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Affective interfaces: a conceptual framework of emotional design at mobile routing applications

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Abstract

Humans perceive reality in, at least two ways; one is emotional (intuitive and experiential), and the other is rational (analytical and cognitive). Therefore, the emotional or affective design has become a hot topic in applications' design, as well as in human factors. Nowadays, the success of an application requires understanding what the users want and prioritize their needs since when the designers understand the user in depth, they can implement small changes in design that have a significant impact on users' experience (UX). The current paper presents the conceptual framework of an affective design process that allows understanding users' affective needs. The primary purpose is to build a conceptual model for application interface design, to uncover and document user emotional needs. The primary purpose of this framework is to prompt the designer to consider both affective and functional requirements of the user when conceptualizing the design of the application.

Keywords: Affective design, User Experience, User Interface

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1. Introduction

People have unspoken needs, which can be revealed by exploring their emotions. The logic of emotion is how it deals with the urges, instincts, and requirements people have, by creating a mental connection with the limbic system. Therefore, incorporating emotion into applications' design has become an essential strategy for increasing competitiveness in the consumer market (Chang and Wu, 2007). The emotional or affective design has become a hot topic under discussion in applications' design, as well as in human factors (Helander and Khalid, 2007). Nowadays designers have started to expand the emotional approach, by incorporating it to their designs, trying to utilize affective design parameters, especially through semantics. This semantic approach implies that each designed object has a meaning that goes beyond its functional requirements (Krippendorff, 2006), a recognition that emotions are essential for design (Norman, 200).

However, affective design has many barriers. First of all, it requires that the designer understands and knows how to implement the affective design components. Additionally, it demands to develop a mechanism to understand the source of these emotions and try to predict their connections with the design features for each user. Applications today, are designed considering the maximization of utility, covering in such a way only some of the users' needs. But, besides usability and functionality, emotion is equally crucial in application development.

From the literature, we can see that affective user needs can be captured using various concepts. The most used ones are the Kansei and the Citarasa methodologies. Kansei Engineering techniques support emotional product design by linking customer needs mathematically to the technical characteristics of the product (Birge, 2003). Citarasa, on the other hand, expresses the emotional intent, needs, and taste of the user. Unfortunately, affective elements are challenging to identify. They vary over time, and users often have difficulties in explaining what their conditions are. They may say "I like it" which is a statement with a very high level of abstraction and not useful for design. We need to break down to lower levels of abstraction, where design elements can be identified such as preferred shape, color, font, and so forth (Helander et al., 2007).

In the current study, a users' survey is being structured that would allow us to understand users' affective needs for routing mobile applications. The primary purpose was to uncover and document user emotional needs, intending to use the data in building a conceptual model for application interface design. This framework is intended for use by application designers, in particular, and by marketing, sales, and engineering design, in general.

2. Affective design

1.1 The need for personalization

Referring to User interfaces (UI) as being part of the information design of an application, we could say that a complete UI is comprised by an interdisciplinary approach that includes of document design, typography, human factors, technical communication, ethnography, linguistics, graphic design, architecture, instructional design, library science, and most recently emotional design (Albers, 2003). However, as Albers notes at his "Content and Complexity: Information Design in Technical Communication" the "proportions which each underlying discipline contributes widely and tends to be apparent in any individual definition." So, to which extend each UI component is significant is different for each individual, so it is personalized.

Despite the variety of its components, a good UI, as historically understood, is fundamentally about making information more manageable for users to understand, where user speed, efficiency and accuracy expedience define "easy". So, users' needs and emotions is a key factor in software product success, when interacting with an application (Väänänen et al., 2008). This success requires to understand what the users really want and prioritize their needs since when the designers understand the user, they can understand how small changes in design can have a significant impact on users' experience (UX).

The first step towards a more profound understanding of users is to visualize their attitudes and behaviours in an empathy map. Empathy is a critical part of the human-centred design. Empathy has been employed as a defining characteristic of designer-user relationships when the design is concerned with user experience entails (Wright and Mccarthy, 2008). Traditional empathy map from Mathews is split into four quadrants (Says, Thinks, Does, and Feels), with the user or persona in the middle. After, Bland (2012) improved the empathy map by including

Pain and Gain areas. As a result, the empathy map consists of six areas: (a) See – what the user sees in his/ her environment; (b) Say and Do – what the user says and how s/he behaves in public; (c) Think and Feel– what happens in the user's mind; (d) Hear –how the environment influences the user; (e) Pain– the frustrations, pitfalls, and risks that the user experiences, and (f) Gain –what the user really wants and what can be done to achieve one's goals. Empathy maps provide a glance into who a user is as a whole, by helping the team members understand the user's mindset and allows capturing and using specific personas in the UX design.

According to the ISO 9241 (2010), users' experience (UX) is defined as: "a person's perceptions and responses that result from the use and/ or anticipated use of a product, system or service". The user experience explores how a person feels about using a product, i.e., the experiential, effective, meaningful and valuable aspects of application use (Vermeeren et al., 2010). The focus on the user's personal needs and emotions while interacting with an application is a critical factor for an application's success (Sproll et al., 2010). Therefore, user experience modelling is especially important for understanding, predicting and reasoning about UX processes, with implications for the software design (Law et al., 2012).

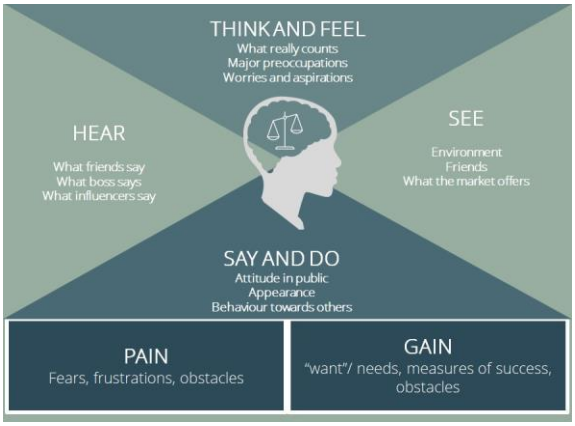

Fig. 1 Empathy Map template

What this concept neglects, however, and what experience design embraces, is the complex interactions of mind, body, and emotion where the target of an application is not a user ripe, but instead a person, a sophisticated agent who requires **entertainment, emotional satisfaction, complexity**. A person respected not only for their mind but for their body and soul, too.

So, there is a clear demarcation between the design that focuses on users in general and the design that focuses on peoples as individual persons. In the first case of the more traditional models, the scope is on "thinking and performance", also known as **self-interest**, while newer models recognize the complex interactions of **emotion and cognition** too. Thus, personalized design is, by all means, trying to penetrate the ways humans interact with technology, emphasizing on their pains and gains, figuring out how to make the experience more useful, usable and most of all **compelling**, creating a personalized experience.

So, what experience design is attempting to do is go further the traditional user-centered design (UCD) where people were mainly considered in terms of their thinking and performance. In contrast, newer models such as **affective design** recognize the need to contemplate people's thoughts and feelings, pains and gains that is, the interaction between cognition and affect (Schriver, 2001; Albers and Mazur, 2003).

1.2 Background to affective design

Emotions have a critical role in dual-process theories of thinking, information processing, and decision making. When making decisions, both the positive and negative feelings, either consciously or unconsciously associated with the mental representations of the objects, are employed as cues for judgments (Solvic et al., 2002). Without emotions, people are unable to consider and make a decision between alternatives (Khalid and Helander, 2006). Russell (2003) introduced the concept of core affect, combining the emotional dimension with physiological arousal into a circular two-dimensional model, as shown in Figure 2. Plutchik evolved this two-dimensional model into a three-dimensional form, in Robert Plutchik's Emotion Wheel theory where he proposes a psycho-

evolutionary classification approach for general emotional responses, also shown in Figure 2.

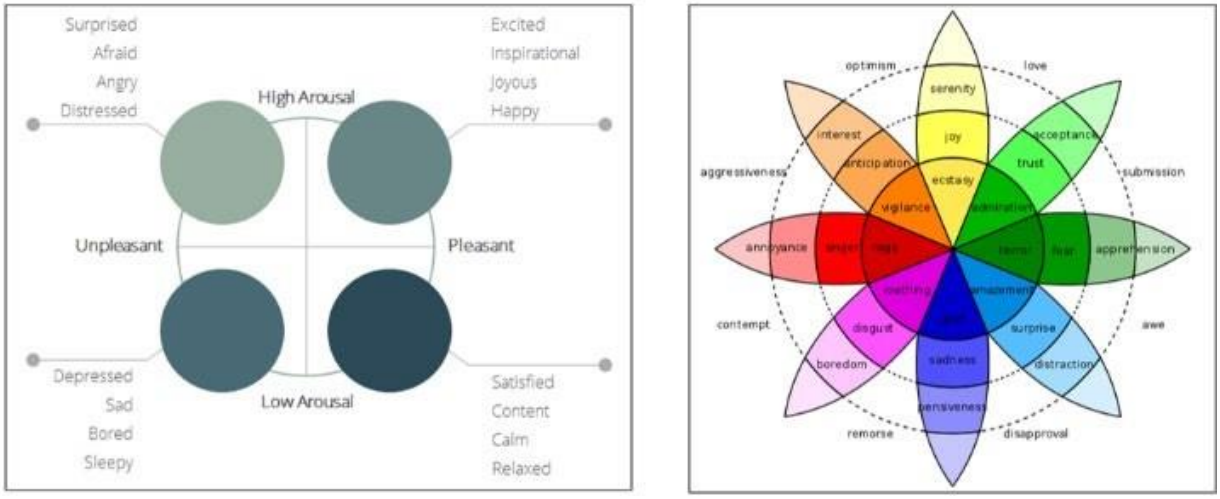

Fig. 2 Circumplex Model of Core Affect with Relevant Emotions (Russell, 1980) and Plutchik's Emotion Wheel theory (Plutchik, 1980)

In both models, the horizontal axis represents demeanour (from unpleasant to pleasant), and the vertical axis represents activation (from high to low arousal). The various positions indicate affective responses that can be experienced in user-application interaction. However, the relationship between the design of an application and the user emotions elicited is not one-to-one, which means the same application can induce significantly different feelings in a different context with different people. Even for the same application, evaluated by the same person, it may receive different emotions under different circumstances.

Today, users look beyond functionality in the products they purchase and the applications they use. They desire products and applications that can satisfy both aesthetic and emotional needs. This provides a challenge to designers in designing applications that not only fit the purpose but also embody the image and convey the meaning that users seek in timeless elegance or exciting newness, depending on the personal life values of each user. While styling in itself can give pleasure, the pleasure is diminished if the appearance of the application bears no relationship to its function. In other words, good design works, but a successful design induces pleasure (Norman, 2005; 2007). For a successful design to be achieved, a systematic method has to be developed that includes the typical usability parameters, but also affective design has to be taken into account.

Humans perceive reality in, at least two ways; one is **emotional** (intuitive and experiential), and the other is rational (analytical and cognitive) (Epstein, 1994). Formal decision making relies on analytical and cognitive abilities, which are quite complicated and make this mode really slow. On the other hand, the affective (experiential) system runs much quicker. When a person seeks to respond to an event, there will be an automatic search and matching with one's experiential system, including its emotional contents (Epstein, 1994). Emotions do not cause thinking to be non-rational. Rational thinking entails feelings, and affective thinking entails rationality. Cognition thought is more precise, comprehensive, and insightful than emotional thinking.

Emotions are used to validate and assess, while cognition is used to describe objects, and understand the user (Norman et al., 2003). Cognition refers to the "head" to denote thinking, while affect refers to the "heart" to denote feeling. Thus, cognition and emotions are unified and work conjointly and equally in the control of thought and behaviour (LeDoux, 1995). Additionally, cognition contributes to the adjustment of emotion.

Contemporary views in artificial intelligence are also embracing an integrated view of emotion and cognition. In fact, the Hindus describe the relationship between thoughts and feelings in a term called "Kama-Manas" (Garant, 2001). Kama-Manas describes that there is an emotion behind all thoughts and vice versa. This united partnership is deep-rooted to the way a human perceives the world. It is fundamental to understanding the design's impact upon consciousness, the human spirit and how people as a whole fit into the cosmic order.

3. Affective Design Conceptual Model

3.1. Affective design in application conceptualization

As postulated in the previous section, by using affective design processes, designers can transform affective users' needs into features of an application. Before application conceptualization, designers need to understand user requirements, which are classified in our research as functional and affective. This presupposes that users' emotions are involved in the application usage and the design must therefore also address users' affective needs. This process can be expressed in the form of mapping between the user domain and the design domain. This process involves the three basic UCD approach steps, which are namely: obtaining, analysing and satisfying user needs.

Creating flexible and agile process guides, having the user in the centre of the procedure, is the core of developing the methodology of application design. Whether being internal or external, empathy for users' needs is the key driver to the design process. The goal is to create transformative experiences which are user-focused providing full user experience lifecycles.

Thus, the relationship among the user and the designer is bilateral; first, the user perceives, responds, and evaluates the application; second, the designer achieves the detailed design solutions successfully by satisfying the user's true needs, including both affective and functional requirements. Designer communicates and negotiates with the users to arrive at optimal design solutions. A good designer will ensure that a system image of the application matches the target user's model (Norman, 2004). The relationship between the user domain (understanding user needs) and the designer domain (application features, look and feel) is illustrated in the following figure.

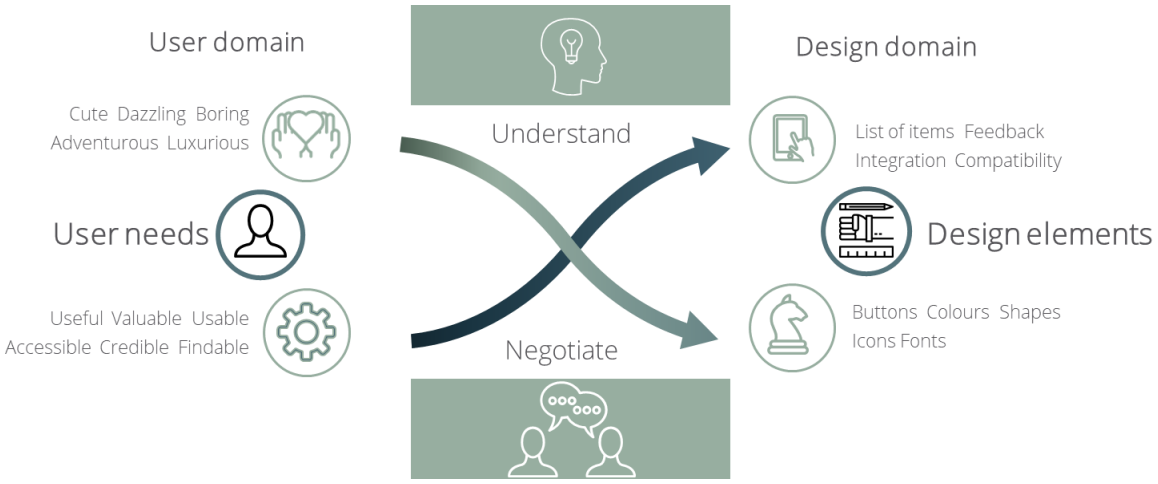

Fig. 3 *The relation between users' needs and design requirements.*

When start conceptualizing a new application design, the designer has to define the design information and constraints, as well as to formulate the design equations. This is the modelling of the design, which in our case includes all the application design components that can be modified to achieve personalization of the interface. The second step is to conduct a user's survey using elicitation techniques. The survey is the main source for a gathering of affective users' needs. One questionnaire was developed, and it is presented in the next Section to elicit user needs around routing applications. The survey measured users' demographics, experience, expertise, affective needs, and design requirements. The survey provided data about users' desires, application usage, strengths and limitations of current application design, and requirements of application design. The figure below depicts the way the emotions are coupled with cognition and also maps this coupling with the modelling process methodological framework.

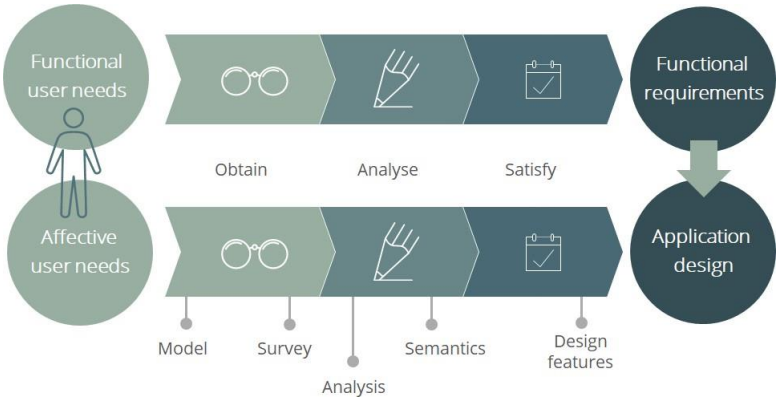

Fig. 4 Coupling emotions and cognition and mapping the process into the methodological framework.

3.2. Modelling Affective User Requirements

In order to model the affective requirements of the users into application design components we use Design matrices, and we, therefore, provide a brief explanation of how the matrices work (Suh, 1990). Axiomatic design is a systems design methodology which uses matrices to manage interactions between elements of the design and functional requirements – and in our case also affective requirements (Suh, 2001; Suh and Lee, 2006). Axiomatic design is a valuable generic design framework for designing complex systems. Many studies in the last decade have persuasively shown the benefits of Axiomatic design in solving a variety of design problems. Axiomatic design principles have been used for software and quality system design (Kim et al., 1991; Chen, 1998; Suh, 1995).

Axiomatic design problems are separated into four different domains: User domain, functional domain, physical domain, and process domain. Associated with each domain are the design elements: user attributes (CAs) or needs which are satisfied by selecting an appropriate set of functional requirements (FRs) and constraints (Cs), which in turn are embodied into design parameters (DPs). The axiomatic design principal concepts are summarized as follow:

- Design domains are used to group similar types of design attributes.
- Decision making is perceived as a mapping process between two adjoining domains, such as functional requirements and design parameters.
- Design equations are used to represent the mapping between domains.

According to Suh (1990), at each level of the design hierarchy, the relationships between the FRs and the DPs can be written in the form of "a design equation" as:

$\{FFFF\} = [AA] * \{DDDD\}$, where the design matrix [A] characterizes the application design.

Functional requirements {FRs} represent design goals based on user requirements, or in other words what a user wants to have. Design parameters {DPs} represent design elements, or how the designer plans to fulfil the user needs.

The matrix of a design with three FRs and three DPs looks like the following:

$$[AA] = \begin{matrix} AA_{11} & AA_{12} & AA_{13} \\ AA_{21} & AA_{22} & AA_{23} \\ AA_{31} & AA_{32} & AA_{33} \end{matrix}$$

Conventionally the values of A_{xx} in a design matrix will be either "X" or "0", where "X" represents a mapping between the corresponding vector components and "0" signifies no mapping.

The design process starts with identifying user needs, which are translated into functional requirements and Affective requirements {ARs}. The design parameters {DPs} corresponding to specific FRs or ARs must be selected. This process of mapping is repeated until all the design parameters have been broken down to a

convenient level. The gathered ARs and FRs can be mapped onto design parameters through the design matrix. The *Design matrix* refers to the relationships between ARs, FRs, and DPs at a given level of design hierarchy. The design equation is then written as follows.

$$\begin{matrix} FFFF_1 \\ FFFF_2 \\ AAFF_1 \end{matrix} = \begin{matrix} xx & 0 & 0 \\ xx & xx & 0 \\ 0 & 0 & xx \end{matrix} * \begin{matrix} DDDD_1 \\ DDDD_2 \\ DDDD_3 \end{matrix}$$

Where:
FR = Functional Requirements
AR = Affective Requirements
DP = Design Parameters
X = Mapping

The main purpose of this design process is to prompt the designer to consider both affective and functional requirements of the user when conceptualizing the design of the application. It gives the designer the possibility to be aware of the importance of affective design and instruct them sometimes to make trade-off decisions that can promote affective design.

Summarizing the Axiomatic design principles with our methodological framework, the following design model emerges.

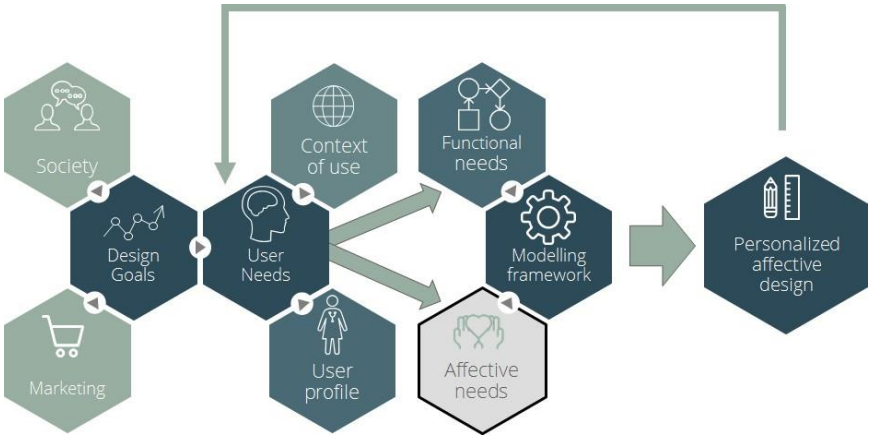

Fig. 5 Affective design modelling framework.

The left part of the affective design framework depicted above is related to the designer goals, information, and constraints, as well as to the user needs elicitation. To put it in Axiomatic design terms, this part is related to the design constraints (Cs), as well as the user attributes (CAs). The mid part is related to the Formulation of Design Equations for Analysis and Decision making based on the appropriate set of functional requirements (FRs) and affective requirements (ARs). Finally, the right part presents the results of the modelling framework which is a personalized interface according to the user's individual needs and preferences.

4. User Affective Requirements Elicitation

4.1. Introduction

User needs, especially affective ones tend to be imprecise and ambiguous due to their linguistic origins. Therefore, it is necessary to elicit the latent user needs so as to know why some needs are important, and how they can be denoted using explicit expressions that are describing them properly. The acquisition stage involves understanding latent user needs and developing of component descriptors to address these needs. The technique used in the study for extracting user needs is survey-based. Specifically, web survey methods were employed to document user needs.
Before conducting the web survey, an analytical model was developed to identify the design elements in the application ecosystem that might help satisfied users affective needs. The scope is to identify the mapping

relationship between affective needs and design elements so as to quantify, later on, user satisfaction concerning the corresponding affective needs.

4.2. Web Survey Outline

The scope of the web survey was to gather the affective needs of the users, defining specific descriptors for the interface components and mapping them to specific user profiles. The design of the questionnaire was driven by modelling framework described in the previous section. The questionnaires existed in two forms: manual and electronic. They were developed in English and then translated in to Greek, Spanish and Portuguese.

This survey is a tool comprised primarily by close-ended questions related to users' demographic data, identity/ personality features and habits, as well as transportation patterns (stated preferences) and application design (Use Interface) preferences.

The questionnaire is separated into three parts:

Part I: Demographic data and identity attributes

This part deals with the users' personal data and information that will create his/ her profile, based on the demographic data, as well as his/ her lifestyle, personality, social norms, and habits. None of the questions records user name or contact details as the information remains anonymous.

Part II: Transportation experience and user needs

This part deals with the users' transportation experiences, their stated preferences in terms of mode. It depicts users' current habits and determines factors that may change them.

Part III: Application design requirements

This part deals with questions related to the connection of the users' affective requirements to the UI elements of the applications. Starting with questions that define the users' experience with using such applications and concluding with questions related to the user's preferences on the UI elements according to specific affective factors.

4.3. Application design components

Formal and experiential application features can be subdivided into multiple categories including color, form, graphics, materials, sounds, and interaction design. In Part III of the questionnaire, a set of application design components was presented to the users. These interface components are postulated to have the greatest affective power over an application design. Additionally, the selection of a set of components, instead of all of them, allowed avoiding great workload of the responders and on the other hand, simplifying the work of the designer. A representation of the specific components appears below.

- Colour

Colour can arouse very strong associations. Additionally, it is particularly powerful because people see colour before other characteristics of an application. Itten, argues that colour can be manipulated to achieve desired emotions. Colour has been used code elements. It can increase the velocity of comprehension, and it can establish a unique identity for elements. Also, colour can be used to guide a user's attention; it can be used as a locator signal and can liven up an application. Thus, we can postulate that colour adds an affective dimension to user experiences, by "colouring" them and impacting user moods. Colour, as this brief review suggests, although a very subtle cue that is most often processed pre-attentively or unconsciously, carries enormous importance for the formal aspects of an application and when used carefully within cultural expectations, can become a very powerful informational tool.

- Form

The term form is about an object's shape, its overall presence in three dimensions that combines different shapes into a single design. The form further extends to the way a component is used, such that it can be clicked using one finger, and how its shape alerts people to the proper use of an interface component. The role of form in application design seems highly neglected. However, most application designers can demonstrate significantly different forms that provide a different experience to the user and satisfy specific needs. For example, people with specific motor abilities, need buttons with a bigger shape so as to be able to click on them easily.

- Graphics

Graphics will occur in most applications, and their careful use requires significant attention. Icons, for example, pose particular challenges, because very few symbols have reached universal acceptance. Following a similar line of reason, a culturally sensitive visual design practice that takes into account the national origin of readers is also

very important. Beyond revealing the information that users need to know, though, graphics play an important role in carrying the emotional values associated with applications. One particularly powerful graphics element is typography, since one typeface might be "elegant" while another can be "direct," and a third is "friendly". Consequently, the experiential properties of graphics are not limited only to icons, drawings or photographs, but extend to the typeface we use to present verbal text.

- Interaction Design

Interaction design has received much attention from usability and human factors experts, and an entire field of interaction design has evolved alongside and sometimes in competition with information design. In other words, interaction design means thinking through the actions that users will take with an information application to enable that action.

4.4. Pilot study

The questionnaire is being piloted using a small set of actual users in Greece. The scope is to highlight the questions that were difficult to understand, and/or ambiguously worded and they require rephrasing. The pilot will also focus on eliciting the appropriately associated descriptors for the respective interface elements. Selected descriptors were selected from the literature review and were incorporated into the questionnaire. After the pilot's realization, changes will be made to the questionnaire so as to include associated descriptors that were related to routing applications and were fully understood from the users.

Respondents will be asked to rate several images based on selected descriptors from the literature review and rank their preferred images. The scope is to use only the images that have clear design differences according to the users.

5. Conclusions

Most studies regarding application design are focusing on customer needs concerning functionality and utility. Rarely has the issue of customer emotions been investigated, especially in mobile applications domain. Today, many corporations challenge designers to incorporate the emotional part into their designs, so as to manipulate the final users' decisions. Undoubtedly, emotion is one of the strongest aspects that differentiate user experience (UX), since they trigger conscious and unconscious responses for a user interface (UI). When we consider emotion in application design the main purpose of the designer it to keep the users happy, by maximizing positive emotions and at the same time minimizing negative emotions. This manipulation of emotions implies that the developer has deep knowledge of the target users. In such a way, even insignificant changes in UI design, can bring big changes in positive emotions and consequently improve cognitive processing. Applications that create a positive user experience, have significant emotional effects that lead in gains in productivity, efficiency, and effectiveness.

The current paper explicates the background of the affective design and how it can be implemented into the design of a routing application. It provides an overview of the literature concerning the need for personalization when designing products in general, as well as giving a thorough background review on how the affective design is incorporating into products so far. The target is to create a modelling framework inspired by the material domain and adjust it so as to fit interfaces of mobile applications. In material domain, as well as in the UI domain, separating emotion from cognitive functions does not seem helpful. An integrated view of the users' emotional and cognitive needs has to be taken into consideration. Thus, an application should be designed to support user needs –functional and affective, including the customer's persona or personality attributes.

Our affective design conceptual model has been structured based upon the Axiomatic design that allows us to model the affective and the functional user requirements and transform them into specific personalized and affective design parameters and consequently interface elements. The current paper also presents the implementation of the first step of our modelling framework; the users' affective requirement elicitation — providing an overview of the way the survey tool has been structured and the preliminary work that has been realized for the survey to be lounged.

In conclusion, users tend to make decisions based on their feelings, perceptions, identities, and reflections that usually come from their inner feelings rather than their cognition and rational thinking. As such, designers should consider making affective design a bottom line in product design and eliciting the affective user needs part of the

basic user needs captioning together with theit functional needs. Further research is needed to test our modelling framework and assess the way it can be implemented in mobile applications. Additionally, further research should be deveted to develop expressions of emotions that are quantifiable and can be verified easily.

Acknowledgements

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