers to the maximum speed at which a given mental act may be efficiently executed),
iii. *working memory span* (refers to the processes that enable a person to hold information in an active state while integrating it with other information until the current problem is solved – Baddeley, 1992), and
iv. *visual attention* (based on the empirically validated assumption that when a person is performing a cognitive task, while watching a display, the location of his / her gaze corresponds to the symbol currently being processed in working memory and, moreover, that the eye naturally focuses on areas that are most likely to be informative).

3.3 Emotional Processing

Emotional processing is a pluralistic construct which is comprised of two mechanisms:

- Emotional Arousal, which is the capacity of a human being to sense and experience specific emotional situations, and
- Emotion Regulation, which is the way that an individual perceives and controls his emotions.

Main focus has been placed on anxiety, as the main indicator of emotional arousal, because it is correlated with academic performance (Cassady & Johnson, 2004), as well as with performance in computer mediated learning procedures (Smith & Caputi, 2007).

The construct of emotional regulation that has been used includes the concepts of Emotional Control (self-awareness, emotional management, self-motivation) (Goleman, 1995), Self – Efficacy (Bandura, 1994), Emotional experience and Emotional Expression (Halberstadt, 2005). By combining the levels of Anxiety with the moderating role of Emotion regulation, it is possible to examine how affectional responses hamper or promote learning procedures (Lekkas et al., 2007).

3.4 Evaluation – The Case of AdaptiveWeb System

Subsequently, it has been built an adaptive Web-based system, the AdaptiveWeb[1] (Germanakos et al., 2007b), that takes into account users' cognitive and emotional parameters and provides them with information matched to their preferences. All the tests implemented so far to prove components efficiency have been based on a predetermined online content in the field of eLearning multimedia environment, due to the fact mainly that there is an increased interest on distant education via the Web. In this case, it has been feasible to control factors as previous knowledge and experience over distributed information. More specifically, it has been investigated the main research hypotheses drawn:

- Are the cognitive and emotional parameters of the model significantly important in the context of an educational hypermedia application, and
- Does matching the presentation and structure of the information to Users' Perceptual Preferences increase academic performance?

3.4.1 Sampling and procedure

All participants were students from the Universities of Cyprus and Athens; phase I was conducted with a sample of 138 students, whilst phase II with 82 individuals. The 35% of the participants were male and 65% were female, and their age varied from 17 to 22 with a mean age of 19. The environment in which the procedure took place was an e-learning course on algorithms. By controlling the factor of experience, the sample has been divided in two groups: almost half of the participants were provided with information *matched* to their Perceptual Preferences, while the other half were taught in a *mismatched* way. In order to evaluate the effect of matched and mismatched conditions, participants took an online assessment test, on the subject they were taught, as soon as the e-learning procedure ended, in order to control for long-term memory decay effects. The dependent variable that was used to assess the effect of adaptation to users' preferences was participants' score at the online exam.

3.4.2 Results

As expected, in both experiments the matched condition group outperformed those of the mismatched group (Tsianos et al., 2007). Figure 2 displays the aggregated differences in performance (the dependent variable of exam score), in matched and mismatched conditions.

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[1] http://www3.cs.ucy.ac.cy/adaptiveweb

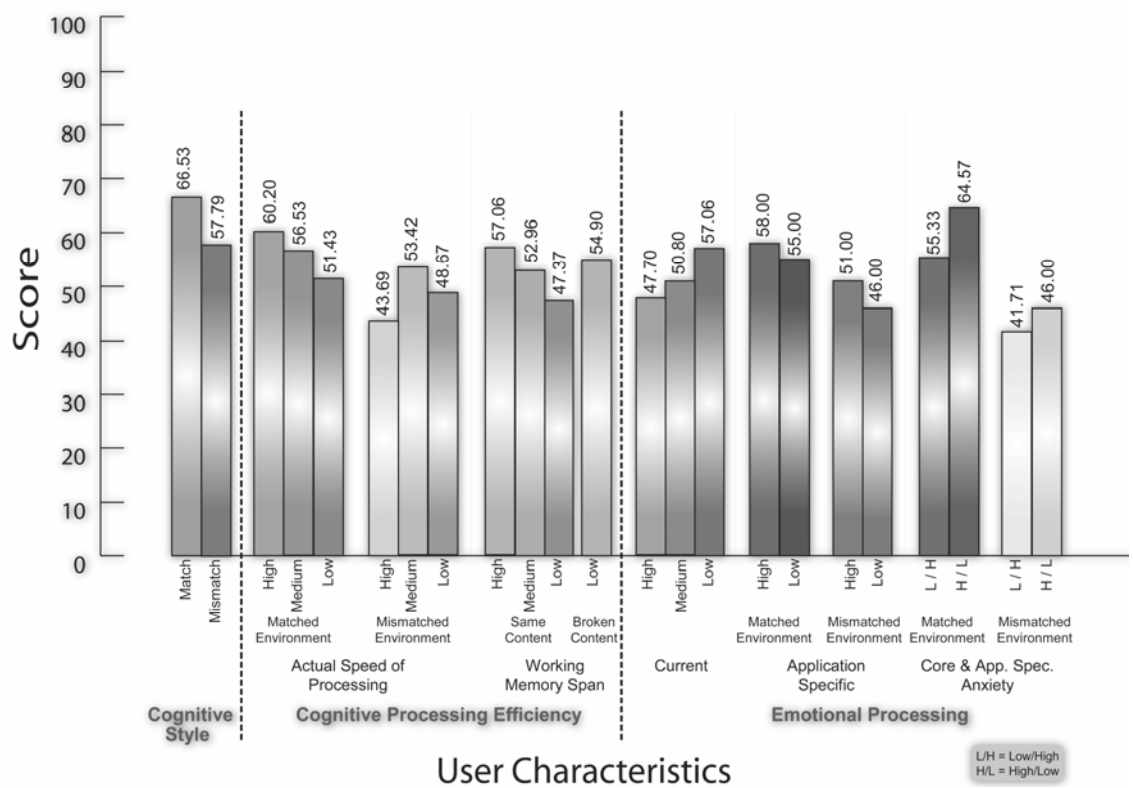

Figure 2. Aggregated differences in matched/mismatch condition

Table 1 shows the differences of means (one way ANOVA) and their statistical significance for the parameters of Cognitive Style, Cognitive Efficiency Speed, and Emotional Processing.

Table 1. Differences of means in the matched/mismatched condition for Cognitive Style and Cognitive Efficiency Speed

	Match Score	Match n	Mismatch Score	Mismatch n	F	Sig.
Cognitive Style	66.53%	53	57.79%	61	6.330	0.013
Cognitive Efficiency Speed	57.00%	41	48.93%	41	5.345	0.023
Emotional Processing	57.91%	23	48.45%	29	4.357	0.042

Moreover, in many cases there is a high correlation between the dimensions of the various factors of the model, validating the psychometric tools that have been used. This fact also demonstrates the effectiveness of incorporating a variety of human factors in Web-based personalized environments.

Finally, emotional processing, and more specifically anxiety, turned out to be an equally important factor; medium levels of anxiety are supportive of increased performance, while aesthetics and extra navigation support helped significantly students that were highly (not extremely though) anxious, always in terms of performance.

4. Future Trends

Future and emerging trends include the further investigation of constraints and challenges arise from the implementation of such issues on mobile devices and channels; study on the structure of the metadata coming from the providers' side, aiming to construct a Web-based personalization architecture that will serve as an automatic filter adapting the received content based on a comprehensive user profile; the incorporation of physiological measurements of emotions and anxiety in such a model, with the use of biometrical sensors; as well as the use of an eye-tracker device to clarify the role of Visual Attention in Web-based communication environments.

5. Conclusion

Adaptive Hypermedia and Web personalization are two distinct well established areas of research both investigating methods and techniques to move conventional static systems beyond traditional borders to more intelligent, adaptive and personalized implementations. They share a common goal: to alleviate navigational difficulties and satisfy the heterogeneous needs of the user population by adapting according to user specific characteristics. In order to do that, the user profile construction is considered necessary.

The basic objective of this article was to make an extensive reference of a combination of concepts and techniques coming from different research areas, Adaptive Hypermedia and Web personalization, all of which focusing upon the user. It has been attempted to approach the theoretical considerations and technological parameters that can provide the most comprehensive user profile, under a common filtering element (User Perceptual Preference Characteristics), supporting the provision of the most apt and optimized user-centred Web-based result.

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7. Terms and Definitions

Web Personalization: It is the process of tailoring pages to individual users' characteristics and/or preferences. It is a means of meeting the user's needs more effectively and efficiently, making interactions faster and easier and, consequently, increasing user satisfaction and the likelihood of repeat visits.

User Modeling: User modeling is a sub-area of human-computer interaction, in which the researcher / designer develops cognitive models of human users, including modeling of their skills and declarative knowledge. User models can predict human error and learning time.

User Perceptual Preference Characteristics: User Perceptual Preference Characteristics are all the critical factors that influence the visual, mental and emotional processes liable of manipulating the newly information received and building upon prior knowledge, that is different for each user or user group. These characteristics determine the visual attention, cognitive and emotional processing taking place throughout the whole process of accepting an object of perception (stimulus) until the comprehensive response to it.

Visual Processing: It is the sequence of steps that information takes as it flows from visual sensors to cognitive processing.

Cognitive Styles: They are consistent individual differences in preferred ways of organizing and processing information and experience

Cognition: A human-like processing of information, applying knowledge and changing preferences. Cognition or cognitive processes can be natural and artificial, conscious and not conscious; therefore, they are analyzed from different perspectives and in different contexts, in anesthesia, neurology, psychology, philosophy, systemics and computer science.

Emotional Intelligence: It describes an ability, capacity, or skill to perceive, assess, and manage the emotions of one's self, of others, and of groups.