Investigating Web Applications Adaptation to User Emotions

The great challenge: real time detection of emotions during user interaction and affective elicitation through Web design

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The main goal of this research is to understand the issue of real time identification of emotions elicited on the users, while they are interacting with Web interfaces. Our aim is to create Web applications adaptable to the emotional state of the users, possibly stimulating more positive emotions, providing benefits to their interactions. This investigation is based on three previous studies oriented to find the key aspects of Web design responsible to stimulate a specific affective state on the users with consequent transformation of the interface to improve their experience. In this perspective, we carried out one test using an Emotiv Insight headset able to detect EEG of five channels to understand problems, potentials and limits related to monitoring physiological signals and their interpretation regarding the emotional state. We report and discuss the results of our analysis, amongst other findings on this challenge.

CCS CONCEPTS • Human-centered computing • Human computer interaction (HCI) • Interaction paradigms • Web-based interaction

Additional Keywords and Phrases: Emotions, Affective interfaces, Web user interface adaptation, Web guidelines

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1 INTRODUCTION

Topics concerning emotions in HCI have acquired increasing attention and started to be widely accepted for their importance [1-3]. However, there is still no unanimous definition on what emotions are [4 -8]. This should give an idea not only of the difficulties on investigating on something which is not yet precisely defined, but also on how to detect and measure it. In fact, the studies often tend to understand emotions by observing the effects (rather than knowing the cause), such as e.g., monitoring internal changes of physiological signals of a person (Electroencephalogram (EEG), Electrocardiogram (ECG), Blood Volume Pulse (BVP), Electrodermal Activity (EDA), Infrared Thermography (IRT), etc.), or extrapolating changes from external aspects (such as facial expressions

through software, self-evaluation methodologies, topographical self-report analysis [9], user's utterance through words, stories, feelings, etc.). Emotions are complex as they depend on individual preferences, attitudes, moods, dispositions, and interpersonal stances; "there is no single standard gold-method for their measurement" [10]. The issue of emotions detection is not a trivial task and it becomes less trivial if this should be done in real time.

Even if there is a general agreement about the importance of the user emotion during the interaction, no concrete design criteria have been proposed in order to support designers to create Web applications able to elicit emotional states. There are many emotions classifications, such as Geneva [11] or Feeltrace [12], scales and questionnaires to measure either two primary (negative-positive) dimensions of moods [13], hedonic and pragmatic dimensions of user experience [14, 15], but little work has focused on typical emotions related to Web interaction. There are studies comparing different versions of Web pages [3] on their attractiveness or aesthetics [16], general emotional perception of Web sites or if one Web site is better than another at eliciting emotions [2], analysis of existing Web sites about their hedonic elements (such as color, images, shapes and photographs) [17] to investigate the emotional appeal or positive impressions on the graphical look of a Website. However, none of these studies has focused on how the various elements of Web interfaces can elicit a specific emotion.

Section 2 of this paper analyses three previous studies on criteria of Web design to elicit emotional state, while section 3 describes the experiment with an Emotiv Insight headset, and section 4 provides a discussion about future evolution of this research.

2 WEB DESIGN ELICITING EMOTIONAL STATES

We investigated how Web design could elicit some emotional states on the user during the interaction. In particular, this research emphasized some key design characteristics responsible of specific emotional effects. To accomplish this goal, we performed three different user studies.

2.1 STUDY 1: Design Criteria for Web Applications Eliciting Emotions

With this first study we tried to identify a set of emotions and design features typical of Web interaction [18].

2.1.1 A Survey gathering Opinions about Emotional Web.

As a beginning, we organized a survey with 57 participants (25 females and 32 males) with an average age of 38,21 years (ranging from 26 to 59). Users of this sample had heterogeneous educational level and Web development experience. We asked each participant to suggest some typical emotions (maximum 8) involved during Web interaction. The only constrain for each proposed emotion was to indicate also the opposite one (depending on the negative or positive emotional valence, in their perception). Users had to order each proposed emotion on the base of their perception from the most negative to the most positive. After that, they had to associate each proposed emotion with specific characteristics of Web design we showed them (such as colours, page structures, contents distribution, type of media, navigation & interaction elements, etc.).

We collected 219 emotions perceived as negative and 219 perceived as positive, and from these we discarded synonyms, emotions with a low number of preferences (less than 10) or having the same Web characteristics suggested by different users. As final result of this process, we obtained a filtered scale of six emotions: hate, anxiety, boredom, fun, serenity, love. The goal of this process was not to provide a further emotion classification, but rather trying to identify some clearly distinguishable design characteristics that could elicit a specific emotional state. This small set composed of six emotions oriented to Web interaction has been a basis of our study. *Hate* and *love* express

the sense of disliking/liking for something (e.g., typical of Web social networks). *Anxiety* and *serenity* express the emotional state during critical/safe actions (e.g., the user is booking/buying something on Web inserting personal or credit card data). *Boredom* or *fun* depend on the way the contents are presented attractively.

For each emotion, we collected some Web design features as potentially able to stimulate the target emotional state, as suggested by the users. Examining the data, emotions close in the scale have some common design features and some others distinguishable: this indicates the complexity of the emotions and that there is not a well definite borderline between similar (but not equal) emotional states.

2.1.2 User Test.

After the preliminary survey, we wanted to check if the collected Web design indications were effectively efficient to elicit the target emotions. We implemented six Web interfaces applying the Web design criteria suggested in the survey. We chose the Beatles' musical history as a topic for the Web six interfaces. Each Web interface presented the same content (except very minimal additions suggested by the users), but with a different design style. Each interface aimed to stimulate one of the six emotions.

Fifty different users (21 females and 29 males) with an average age of 38,28 years (ranging from 26 to 77), evaluated through a user test, the effective elicitation potential of the six interfaces. The sample considered users with heterogeneous educational level and Web development experience. The interfaces contained a short textual biography, a player where the user could listen to five famous songs, a video, a form to buy virtual tickets for revival events and six clickable graphic covers of famous albums.

The 50 users evaluated in random order each one of the six interfaces evaluating them in a scale from 1 to 5 scale (where the value 1 indicated the page as very ineffective to stimulate the target emotion, while value 5 indicated the page as very effective, and the value 3 represented the neutrality). Users had to perform three tasks for each interface: a) find the answer to a question in the biography (reading text) b) clicking one of the six albums (testing the navigation elements without listening the songs) c) filling in the form (testing the interactive elements).

The design of the six Web interfaces had these peculiarities: a) the interface eliciting *hate* had the content distributed in one single page, a confused layout, and blurred text and elements; b) the interface eliciting *anxiety* presented the contents distributed in multiple pages with intermittent light effects and jerky transformations, a countdown to generate stress pressure factor when filling in the form; c) the interface eliciting *boredom* was one single page with long text, without images or videos, requiring more fields in the form to be filled; d) the interface eliciting *fun* had the contents distributed in multiple pages, showing unpredictable animations and dynamic effects; e) the interface eliciting *serenity* was very simple minimizing the user's effort and allowing an easy navigation through TABS elements; f) the interface eliciting *love* was a long page usable with an appealing graphics.

2.1.3 Results.

The sample appreciated positively the emotional effectiveness of the interfaces to stimulate the desired emotional state. The average evaluation scores (in a scale from 1 to 5) and the deviation standard (SD) related to the six designs were: 4.48 (SD 0.64) for hate, 4.52 (SD 0.61) for anxiety, 4.16 (SD 0.88) for boredom, 3.32 (SD 1.21) for fun, 4.22 (SD 0.72) for serenity and 3.64 (SD 1.06) for love. Web design criteria related to fun and love were considered the more critical (even if the judgment was more than neutral) because the presence of animations/dynamics effects applied for fun was considered excessive, and the colours applied for love were perceived too shocking.

2.2 STUDY 2: Identifying Key Design Features Responsible for Eliciting an Emotional State

With this second study we wanted to identify the main aspects of Web design responsible for eliciting specific emotions [19].

2.2.1 User Test.

After the promising results of the previous user test, we wanted to go more in detail trying to understand if some Web design features were more relevant to stimulate the target emotional state. Most users of the survey suggested music as topic for an emotion-based Web application. To accomplish this goal, we designed and implemented a Web application *Emotional Music System* (EMS) to search musical authors or bands, able to adapt its design selected manually by the user corresponding to specific affective criteria. We created two versions (implemented with different Cascading Style Sheets) for each emotion: the first version applied the criteria of the previous user test but with some improvement suggested by the users; the second version presented small differences for those elements considered controversial in the previous user test (such as colours, visual characteristics, blurred or clear text and dimension of images/videos). Forty different users participated to this test, divided in two groups A and B of 20 users each. Group A (11 females and 9 males) evaluated the first version of the six interfaces for each emotion and Group B (14 females and 6 males) evaluated the second one. Both groups were heterogeneous for their education and developing experience. Each user evaluated only one version of the six design in random order performing first three similar tasks of the previous user test, and secondly giving a judgement (in a scale from 1 to 5) about the emotional impact. Besides, each user had to choose the main three features of Web design (from a proposed list) she/he considered fundamental to stimulate the target emotion.

2.2.2 Results.

The results of the two groups appeared consistent [8], based just on the design criteria. The scores related to the emotional impact improved with respect to the results of the previous user test, except for the boredom because the information to find was at the beginning. The key design features for the six Web interfaces resulted as follow: **a) hate:** confused layout, difficult interaction & navigation; **b) anxiety:** stress factors, blurred text/images/videos, dynamic effects; **c) boredom:** excessive information, absence of dynamic effects, absence of images/videos; **d) fun:** appealing graphics/aesthetics, dynamic effects, colour images/videos; **e) serenity:** ordered layout, reassuring elements, easy interaction & navigation; **f) love:** usability, appealing graphics/aesthetics, reassuring elements.

2.2.3 Discussion.

The main result of this test highlighted that usability, even if it is an important factor, it is not the unique aspect responsible to elicit an emotional reaction on the user.

2.3 STUDY 3: Transitions between Web Affective Interfaces

The goal of this third study aimed to looking for effective transitions when changing Web interfaces from one stimulating a negative affective state to one eliciting more positive emotions [20]. Interface transformation in the adaptation transitions needs to improve user experience and usability paying attention to avoid undesired user disorientation, which can be a consequence of the change.

2.3.1 User Test.

To carry out our study, we improved the *Emotional Music System* (EMS) Web application. EMS supported the most relevant Web characteristics for each one of the six designs corresponding to the six emotions identified in previous studies. A control panel window allowed the user to select manually one initial emotion on the negative side (hate, anxiety and boredom) and then a positive one (love, serenity and fun) preparing a transition between designs. We thought three general types of transitions:

- **Immediate**: All the Web design changes were instantaneous, without animated effects.
- **Overview**: Design changes were presented by a small overview window, through icons associated with the various interface parts. Animations were displayed to show the changes and their repositioning.
- **Gradual**: The changes were progressively applied to the interface supported by animated effects.

We involved 40 different participants, (23 females and 17 males) with average age of 36 years (ranging from 26 to 66) and standard deviation 13.48. The sample was heterogeneous as education and as developing experience.

To better understand the impact of the transition before and after the transformation of the interface design, the participants had to carry out one task (Task 1) on the initial interface and another (Task 2) on the interface after its transformation. Task 1 and Task 2 were equal in terms of cognitive effort, but different for the required operations. After that they had to fill in a questionnaire. Before the questionnaire, we explained the participants we wanted:

- a) to understand in their evaluation, if the three transitions allowed them to experience the Web design changes without disorientating them, and if it was easy to continue interacting with the new interface.
- b) to understand if the transitions were attractive, stimulating pleasant continuity of interaction.

Points a and b define user experience and usability, but we did not mention those terms, for the sample expertise.

2.3.2 Results.

Users indicated the gradual transition as the least disorientating and the most pleasant and stimulating when changing the Web user interface. Results emphasized that usability and user experience are strictly connected. Analysis of the times to perform Task1 (before the transition) and Task2 (after the transition) showed a significant shorter average T2 (time to complete Task2) with respect to T1 (time to complete Task1) for the Overview and Gradual transitions. Longer average time T2 after the Immediate transition (where changes were instantaneous) was an indication of an increase of users' confusion.

From these three studies, we learned that some Web design elements have a particular role to orient the affective stimulation towards a specific emotional state. The six emotions (typical of Web interaction) are just a basic set, extrapolated from the users' indications of the survey, with the goal of creating designs capable of stimulating distinguishable emotions. Most usable websites are not necessarily capable of stimulating a desired emotion. Live detection of emotions is essential to explore the Web adaptation potential and some physical sensors can provide additional indications.

3 CHALLENGE OF BUILDING AUTOMATIC AND ADAPTABLE WEB APPLICATIONS

The encouraging results of these studies have reinforced our goal aiming to build Web applications able to automatically adapt to the user's emotional state. The achievement of this goal requires the performance of three

general steps: a) real time and continuous recording of the state of the person; b) real time elaboration and interpretation of the state changes; c) consequent transformation of the interface.

Considering that there is not a precise and unanimous definition of emotions, their identification (which is a current object of scientific discussion) can be detected through many ways, most of them looking at the internal effects (such as monitoring physiological signals) otherwise not visible exteriorly or analyzing external changes (such as facial expressions, body language or listening to users' feelings and sensations during an experience).

Our experience with software able to detect facial expressions based on the Ekman's six emotions classification (anger, disgust, fear, happiness, sadness, surprise) [21], which has nothing to do with our six emotions basic set, have emphasized many limits, for the fact that users have to exaggerate their facial expressions in order to detect emotions by this kind of software.

Many devices able to detect physiological signals are available in commerce. As a preliminary attempt to investigate the potential of this kind of devices, we started our experimentation with an Emotiv Insight 5 channels EEG headset to understand the utilities and problems for our research goals.

3.1 Managing Physiological Signals

We performed a test using an Emotiv Insight 5 channels EEG headset (i.e., with 5 sensors to be placed in contact on the cranial scalp together with a physiological solution to facilitate transmission).

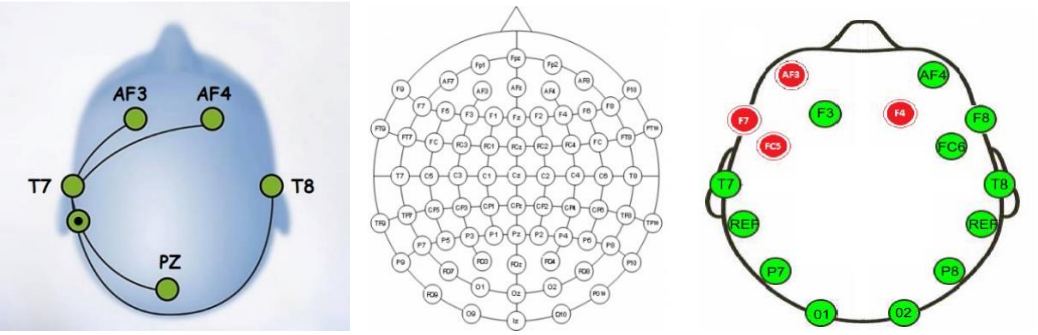

Figure 1: (a) Position of 5 sensors of the Emotiv Insight helmet (Emotive Pro manual); (b) Example of location of 74 sensors (https://www.brainlatam.com/manufacturers/easycap); (c) Positions of the 4 channels FC5, F4, F7, AF3 for the left frontal lobe ([23]).

The use of 5 sensors (Figure 1a) brings a simplification compared with a higher number of sensors (Figure 1b) of *Modified combinatorial nomenclature of the 10–10-system* standard, but also a limitation in the information detected: "measurements taken with the Emotiv Insight do not prove to be reliable for a classification task as simple as right versus left motor activity and that the device is not recommended as a Brain Computer Interface" [22].

3.1.1 User Test.

The test was carried out with 3 users. We showed them six consecutive short emotional videos taken from movie scenes or commercial spots. The scenes were selected with the aim of stimulating various types of moods such as: fear, anxiety, fun, sadness, anger, love. After a preliminary brief training phase required by the EmotivPRO software, the EGG signals were recorded for each user. Comparing the three users' EEG signals (for the 5 channels AF3, T7, Pz, T8, AF4) at the same scene instants, it emerges that they often are completely different (Figure 2). This shows that the internal physiological reaction is different for each user despite the same emotional stimulation

(observation of the same scene), and each person manages her/his emotions in a personal way. Trend of the signals (peaks and oscillations) allows us to understand which user is particularly emotional reactive in some moments of a scene.

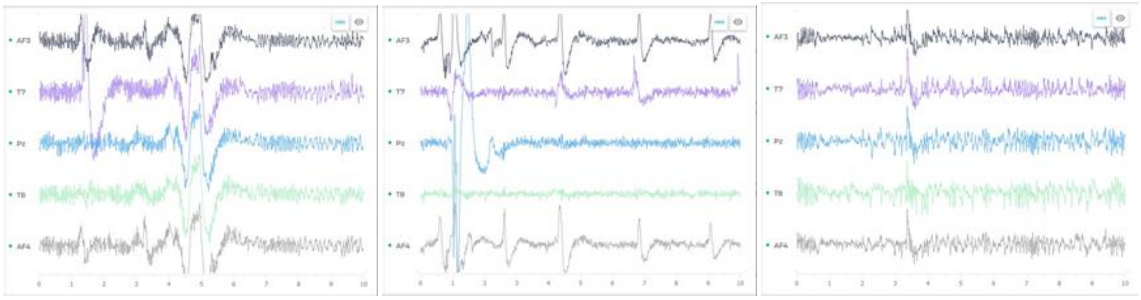

Figure 2: Example of the EEG signals of three users in correspondence with the same instant of a scene.

The EmotivPRO software allows also saving the Performance metrics, the Motion sensors and the Frequency analyses. *Performance Metrics* (based on Emotiv algorithms) expresses some indications on the levels of Stress, Engagement, Interest, Excitement, Focus, Relaxation of the person. *Motions Sensors* indicates data concerning headset's position and orientation. They can provide useful information on the user's movements in correspondence with emotional reactions. *Frequency analyses* shows the levels of the Theta, Alpha, Low Beta, High Beta and Gamma waves generated in time for the AF3, T7, Pz, T8, AF4 channels. Levels of these waves are important because they can give interesting indications about the **laterality** of the signals (Figure 3).

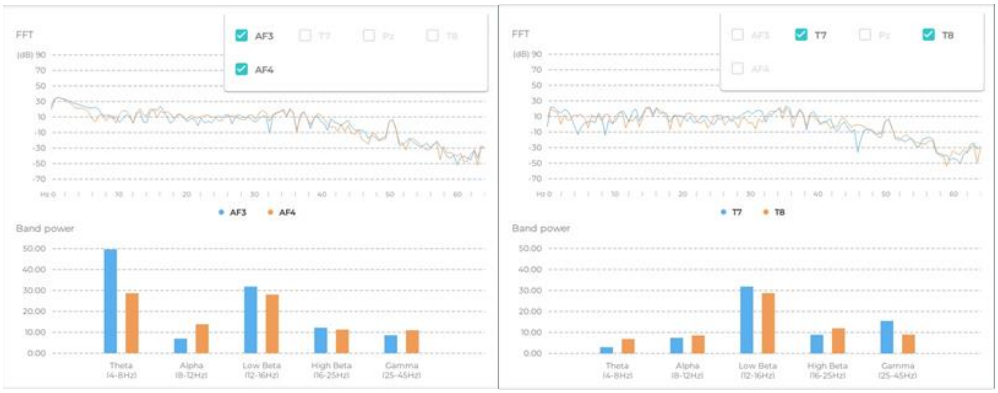

Figure 3: Example of Theta, Alpha and Beta waves generated in AF3/AF4 and T7/T8 for one user in a particular instant.

Laterality indicates if peaks of the EEG signals or waves occurs in one hemisphere (left or right) rather than in both the same time and can give an important indication whether an internal physiological reaction generated is pleasant or not. For example, the study [24] shows that damage in the left or right prefrontal cortex can cause a weakened or even disabled generation of certain emotions, and the study [26] shows that the prefrontal lobe area plays a role in linking the subject's pleasantness. Research [25] confirms that there is a lateralization pattern in the frontal lobe during the processing of positive and negative emotions and the study [27] shows that an asymmetrical pattern in the frontal lobe during the observation of pleasant/unpleasant commercial advertisements. In particular, [27] highlights that in the analyzed sample, the maps of the power spectral density (PSD) showed an asymmetrical

increase in theta and alpha activity related to the observation of pleasant (unpleasant) announcements in the left (right) hemisphere. Consistent with [24, 25, 26, 27], human emotions are also associated with the frontal lobe [23].

Analyzing our data recorded by the sessions with the three users, in many cases has been possible to understand whether an emotion was pleasant or not (although not always). However, if for example, the 4 channels relating to the positions of the electrodes FC5, F4, F7 and AF3 correspond to the position of the left frontal lobe (Figure 1c), the fact that the Emotiv Insight (Figure 1a) has only the AF3 channel (for the left frontal lobe) and AF4 (for the right frontal lobe) shows a clear limitation. A limitation seen previously for the Emotiv Insight [22] has to do with the effects on the laterality in relation with the valence (pleasant or unpleasant) of an emotion; this also concern the fact that there is no difference in the brain between a movement performed or imagined [28, 29, 30, 31].

4 DISCUSSION AND FUTURE WORK

Emotions detection it is not a trivial task. Causes are not only the not well-defined boundaries of an emotion state generated inside a person or the discussed problems, but also the limits of using off-the shelf devices. Difficulties increase especially if we take into consideration the design of Web interfaces as the source of the emotion elicitation, which has not the same impact of film scenes. Web design is the way contents of a Web interface are presented, and there are many possibilities, which can influence the user's perception. Besides, design is not the unique factor, but also a specific context and contents can further influence the emotional state of a person.

Since usability and user experience are strictly connected, a Web design feature has the potential to influence not only the usability (which is the classical factor considered in HCI for years) but can also elicit bad or good moods and feelings on the user. If usability indicates “how an interface is simple to be used” and user experience aims “to make the interaction experience pleasant”, the way a designer presents the contents can generate “different levels of pleasure or displeasure”. A poor or well usable interface can unknowingly and accidentally generate negative or positive affective states. This is an important point, and it needs to be investigated further in details in the future.

Main goal of this work aims to understand the issue of real time identification of emotions on Web, by interpreting physiological signals. While discerning if an internal reaction is pleasant or not is not easy, identifying a specific emotion is still takes a long way. As a first attempt, we used a commercial headset and the test emphasized the difficulties to detect an emotional state only with EEG. We are aware that tests with different devices (e.g. Empatica E4) and other physiological signals are necessary, together with self-report evaluations, because listening to the users can provide key indications. Unfortunately, using many devices requires the elaboration of a more complex amount of data in real time for their interpretation. Each manufacturer provides proprietary protocols and libraries to create customized applications and it is not easy to get all devices to communicate together.

For creating more effective adaptable Web application, we plan to investigate on specific application domains. There are many scenarios where emotional criteria can provide benefits to the user, arousing moods for interacting in a more engaging way (e.g. e-learning process can be more exciting, tele-medicine environments can be more reassuring, gaming contexts can result more thrilling, interactive museum applications can improve curiosity, etc.).

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