HUMAN FACTORS AS A PARAMETER FOR IMPROVING INTERFACE USABILITY AND USER SATISFACTION

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Abstract

The endeavour to optimize HCI should integrate a wide array of user characteristics that have an effect throughout users' interactions with a system. Human factors such as cognitive traits and current state, from a psychological point of view, are undoubtedly significant in the shaping of the perceived and objective quality of interactions with a system. The research that is presented in this paper focuses on identifying human factors that relate to users' performance in Web applications that involve information processing, and a framework of personalization rules that are expected to increase users' performance is depicted. The empirical results that are presented are derived from environments both learning and commercial; in the case of e-learning personalization was beneficial, while the interaction with a commercial site needs to be further investigated due to the implicit character of information processing in the Web.

Keywords: User profile, Intelligent user interfaces, Individual differences, Context awareness, Cognitive processing, Emotional processing, Personalization, Adaptive hypermedia, E-services, HCI.

1 INTRODUCTION

In recent years, the main research focus of Human Computer Interaction (HCI), as well as of Web personalization and Adaptation, communities has been placed on extruding information about the user, which can be proven of significant importance in enhancing the quality of HCI, with emphasis placed upon cognitive and emotional characteristics. In our approach, the term cognitive describes systemic functions of the mind that are involved in information perception and processing, whilst emotional parameters refer to the arousal of emotions that affect the learning (as a process) performance, combined with the moderating role of emotional intelligence and skills. The clarification and the weighting of the effect of these human factors could provide extended insights to personalization systems and intelligent user interfaces. In addition, the semantic enhancement of both user profile and services content are expected to increase the quality of eServices, delivered in an optimized manner.

This related semantic information, which actually is the basis of user profiling, provides adequate feedback to an adaptive system that personalizes the Web environment provided to the user according to his preferences or abilities- the context at an intrinsic level that is. This approach and the proposed user model of information processing characteristics also may have a modular role in a context aware computer-mediated system, along with other parameters that compose the broader concept of context.

Moreover, even if such a perspective may seem theoretically viable, we nevertheless consider that its validity may be objectively and empirically measured, in the sense that users are either benefited or not by introducing their intrinsic characteristics as interface design related information. This empirical validation is the backbone of this paper, in an effort to elucidate if a certain set of application design guidelines may gradually be developed. Addressing the issue of HCI design, it would be of high practical value to explore new ways of translating theories from the field of social sciences and psychology into apt design rules.

One of the key issues is nevertheless the notion of adaptivity that allows the meaningful use of context related information in the area of individual differences. The function of adaptivity may as well be considered as a level of intelligence embedded in a Web environment, regardless of whether users' or interface/technical characteristics are involved. A certain form of mapping rules and corresponding implications on the information space are required, in order for a system to alter visible to the user aspects of the environment, utilizing in our case the intrinsic context information. Therefore, a serious analysis of user requirements and characteristics has to be undertaken, documented and examined, taking into consideration their multi-application to the various delivery channels and devices.

To be more specific about users' requirements (characteristics, abilities and preferences), our psychometrically based research focuses on user cognitive and emotional characteristics that have an effect on real-time information processing. We consequently approach the issue of HCI from the perspective of the psychology of individual differences, aiming to maximize the performance of users within information distributing Web environments, by personalizing on the basis of their needs. This is somehow related to previous work on adaptive hypermedia, mainly educational, where learners' characteristics are the motivating factor of a personalization mechanism (Papanikolaou et al., 2003; Carver et al., 1999; Gilbert et al., 2000).

Within this framework, we are in the process of building, evaluating and validating a user profiling model that could be applied in various Web-based settings, since our first efforts in the field of educational applications have been fruitful (Germanakos et al., 2007a; Germanakos et al., 2007b) the generalization of this perspective of context that focuses on users regardless of application specific aims would much contribute to a coherent theory of information processing in the Web.

2 THEORETICAL BACKGROUND – USABILITY AND VISIBILITY DESIGN PRINCIPLES

Knowledge of human cognitive and perceptual capabilities has provided a solid ground for formulating principles and guidelines for designing usable and pleasant computer-mediated applications that will increase user performance, with regards to assimilation of the targeted information, and satisfaction during interaction time.

According to Ottersten and Berndtsson (Ottersten & Berndtsson, 2002) a common mistake when developing interactive applications is to neglect interaction design. The consequence of not viewing interaction design as an important and controlled process is usually that user interfaces become a reflection of the underlying technological architecture, hence forcing the user to understand how the system works. Interaction design is sometimes confused with graphic design. Whereas graphic design involves the graphic part of interfaces, the interaction designer works mainly with the behaviour of a system, which is the part that is *not visible*. The purpose of interaction design is to describe the interaction between the application and the user. This involves designing the user interface content, behaviour and presentation in a way that pleases the user. Usability goals are central for interaction design. Norman (Norman, 2002) describes the most common usability design guidelines. These are briefly related to:

- *Visibility*: Important and frequently used functions should always be easy to find. In fact, with visible functions the user is more likely to understand what to do next when interacting with an object or a system;
- *Feedback*: After an action, the user wants to know the effect of this action. Informing the user of this effect is feedback. Without feedback in our daily life, it would be almost impossible to carry out the simplest of tasks;
- *Constraints*: Taking advantage of constraints in design means restricting the actions that can be executed by the user;
- *Mapping*: Mapping refers to a relationship between a control and the effects of using that control. Norman (2002) discusses *natural mapping* which means using physical analogies and cultural standards in design.
- *Consistency*: Consistency refers to keeping related operations for achieving related tasks.
- *Affordances*: Affordances are the properties of an object that give an indication of its operations.

Whereas the design principles described by Norman keep focus on usability, Mullet and Sano (Mullet et al., 1995) discuss communication oriented visual principles and techniques. These techniques are based on psychological phenomena and functional aesthetics found in graphic design, industrial design and architecture. The most predominant visual principles are:

- *Elegance and simplicity*: The meaning of elegance is to carefully select elements in a design with conscious decision. Simplicity involves solving a design problem in a clear and economical manner. Being strongly related it is no coincidence that both elegance and simplicity are evident in practically every timeless design. In fact, the simplicity of an elegant solution is usually striking. Simplicity is also a design principle that many other principles depend on. Thus, to increase quality of design, conceptual and formal components must be reduced to a minimum.
- *Scale, contrast and proportion*: To create harmonious designs a good relationship between scale, contrast and proportion must be accomplished. These aspects are some of the subtlest in design and they require practice. The design will always suffer if elements are too big or small, too light or dark, too prominent or indistinct. Scale refers to the size of an element relative the whole composition and other elements. Contrast is the provider of visual distinctions in the form of position, shape, texture, size, colour, orientation and movement. Both scale and contrast can be used to emphasize and differentiate elements from each other. Proportion involves balance and harmony of relations between elements. Techniques for accomplishing harmonious designs are establishing perceptual layers, sharpening visual distinctions and integrating figure and ground.
- *Organization and visual structure*: Keeping elements in a design organized and structured help the user in finding guidance to interaction. The perception of structure happens automatically and is

usually one of the first impressions of a product. Hence, the structure can either support or disrupt interaction. Without good organization the content may very well be difficult to interpret and understand. Users will however always try to find structure even where it's not obvious. Organization and structure in interfaces can be accomplished by grouping related elements followed by the establishing of a hierarchy based on importance. The composition must also be kept balanced and revealing the relationships between elements.

- *Image and representation*: Being essential for communication, images are often an obvious element of GUI (Graphical User Interface) design. Despite this fact, imagery is one of the least understood aspects of interfaces. First, images must follow the same principles as the whole composition and second, they must be perceptually immediate to be recognized at once. Images must also be sensitive to the conceptual, physical and cultural context in which they will be displayed. Representation is used to give a GUI meaning. The analysis of representations depends on the relationship between the representamen and its object. Three forms of this relationship can be identified; an icon, which relates to the object by resemblance, an index, which is an association not based on resemblance and a symbol, which relates to the object by convention.

3 THE PROPOSED THREE-DIMENSIONAL COGNITIVE MODEL

Preece, Rogers and Sharp (Preece, 2002) describe how usability can be broken down to a set of *usability goals*, which are: effectiveness, efficiency, safety, utility, learnability and memorability.

Our proposed perspective that focuses on user profiling includes cognitive and emotional processes that could be described as User Perceptual Preference Characteristics (UPPC); the aim of constructing such a user model is to enhance information learning efficacy by personalizing the Web content and therefore increasing user usability and satisfaction.

This approach aims to satisfy the abovementioned criteria of usability, with the exclusion of safety. Certainly, considering that the focus is on cognitive processes, the most dominate effect is expected on learnability and memorability, and efficiency, effectiveness and utility should be achieved through the enhancement of the former constructs.

UPPC could be described as a continuous mental process, which starts with the perception of an object in the user's attentional visual field, and involves a number of cognitive and emotional processes that lead to the actual response to that stimulus (Germanakos et al., 2005).

The primary parameters of this model, which has been extensively discussed in previous work of authors (Germanakos et al., 2008a; Germanakos et al., 2007a), formulate a three-dimensional approach to the problem. The first dimension investigates the visual and cognitive processing of the users (Cassidy, 2000; Demetriou et al, 1993) and the working memory span (Baddeley, 2000; Loggie, 1990); the second their cognitive style, favoring amongst the numerous proposed cognitive style typologies (Cassidy, 2000; Kolb & Kolb, 2000; MyersBriggs, 1998), Riding's Cognitive Style Analysis (Riding, 2001); while the third captures their emotional processing mechanism during the interaction with the information space. 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 in which an individual is perceiving and controlling his emotions. We focus on these two sub-processes because they are easily generalized, inclusive and provide some indirect measurement of general emotional mechanisms. These sub-processes manage a number of emotional factors like anxiety boredom effects, anger, feelings of self efficacy, user satisfaction etc. Among these, our current research concerning emotional arousal emphasizes on anxiety (Kim & Gorman, 2005; Barlow, 2002), which is probably the most indicative, while other emotional factors are to be examined within the context of a further study.

3.1 System Design Implications

For a better understanding of the three dimensions' implications and the UPPC model as well as their relation with the information space a diagram that presents a high level correlation of these implications with selected tags of the information space (a code used in Web languages to define a format change or hypertext link) is depicted in Figure 1 (Germanakos et al., 2007a; Germanakos et al., 2007b).

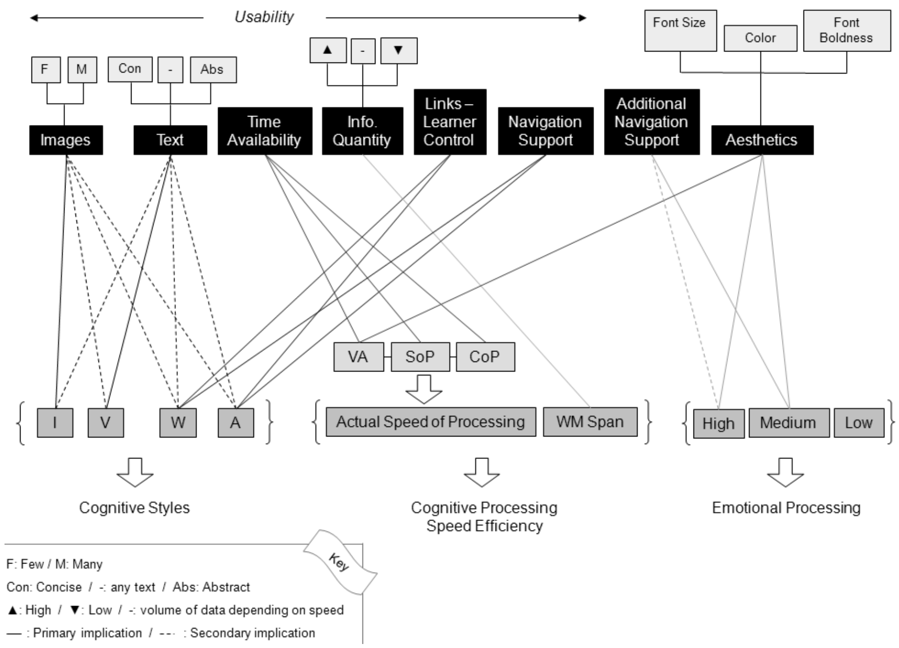

Figure 1. Data – Implications Correlation Diagram

These tags (images, text, information quantity, links - learner control, navigation support, additional navigation support, and aesthetics) have gone through an extensive optimization representing group of data affected after the mapping with the theoretical implications. The main reason we have selected the latter tags is due to the fact that represent the primary subsidiaries of a Web-based content. With the necessary processing, mapping and / or alteration we could provide the same content with different ways (according to a specific user's profile) but without degrading the message conveyed.

The particular mapping is based on specific rules created, liable for the combination of these tags and the variation of their value in order to better filter the raw content and deliver the most personalized Web-based result to the user. As it can be observed from the diagram above each dimension, based on theory, has primary (solid line) and secondary (dashed line) implications on the information space altering dynamically the weight of the tags.

Henceforth, with regards to the cognitive style (CS) (imager(I)/verbalizer(V), wholist(W)/analyst(A)), the number of images (few or many) for example to be displayed has a primary implication on imagers, while text (more concise or abstract) has a secondary implication. An analyst may affect primarily the links - learner control and navigation support tag, while might secondary affect the number of images or kind of text to be displayed, consequently. Cognitive processing speed efficiency (CPSE), which is composed of the actual speed of processing parameters (visual attention (VA), speed of processing (SoP), and control of processing(CoP)) as well as working memory span (WMS), is primarily affecting information quantity. Eventually, emotional processing (EP) is primarily affecting aesthetics, as visual attention does, while secondary affects additional navigation support. An example of the content reconstruction based on the UPPC of a particular user and the imminent aforementioned implications is shown in Figure 2.

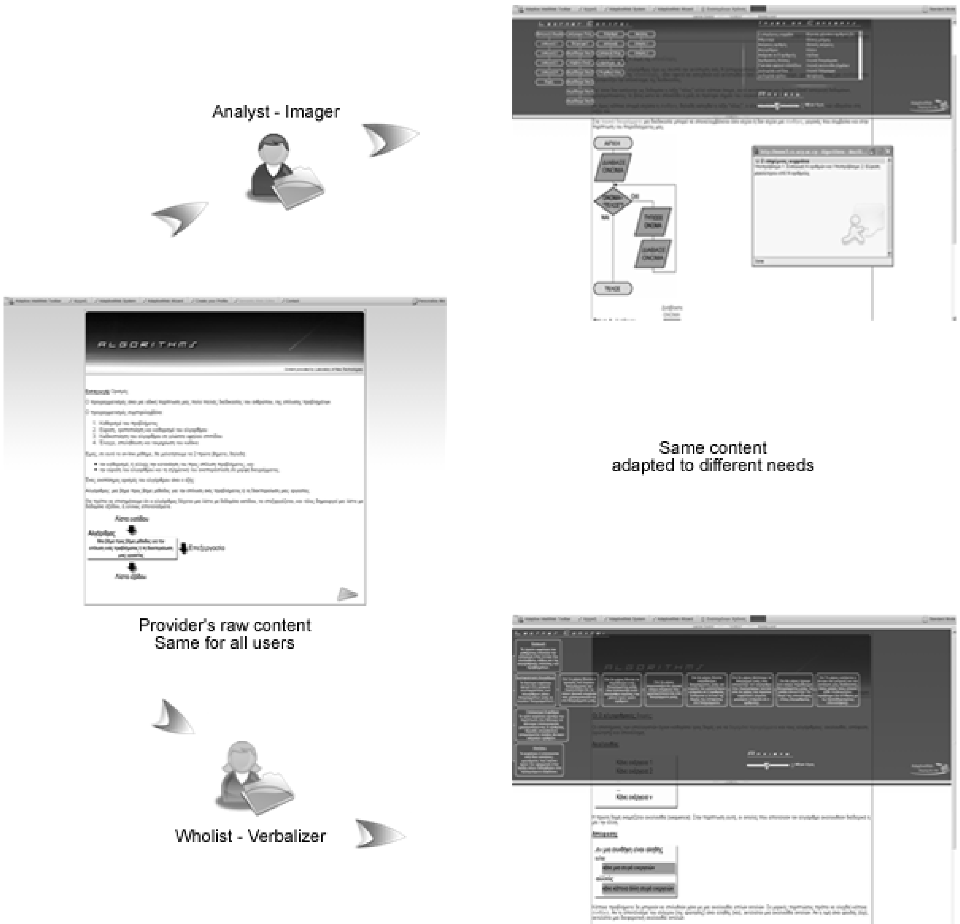

Figure 2. Content adaptation according to user's comprehensive profile

Additionally, since emotional processing is the most dynamic parameter compared to the others, any changes occurring at any given time are directly affecting the yielded value of the adaptation and personalization rules and henceforth the format of the content delivered.

Based on the abovementioned considerations an adaptive Web-based environment has been developed, trying to convey the essence and the peculiarities encapsulated. The current system, AdaptiveWeb[1] is a Web application that can be ported both to desktop computer and mobile devices. It is composed of four interrelated components, each one representing a stand-alone Web-based system (Germanakos et al., 2008b; Germanakos et al., 2007b; Germanakos et al., 2007c). All the tests implemented at this stage, to prove components efficiency as well as the effect of our cognitive three-dimensional model described above into the Web, have been based on predetermined online contents in the field of eLearning and eCommerce multimedia environments respectively. The current system has been evaluated both at system's response time performance and resources consumption, as well as with regards to users' learning performance and satisfaction, with really encouraging results as it is described into the following two sections.

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

4 EMPIRICAL EVALUATION OF THE PROPOSED MODEL IN AN EDUCATIONAL ENVIRONMENT

Due to the fact that there is an increased interest on distant education via the Web, we have decided to implement the first phase of our experiments in an e-Learning environment, with the corresponding characteristics and constraints imposed by its nature. In this case, we were able to control factors such as previous knowledge and experience over distributed information, as well as the given interaction time of the users with the system, since learning in the context of a specific course is a far more controlled condition than Web browsing.

This section presents the results from experiments that were conducted in the context of an educational Web-setting, which support our approach in terms of optimizing users' performance in the sense of information comprehension.

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. 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 undergraduate course on algorithms. The course subject was chosen due to the fact that students of the departments where the experiment took place had absolutely no experience of computer science, and traditionally perform poorly. By controlling the factor of experience in that way, we divided our sample of the first phase in two groups: almost half of the participants were provided with information matched to their cognitive style, while the other half were taught in a mismatched way. In the second phase, the sample was divided in six, with a matched and mismatched condition for each factor. We expected that users in the matched condition, both in phase I and phase II, would outperform those in the mismatched condition.

In order to evaluate the effect of matched and mismatched conditions, participants took an online assessment test on the subject they were taught (algorithms). This exam was taken 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.

At this point, it should be clarified that matching and mismatching instructional style is a process with different implications for each dimension of our model. These are described below:

- *Matched CS:* Presentation and structure of information matches user's preference
- *Mismatched CS:* Presentation and structure of information does not coincide with user's preference
- *Matched WMS:* Low WMS users are provided with segmented information
- *Mismatched WMS:* Low WMS users are provided with the whole information
- *Matched CPSE:* Each user has in his disposal the amount of time that fits his ability
- *Mismatched CPSE:* Users' with low speed of processing have less time in their disposal (the same with "medium" users
- *Matched EP:* Users with moderate and high levels of anxiety receive aesthetic enhancement of the content and navigational help
- *Mismatched EP:* Users with moderate and high levels of anxiety receive no additional help or aesthetics

4.2 Questionnaires

In this specific e-learning setting, Users' Perceptual Preferences were the sole parameters that comprised each user profile, since demographics and device characteristics were controlled for. In order to build each user profile according to our model, we used a number of questionnaires that address all theories involved.

- *Cognitive Style:* Riding's Cognitive Style Analysis, standardized in Greek and integrated in .NET platform
- *Cognitive Processing Speed Efficiency:* Speed and accuracy task-based tests that assess control of processing, speed of processing, visual attention and visuospatial working memory. Originally developed in the E-prime platform, we integrated them into the .NET platform.
- *Core (general) Anxiety:* Spielberger's State-Trait Anxiety Inventory (STAI) – 10 items (Only the trait scale was used).
- *Application Specific Anxiety:* Cassady's Cognitive Test Anxiety scale – 27 items (Cassady, 2004).
- *Current Anxiety:* Self-reported measures of state anxiety taken during the assessment phase of the experiment, in time slots of every 10 minutes – 6 Time slots.
- *Emotion Regulation:* This questionnaire was developed by us; cronbach's α that indicates scale reliability reaches 0.718.

4.3 Results

As expected, in both experiments the matched condition group outperformed those of the mismatched group (Tsianos et al., 2007; Tsianos et al., 2008a). Table 1 shows the differences of means (one way ANOVA) and their statistical significance for the parameters of cognitive style, cognitive processing speed efficiency, and emotional processing.

As hypothesized, the mean score of those that received matched to their cognitive style environments is higher than the mean score achieved by those that learned within the mismatched condition ($F_{(2,113)}$=6.330, p=0.013). This supports the notion that cognitive style is of importance within the context of Web-education and that this construct has a practical application in hypermedia instruction. The same applies with the case of CPSE: $F_{(2, 81)}$=5.345, p=0.023). It should at least be of some consideration the fact that in case designers' teaching style mismatched learners' preference, performance may be lowered.

In the case of EP, results show that in case an individual reports high levels of anxiety either at the core anxiety or the specific anxiety questionnaire, the matched condition benefits his/her performance ($F_{(2, 81)}$=4.357, p=0.042) (Lekkas et al., 2008).

	Match Score	Match n	Mis-match Score	Mis-match n	F	Sig.
CS	66.53%	53	57.79%	61	6.330	**0.013**
CPSE	57.00%	41	48.93%	41	5.345	**0.023**
EP	57.91%	23	48.45%	29	4.357	**0.042**

Table 1. Differences of means for Cognitive Style and Cognitive Processing Speed Efficiency

The relatively small sample that falls into each category and its distribution hamper statistical analysis of the working memory span parameter.

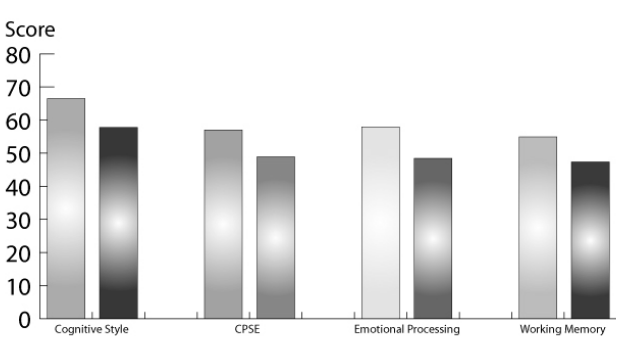

Figure 3. Differences of matched and mismatched condition regarding each personalization parameter

In any case, the difference between those with high WMS and those with low WMS, when both categories receive non-segmented (whole) content, approaches statistical significance: 57.06% for those with High WMS, 47.37% for those with low WMS, Welch statistic= 3.988, p=0.054.

This demonstrates that WMS has indeed some effect on an e-learning environment. Moreover, if those with low WMS receive segmented information, then the difference of means decreases and becomes non-significant (57.06% for High WM, 54.90% for those with low WMS, Welch statistic=0.165, p=0.687).

All the aforementioned differences between the matched and the mismatched condition are illustrated in Figure 3.

5 EXTENDING THE PROPOSED USER MODEL IN GENERIC WEB ENVIRONMENTS

The second phase of our research was to apply our evaluated information processing model in a setting other than educational. For the purposes of such an empirical validation, we created an adaptive version of a commercial site[2], in order to investigate users' possible responses to a personalization process as the (Tsianos et al., 2008b).

At this point we should mention that our methodology in this preliminary study is not yet concrete, since we have no objective dependent variables to indicate users' performance, but only their self-reported levels of satisfaction and a measurement of the amount of time spent for the completion of a set of simple tasks.

5.1 Sampling and Procedure

A between participants experimental design was adopted; almost half of the participants were provided with the original Website, whereas the other half navigated through a personalized version. In order to motivate them to explore the site at a satisfactory level they were asked to perform a set of simple tasks. Specifically, the Web pages they visited in each condition presented a number of laptops, and their tasks were to find information in order to answer a 7 item questionnaire concerning which laptop model is most suitable for a specific use.

The experiment was conducted with a total sample of 144 users; 19 users were excluded from the analysis process since they were considered to have spent insufficient time navigating in the environment they were allocated in. All participants were students from the University of Cyprus; their age varied from 19 to 23, with a mean of 20 years. Approximately 40% were male and 60% female. All of them were quite proficient in the use of the English language, and due to their academic status were familiar with technological issues such as those involved in our study- though since this was a comparative study between two environments, both of these factors were not expected to have a main effect.

After completing the task questionnaire, users were asked to fill in a satisfaction questionnaire[3]. The amount of time that was required for each user to complete the tasks was also measured.

5.2 Personalization Rules

Given the nature of the generic Web structures (other than eLearning) and the experimental constraints we could initially impose, the parameters that constituted each user's profile were cognitive style and working memory span, for this preliminary study. According to these factors, the implications were similar to those described above for the case of the educational setting. The I/V dimension of cognitive style affected the representation of the Web content (pure text or diagrammatical presentation), whilst the

[2]See http://www.sonystyle.com (date extracted: September 19, 2007)
[3] http://www.wammi.com/questionnaire.html

W/A dimension had an effect on the structure of the environment and the number of links. Wholists also had an extra navigational and tabbing tool.

For the case of users with low WMS, instead of segmenting the content (which was already rather clear cut and susceptible to cognitive style differences in terms of structuring the navigational patterns), we provided users with an additional tool that served as an extra buffer for storing information that was considered to be relevant to the tasks involved.

5.3 Preliminary Results

The levels of satisfaction that users reported were identical in both conditions. There was absolutely no difference between the two conditions, as perceived by the users, since their overall mean in a scale from 1 to 5 was 3.2, with very little dispersion.

Even if the personalized environment was rather burdened with personalization tools and was more complicated, users didn't seem to be discouraged; this could be interpreted as positive, presuming of course that in the intrinsic level of information processing there could be some improvement. Still, since there is no objective dependent variable indicating performance in this study, we can only conclude that the extra Web-site features did not have a negative effect on perceived ergonomics and usability.

There were however differences in the amount of time that users spent navigating in the environments before they decided to fill in the task questionnaire. By dividing users in four categories, according to the level of personalization provided or not, statistically significant differences were found. The division was as follows: non-personalized environment for users with low WMS, non-personalized environment for users with normal or high WMS, personalized environment for users with normal or high WMS and personalized environment for users with low WMS; there is some linearity in the sense that the degree of personalization involved increases from the first to the fourth group. Post hoc analysis of variance has shown that there was a difference in navigation time spent between users in the first and the fourth group (see Table 2).

Dependent Variable: time

Tukey HSD

(I) Condition	(J) Condition	Mean Difference (I-J)	Sig.
		Lower Bound	Lower Bound
Personalized/ Low WMS	Personalized	1.29899	.421
	Non-Personalized	1.43759	.372
	Non_ Personalized/ Low WMS	**3.01974(*)**	**.011**
Personalized	Non-Personalized	.13860	.997
	Non_ Personalized/ Low WMS	1.72074	.129
Non-Personalized	Non_ Personalized/ Low WMS	1.58214	.227

* The mean difference is significant at the .05 level.

Table 2: Post hoc analysis of differences between user groups with regards to navigating time

The interpretation of this finding is somehow ambiguous. It perhaps implies that users did indeed make use of the additional tool, and were willing to spend more time navigating in the specific Web-environment. Taking into consideration the fact there were no time limits imposed and users' were free to leave the session whenever they wished to, there could be a positive interpretation of this finding. On the other hand, in the absence of an objective measurement of the quality of information processing, there cannot be any conclusive results extracted.

For the time being, we have found that restructuring a generic Web environment according to users' preferences and altering the typical methods of information representation in the Web does not have a negative effect on users' perceived satisfaction. The next experimental sessions will necessarily include a measurement of accuracy in fulfilling the tasks, in order to examine the depth of comprehension that was achieved in both conditions (personalized vs. non-personalized). Moreover, a within participants experimental design seems more objective, in order to control for elusive confiding variables among different participants.

6 DISCUSSION

Considering the user as a vital part of computer-mediated systems may improve the quality of services offered, especially if the aim is learning or higher order information processing is involved. It makes sense that if one examines the characteristics of a device or the location of the user in providing eServices, the same should be applied with the case of human factors. In the same way that a device has a certain processing ability, individuals differ in their perceptual and processing preferences and abilities. Therefore, it could be supported that an essential part of HCI are the users themselves.

The empirical study on the field of e-learning presented above demonstrates that an "intrinsic" context aware application (in our perspective) is proven helpful for users and an actual benefit is objectively measured. All things considered, such a statistically significant effect that is consistent to the psychological theories supporting it is rather encouraging for the notion of expanding individual differences theories to various research areas.

The case of the Web-environment, on the other hand, yields rather ambiguous results. Users do not seem to distinguish between the personalized and the raw environment in terms of preference, while a specific group of users spent more time navigating within the environment in the personalized condition. That may be positive if the goal is educational or commercial, though in the event of a costly mobile access that might not be desirable.

The next step of our work, besides improving the methodology of our experiments in a commercial Web environment (introducing objective measurements of task accuracy and following a within the subjects experimental approach), is the integration of the remaining parameters of our proposed model as personalization factors in the Web. With regards to emotional processing, we are setting out a research framework that involves the use of sensors and real-time monitoring of emotional arousal (Galvanic Skin Response and Heart Rate). As a matter of fact, the use of sensors is closely related to existing context aware systems research, and as mentioned in the definitions that were referred to in the introduction of this chapter, users' physiological state is also an issue of context.

Thus, describing the user, he/she requires a multi dimensional model of representation, which should incorporate cognitive and emotional characteristics that seem to have a main effect in interacting with applications that involve information processing. It is not argued of course that demographical and "traditional" profiling characteristics are of lesser importance; our proposed model could have a modular role in a setting that defines context in a variety of ways, by adding another dimension focused on intrinsic processes.

In the introductory section of this paper we also mentioned the utter goal of setting a framework of guidelines for HCI that address individual differences. At this point of research, it seems that these differences are indeed important, and the way that theory was put into practice in our system did seem to be functional. There are of course many considerations regarding the generalization of this approach, and further experimental evaluation is required; still, especially within an educational environment, we have clear indications that user's intrinsic characteristics may be used in a meaningful manner.

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