Chapter XVI
Incorporating Human Factors in the Development of Context-Aware Personalized Applications:
The Next Generation of Intelligent User Interfaces

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ABSTRACT

The notion of context in context-aware applications is not merely an issue of external situational circumstances or device/channel properties, but it could also refer to 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, and by defining context in that sense,

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personalization may as well become an essential function of context aware applications. The research that is presented in this chapter 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 environments that empirical results were derived from were 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.

INTRODUCTION

In the spectrum of all parameters that can be considered as the context of context-aware applications, users' intrinsic characteristics should not be disregarded, especially if information processing is involved. Though it seems that this approach is not the predominant in context aware systems research (Korkea-aho, 2000), human factors are by definition a crucial parameter in the shaping of human computer interaction (HCI)—as suggested by the term itself. According to Dey (2001), "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"; Schmidt et al (1999) depict context as a three dimensional construct, including the dimension of self (device state, physiological, cognitive).

In accordance to the aforementioned definitions, our research interests focus 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. 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 new insights to context-aware personalization systems and intelligent user interfaces. In addition, the semantic enhancement of both user profile and services content are expected to increase the effectiveness of eServices, delivered in the best qualitative manner.

This context 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 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 context related information. This empirical validation is the backbone of this chapter, 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 character-

istics 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- though the latter issue of delivery and device context is not part of our research at this point.

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 context 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, Howard, & Lane, 1999; Gilbert & Han, 2002).

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, 2008); 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.

This chapter describes in section 2 the theoretical framework of applications' design guidelines and our proposed model as well as the resultant three-dimensional construct we propose, whereas section 3 illustrates how our adaptive system translates context-related information to personalization rules. Sections 4 and 5 present (a) the methodology that has been applied in order to clarify whether personalization in this context contributes to a significant difference, and (b) the results from two different implementation fields of our model, an educational and a commercial Web environment respectively. Section 6, finally, is comprised of conclusions, future work considerations and discussion.

THEORETICAL BACKGROUND

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

Usability and Visual Design Principles

According to Ottersten and 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 (2002) describes the

most common usability design guidelines. These are briefly related to:

a. *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;
b. *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;
c. *Constraints*: Taking advantage of constraints in design means restricting the actions that can be executed by the user;
d. *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.
e. *Consistency*: Consistency refers to keeping related operations for achieving related tasks.
f. *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 (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:

a. *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. Simplicity itself depends on the principles of *unity, refinement* and *fitness*. Unity involves ensuring that elements are perceived as a coherent whole. Refinement means keeping the users attention on vital properties of the design. Fitness involves assessing the appropriateness of a specific design. Elegance cannot, as simplicity, be reduced to a set of principles, as it often involves taste. Reducing design to its essence however usually enhances elegance, regularizing elements (keeping a predictable a regular pattern) and letting elements have multiple roles.
b. *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.
c. *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.

d. *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.

The Proposed Three-Dimensional Cognitive Model

Preece, Rogers and Sharp (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 of context that focuses on user profiling includes cognitive and emotional processes that could be described as user "perceptual preferences"; 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.

User Perceptual Preferences 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., 2005a).

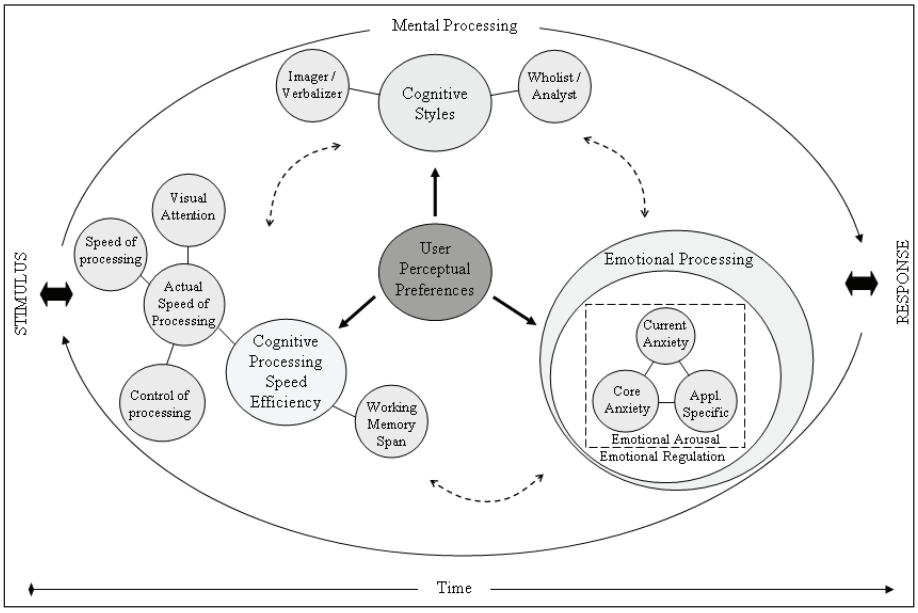
This model's primary parameters formulate a three-dimensional approach to the problem (see Figure 1). The first dimension investigates the visual and cognitive processing of the users, the second their cognitive style, while the third captures their emotional processing mechanism during the interaction with the information space.

Cognitive Processing Speed Efficiency

The cognitive processing parameters (Demetriou, Efklides, & Platsidou, 1993; Demetriou & Kazi, 2001) that constitute the first dimension of our model consist of the:

a. *Actual speed of processing*, that is further composed of the, (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); and (iii) 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 cur-

Figure 1. Three dimensional model of User Perceptual Preferences



rently being processed in working memory and, moreover, that the eye naturally focuses on areas that are most likely to be informative). We measure each individual's ability to perform control/speed of processing and visual attention tasks in the shortest time possible, with a specific error tolerance, while as mentioned the working memory span test focuses on the visuospatial sketch pad sub-component, since all information in the Web is mainly visual.

b. *(Visual) working memory span (VWMS)*, which refers to the processes that enable a person to hold visual information in an active state while integrating it with other information until the current problem is solved. A brief description of the working memory system is that is consisted of the central executive that controls the two slave systems (visuo-spatial sketchpad and phonological loop), plus the episodic buffer that provides a temporary interface between the slave systems and the Long Term Memory (Baddeley, 2000). We are mainly interested in the notion of the working memory span, since it can be measured and the implications on information processing are rather clear. Due to the visual form of presentation in the Web, we have focused especially on the measurement of visual working memory (Logie, Zucco, & Baddeley, 1990) in terms of psychometrics.

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, Fischler, & Dunn, 2003). Amongst the numerous proposed cognitive style typologies (Cassidy, 2004; Kolb & Kolb 2005; MyersBriggs et al, 1998) we favour Riding's Cognitive Style Analysis (Riding, 2001), because we consider 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.

We prefer the construct of cognitive rather than learning style because it is more stable (Sadler-Smith & Riding, 1999), and to the extent that there is a correlation with hemispherical preference and EEG measurements (McKay, Fischler, & Dunn, 2003; Glass & Riding, 1999), the relationship between cognitive style and actual mode of information processing is strengthened.

Emotional Processing

In our study, we are interested in the way that individuals process their emotions and how they interact with other elements of their information-processing system. 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, which is probably the most indicative, while other emotional factors are to be examined within the context of a further study.

Anxiety is an unpleasant combination of emotions that includes fear, worry and uneasiness and is often accompanied by physical reactions such as high blood pressure, increased heart rate and other body signals like shortness of breath, nausea and increased sweating. The anxious person is not able to regulate his emotional state since he feels and expects danger all the time (Kim & Gorman, 2002).

Barlow (2002) describes anxiety as a cognitive-affective process in which the individual has a sense of unpredictability, a feeling of uncertainty and a sense of lack of control over emotions, thoughts and events. This cognitive and affective situation is associated as well with physiological arousal and research has shown that an individual's perception is influenced in specific domains such as attentional span, memory, and performance in specific tasks. In relation to performance, the findings are controversial but there is a strong body of research which supports that anxiety is strongly correlated to performance and academic achievement. (Spielberger, 1972; Spielberger & Vagg, 1995)

Accordingly, in order to measure emotion regulation, we are using the cognominal construct of emotion regulation. An effort to construct a model that predicts the role of emotion, in general, is beyond the scope of our research, due to the complexity and the numerous confounding variables that would make such an attempt rather impossible. However, there is a considerable amount of references concerning the role of emotion and its implications on academic performance (or achievement), in terms of efficient learning (Kort & Reilly, 2002). Emotional intelligence seems to be an adequate predictor of the aforementioned concepts, and is surely a grounded enough construct, already supported by academic literature (Goleman, 1995; Salovey & Mayer, 1990).

Additional concepts that were used are the concepts of self-efficacy, emotional experience and emotional expression. Self-efficacy is defined as people's beliefs about their capabilities to produce and perform. Self-efficacy beliefs determine how people feel, think, motivate themselves and

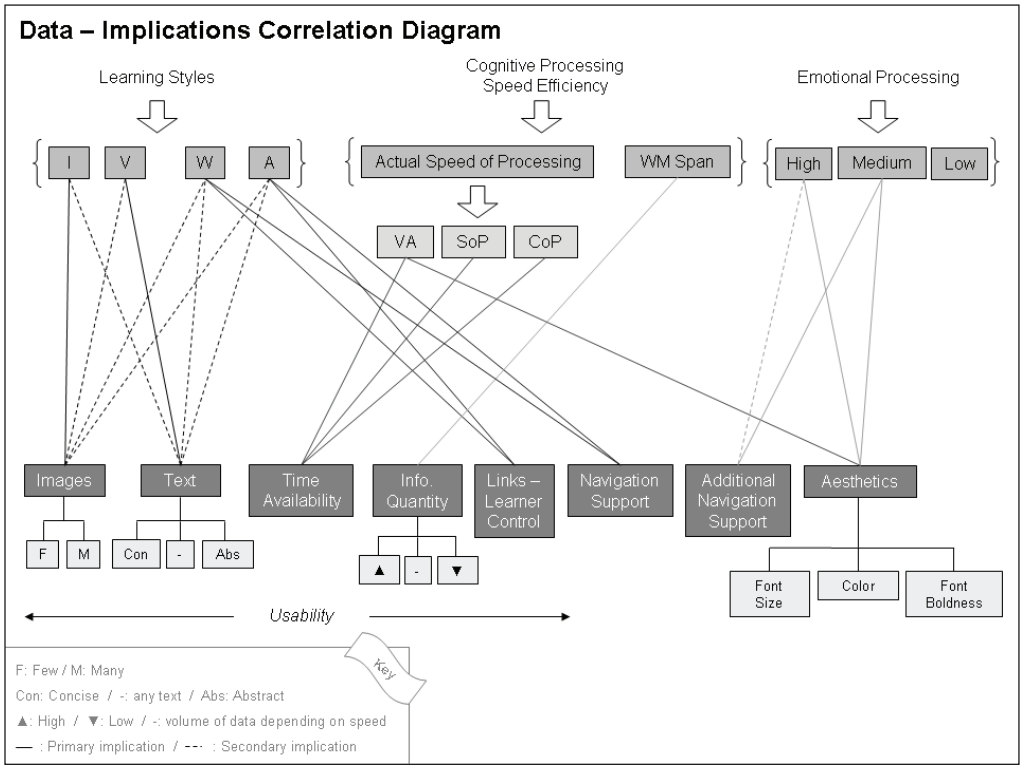
behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective and selection processes. Emotional experience is the conceptualization of an emotion, the way in which the individual is dealing with it and how he perceives it. Emotional expression is the way in which the individual is reacting after an emotion triggers. It is his behaviour after an affective stimulus. It can be argued that emotional expression is the representation of an emotion (Schunk, 1989).

System Design Implications

For a better understanding of the three dimensions' implications and 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 2. 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 implications. The main reason we have selected the latter tags is due to the fact that they represent the primary subsidiaries of a Web based content. With the necessary processing and / or alteration we could provide the same content in different ways (according to a specific user's profile) but without degrading the message conveyed (see Figure 3).

The particular mapping is based on specific rules that are consistent to psychological theory, in order to filter the raw content and deliver the

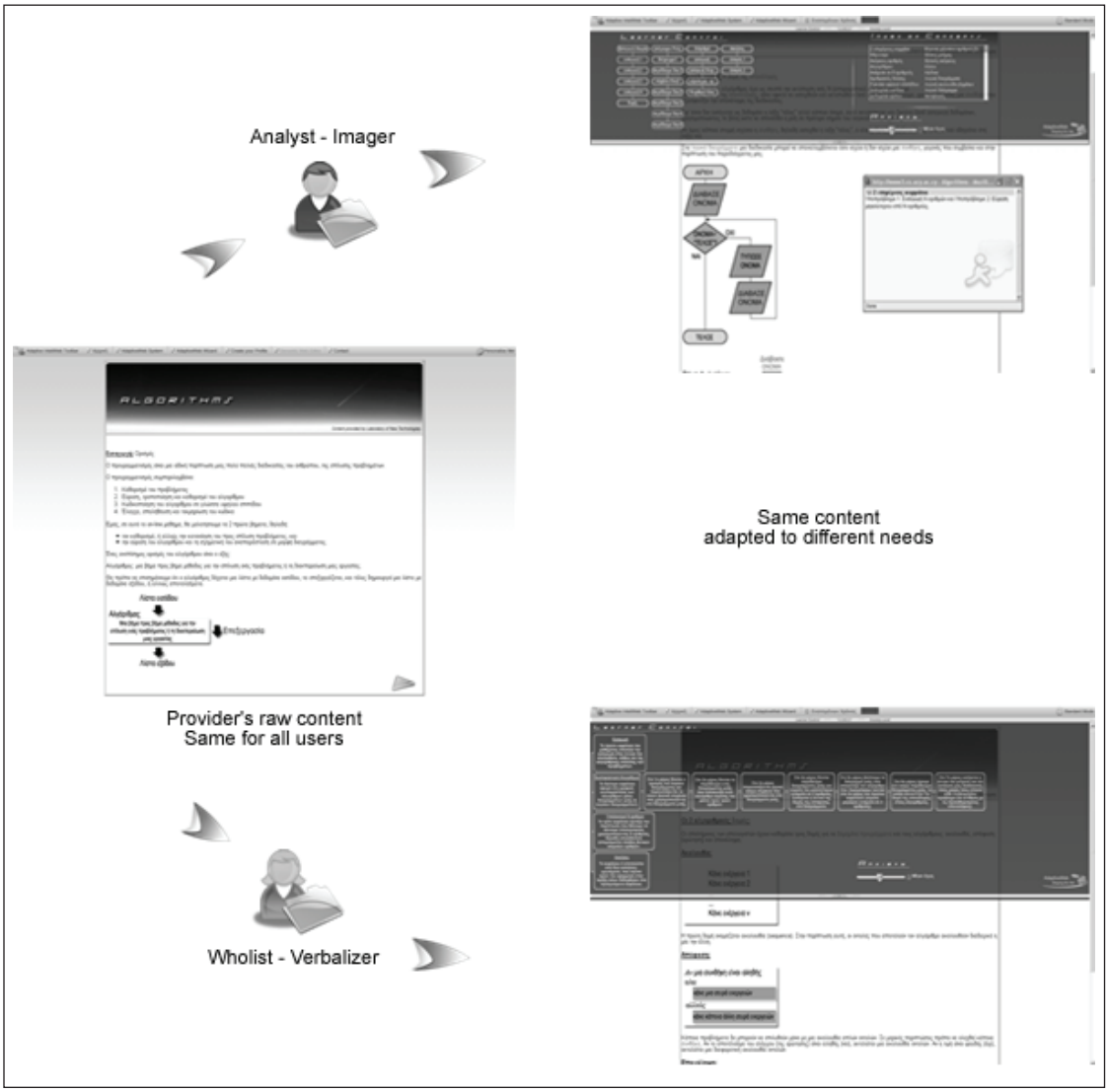
Figure 2. Data – Implications Correlation Diagram



most personalized Web-based result to the user. As it can be observed from the diagram above almost each profiling dimension has primary (solid line) and secondary (dashed line) implications on the information space altering dynamically the weighting of each factor on the creation of the environment.

As mentioned in section 2, Riding's Cognitive Style Analysis has been used in the Cognitive Style dimension, since the CSA applies in a greater number of information processing circumstances, since it deals rather with the broader construct of cognitive, than learning, style. According to theory (see Figure 3), for example, the number of images (few or many) to be displayed has a primary implication on imagers, while text (more concise or abstract) has a secondary implication. The analytic preference has a main effect on the

Figure 3. Content adaptation according to user's comprehensive profile



links (learner control and navigation support tag), which in turn is secondary affected by high and medium levels of emotional processing. Moreover, levels of emotional processing might secondary affect the number of images or the kind of text to be displayed. Actual speed of processing parameters (visual attention, speed of processing, and control of processing) as well as working memory span primarily affect information quantity. Eventually, emotional processing primarily affects the provision of additional navigation support and aesthetics (which is also the case with visual attention), while secondary affects information quantity.

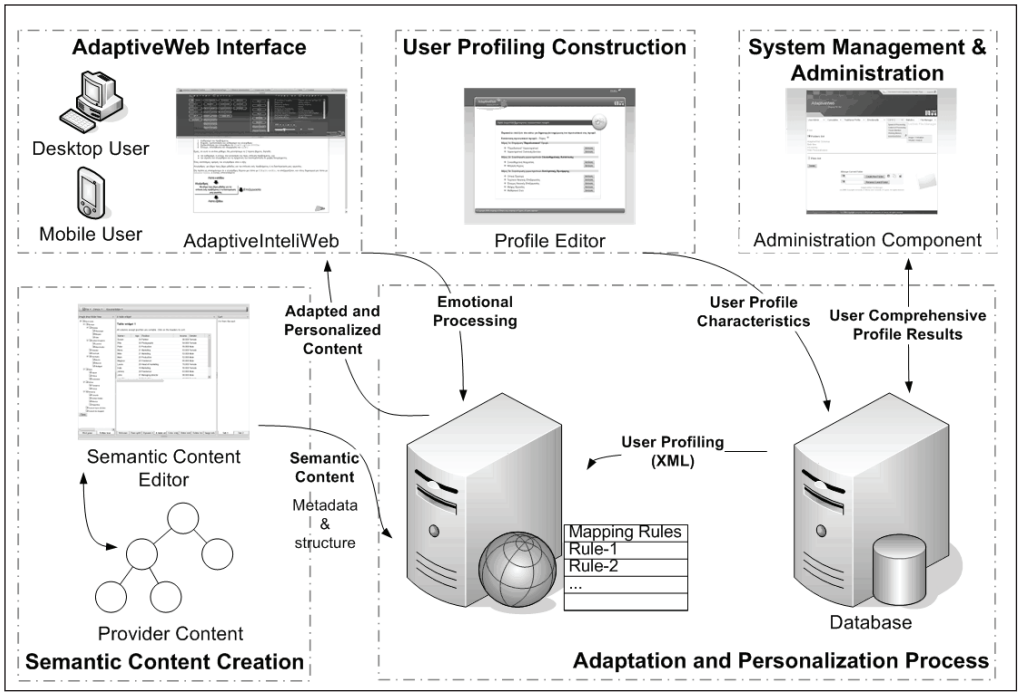
A practical example of the Data – Implications Correlation Diagram could be as follows, a user might be identified that is: Verbalizer (V) – Wholist (W) with regards to the Learning Style, has an Actual Cognitive Processing Speed Efficiency of 1000 msec, and a fair Working Memory Span (weighting 5/7), with regards to his Cognitive Processing Speed Efficiency, and (s)he has a High Emotional processing. The tags affected, according to the rules created and the Data – Implications Correlation Diagram, for this particular instance are the: Images (few images displayed), Text (any text could be delivered), Info Quantity (less info since his cognitive processing speed efficiency is moderate), Links – Learner Control (less learner control because he is Wholist), Additional Navigation Support (significant because he has high emotional processing), and high aesthetics (to give more structured and well defined information, with more colors, larger fonts, more bold text, since he has high emotional processing). At this point it should be mentioned that in case of internal correlation conflicts primary implications take over secondary ones. 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 is overviewed, 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[2], each one representing a stand-alone Web-based system, outlined below (see Figure 4 – Germanakos et al, 2007b; Germanakos et al, 2007c).

1. The *User Profiling Construction* component. The user gives his / her traditional and Device Characteristics and further the component extracts the *User Perceptual Preference Characteristics* by completing a number of real-time tests (attention and cognitive processing efficiency grabbing psychometric tools) as well as answer some questionnaires for generating his / her cumulative profile.
2. The *Semantic Web Editor*. The provider will create his / her own content by defining the content as semantic objects and metadata for describing data and the relation between them.
3. The *Adaptation and Personalization* component. It runs the "mapping rules" process applied to the provider's content according to the user's comprehensive profile.
4. The *AdaptiveWeb User Interface,* AdaptiveInteliWeb. It provides a framework where all personalized Web sites can be navigated. Using this interface the user will navigate through the provider's content (normal and personalized mode), with the necessary learner and navigation support provided based on his / her profile.

The AdaptiveWeb system is currently at its final stage. All the components, except the Semantic Web Editor have been developed and smoothly running. For this reason, all the tests implemented so far, to prove components efficiency as well

Figure 4. AdaptiveWeb system architecture



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.

As it concerns how the AdaptiveWeb system could support mobile applications, it should be considered that the main requirement of providing information "anytime, anywhere and anyhow" is not an easy task. Nevertheless, this adaptable provision of information may be rendered possible through personalization techniques. Such applications should be characterized by flexibility, accessibility, quality and security in a ubiquitous interoperable manner (Germanakos et al, 2005b).

Excluding the issue of security which is not at the scope of our research, user interfaces must be friendlier by a) enabling active involvement (information acquisition), b) giving the control to the user (system controllability), c) providing easy means of navigation and orientation (navigation), d) tolerating users' errors and supporting system-based and context oriented correction of users' errors, and e) finally enabling customization of multi-media and multi-modal user interfaces to particular user needs (De Bra & Nejdl, 2004).

Intelligent techniques have to be implemented in order to enable the development of an open Adaptive Mobile Web (De Bra & Nejdl, 2004), having as fundamental characteristics the directness, high connectivity speed, reliability, availability, context-awareness, broadband connection,

interoperability, transparency and scalability, expandability, effectiveness, efficiency, personalization, security and privacy (Lankhorst et al, 2002; Volokh, 2000).

Specifically, our proposed three-dimensional model by definition addresses users' needs, and aims to provide a friendlier and more flexible user interface in any context-aware environment that involves interaction and information processing. Navigation support and access to information are core elements of our approach at the level of system design; consequently the overall quality of users' experience with mobile applications can be considered as interrelated with the satisfaction of their perceptional needs (UPPC model).

The experiments that are presented in the following sections demonstrate that the factors that are included in the three-dimensional model have a main effect on users' interactions with the information space. Additionally, it is possible to increase the efficiency of these interactions, which also is a key issue in mobile applications. The open architecture of the system and the intelligent techniques that are employed also make possible the integration of the AdaptiveWeb filter into a multi-modal mobile environment that would serve as an application area for future experimentation that could lead to levels of satisfaction and information assimilation similar to those of our already conducted research.

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.

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 Cognitive Style: Presentation and structure of information matches user's preference
- Mismatched Cognitive Style: Presentation and structure of information does not coincide with user's preference
- Matched VWMS: Low VWMS users are provided with segmented information
- Mismatched VWMS: Low VWMS 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 Emotional Processing: Users with moderate and high levels of anxiety receive aesthetic enhancement of the content and navigational help
- Mismatched Emotional Processing: Users with moderate and high levels of anxiety receive no additional help or aesthetics

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.

Results

As expected, in both experiments the matched condition group outperformed those of the mismatched group (Tsianos et al, 2007). Table 1 shows the differences of means (one way ANOVA) and their statistical significance for the parameters of Cognitive Style (CS), Cognitive Processing Speed Efficiency (CPSE), and Emotional Processing (EM).

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 Cognitive Processing Speed Efficiency: $F_{(2, 81)}$=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 Emotional Processing, 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).

The relatively small sample that falls into each category and its distribution hamper statistical analysis of the working memory (WM) parameter. In any case, the difference between those with high WM and those with low WM, when both categories receive non-segmented (whole) content, approaches statistical significance: 57.06% for those with High WM, 47.37% for those with Low WM, Welch statistic= 3.988, p=0.054.

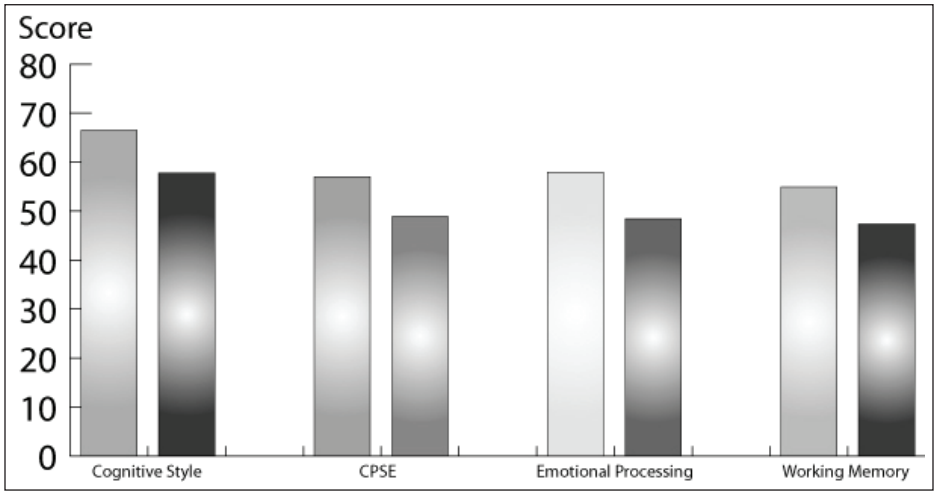
This demonstrates that WM has indeed some effect on an e-learning environment. Moreover, if those with low WM receive segmented information, then the difference of means decreases and becomes non-significant (57.06% for High WM, 54.90% for those with Low WM, Welch statistic=0.165, p=0.687).

All the aforementioned differences between the matched and the mismatched condition are illustrated in Figure 5.

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

	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

Figure 5. Differences of matched and mismatched condition regarding each personalization parameter



Correlations and Statistics of Emotional Processing Constructs

The emotional processing factor is discussed further due to the fact that it can be applied in various environments that relate to performance but do not require extended use of cognitive resources.

It is observed in table 2 that all types of anxiety are positively correlated with each other and are negatively correlated with emotion regulation. These findings support our hypothesis and it can be argued that our theory concerning the relationship between anxiety and regulation has a logical meaning (Lekkas et al, 2008). In tables 3 and 4 we can see an even stronger relationship between emotion regulation and core and specific anxiety respectively. A statistically significant analysis of variance for each anxiety type shows that if we categorize the participants according to their emotional regulation ability, then the anxiety means vary significantly with the high regulation group scoring much higher than the low one. Finally, in table 5 we can see that the two conditions (matched aesthetics/mismatched aesthetics) are differentiating the sample significantly always in relation with performance. Participants in the matched category scored higher than the ones in the mismatched and additionally lower anxious (core or specific or both) scored higher than high anxious, always of course in relation to match/mismatch factor.

Table 2. Correlations of types of anxiety and emotion regulation

	Core Anxiety	Application Specific Anxiety	Current Anxiety	Emotion Regulation
Core Anxiety	1	.613(**)	.288(**)	-.569(**)
Application Specific Anxiety	.613(**)	1	.501(**)	-.471(**)
Current Anxiety	.288(**)	.501(**)	1	-.094
Emotion Regulation	-.569(**)	-.471(**)	-.094	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 3. Analysis of variance between emotion regulation groups and core anxiety means

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.316	2	2.158	18.554	.000
Within Groups	10.700	92	.116		
Total	15.015	94			

Table 4. Analysis of variance between emotion regulation groups and specific anxiety means

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.345	2	4.173	15.226	.000
Within Groups	25.213	92	.274		
Total	33.558	94			

Table 5. Multifactorial ANOVA (Factors—Core Anxiety, Application Specific Anxiety and Aesthetics)

Dependent Variable: Score %

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
	(a)				
Matched Aesthetics	1097.361	1	1097.361	4.238	.043
core_groups * specific_groups* Matched Aesthetics	983.259	1	983.259	3.797	.055

(a) R Squared = .102 (Adjusted R Squared = .017)

We also found that participants with low application specific anxiety perform better than participants with high specific anxiety in both matched and mismatched environments. Additionally, In categories that a certain amount of anxiety exists, match-mismatch factor is extremely important for user performance. Participants with matched environments scored highly while participants with mismatched environments had poor performance. Emotion regulation is negatively correlated with current anxiety. High emotion regulation means low current anxiety and low emotion regulation means high current anxiety. Finally, current anxiety is indicative of performance. High current anxiety means test scores below average while low current anxiety means high scores.

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[3], in order to investigate users' possible responses to a personalization process as the aforementioned.

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.

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.[4] The amount of time that was required for each user to complete the tasks was also measured.

Personalization Rules

For this preliminary study, the parameters that constituted each user's profile were cognitive style and visual working memory span (VWMS). According to these factors, the implications were similar to those described above for the case of the educational setting. The imager/verbalizer dimension of cognitive style affected the representation of the Web content (pure text or diagrammatical presentation), whilst the holist/analyst dimension had an effect on the structure of the environment and the number of links. Holists also had an extra navigational and tabbing tool.

For the case of users with low VWMS, 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.

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

Table 6. Post hoc analysis of differences between user groups with regards to navigating time

Dependent Variable: timeTukey HSD

(I) matched	(J) matched	Mean Difference (I-J)	Std. Error	Sig.
pers_low	pers	1.29899	.84696	.421
	raw	1.43759	.88778	.372
	raw_low	**3.01974(*)**	.95669	**.011**
pers	pers_low	-1.29899	.84696	.421
	raw	.13860	.69557	.997
	raw_low	1.72074	.78162	.129
raw	pers_low	-1.43759	.88778	.372
	pers	-.13860	.69557	.997
	raw_low	1.58214	.82567	.227
raw_low	pers_low	**-3.01974(*)**	.95669	**.011**
	pers	-1.72074	.78162	.129
	raw	-1.58214	.82567	.227

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

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 visual working memory span (VWMS), non-personalized environment for users with normal or high VWMS, personalized environment for users with normal or high VWMS and personalized environment for users with low VWMS; 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 6).

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-raw). Moreover, a within participants experimental design seems more objective, in order to control for elusive confiding variables among different participants.

DISCUSSION

Considering the user as a vital part of what is considered as context in HCI 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 context aware services, 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 context 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), 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 as context 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 chapter we also mentioned the utter goal of setting a framework of guidelines 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 context related information such as user's intrinsic characteristics may be used in a meaningful manner.

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ENDNOTES

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

2 The technology used to build each Web system's component is ASP .Net (http://asp.net)

[3] http://www.sonystyle.com/Webapp/wcs/stores/servlet/CategoryDisplay?catalogId=10551&storeId=10151&langId=-1&categoryId=8198552921644507782&parentCategoryId=16154

[4] http://www.wammi.com/questionnaire.html