Emotions Triggered by Innovative Products

A Multi-componential Approach of Emotions for User eXperience Tools

Damien Dupré
Laboratoire Inter-Universitaire de Psychologie
Univ. Grenoble Alpes
BP 47 - 38040 Grenoble – France
damien.dupre@upmf-grenoble.fr

Anna Tcherkassof
Laboratoire Inter-Universitaire de Psychologie
Univ. Grenoble Alpes
BP 47 - 38040 Grenoble – France
anna.tcherkassof@upmf-grenoble.fr

Michel Dubois
Laboratoire Inter-Universitaire de Psychologie
Univ. Grenoble Alpes
BP 47 - 38040 Grenoble– France
michel.dubois@upmf-grenoble.fr

***Abstract*—User eXperience studies with products, systems or services have significantly increased in companies in order to anticipate their commercial success. Among the user experience dimensions, emotions are predominant. However User eXperience studies used several concepts to refer to emotions and current measures still have some flaws. Consequently, this doctoral project aims firstly to provide a multi-componential approach of emotions based on a psychological view, and secondly to provide Affective Computing solutions in order to evaluate emotions in User eXperience studies. Through a study using hand-gesture interface devices, three components of users' emotions were simultaneously measured with self-reports: the subjective, cognitive and motivational components. The results point out the possibility of measuring different components in order to gain a better understanding of emotions triggered by products. They also point out that self-reports measures could be improved with Affective Computing solutions. In this perspective, two emotion assessment tools were developed: Oudjat and EmoLyse.**

Keywords—User experience; hand-gesture interfaces; self-report; emotion components; open-source software.

I. INTRODUCTION

User eXperience (also called UX) is often referred as a buzzword [1], [2]. However, its inclusive framework is an asset to understand and anticipate users' reactions. UX studies aim to understand and anticipate users' behaviors when interacting with a product in order to improve their experience. The ISO 9241-210, about human-centered design for interactive systems, defines UX as the result of a person's perceptions and responses generated from the anticipated use and/or the use of a product, system or service. If perceptions are positives, users are expected to favorably adopt the product, system or service [3], [4].

Even if an UX definition is now accepted, the number of factors that compose UX is still debating. Park and al. [5] conducted a review based on 127 articles and communications. According to them, three factors are mostly used: *usability*, *emotion*, and *values*. Bargas-Avila and Hornbæk [1] also conducted a review based on 51 articles. They identified the vocabulary used to evaluate UX factors: *affect, feeling, satisfaction, hedonism, attractiveness, fun, engagement, aesthetics, motivation, delight, frustration* and *usability*. It appears that most of these are related to the emotional phenomenon but they also refer to very specific concepts. For example, the terms satisfaction and hedonism are concepts that cannot be valued as emotional indicators if they are used alone. On the one hand, the status of those words is not sufficient to express the complexity of emotional experiences [6], [7], and on the other hand, they do not relate to an emotional concept but rather to a cognitive concept as of *satisfaction* and a motivational concept as of *hedonism*.

Given the problem of taking into account emotions in UX studies, this project has two aims: the first is to bring knowledge of psychology to highlight what emotions are (section I.A) and how to measure them in UX studies (section I.B). This literary review will enable to define a theoretical framework of emotions triggered by UX. Thus, as a case study to illustrate a possible solution to measure emotional components with self-reports, a UX study of an innovative hand-gesture device was performed (section II). However the self-reported measures of emotional components are not without flaws. First, the delay between the feeling of the emotional event and the measure could imply a biased reconstruction of emotions. Second, the use of emotional words is not optimal for emotional measures because they involve a non-natural categorization of emotions. Consequently, the second part of this project is dedicated to find Affective Computing solutions to overcome these two biases (section III).

A. What are Emotions?

Before the study of emotions in UX, it is necessary to know what emotions are. Thus, despite theoretical differences in their conception, emotions are considered as spontaneous reactions initiated by a "stimulus" [8]. The "stimulus" can have multiple identities. It can refer to someone during interpersonal relations, to an event when recalling a souvenir, or a product when using it. Moreover, emotional reactions could be internal and/or external. More precisely they can be studied according to five complementary components [9]:

- The cognitive component consists in series of Stimulus Evaluation Checks (SECs) that describes the cognitive appraisal process. The SECs can be sort into four categories: the relevance of the stimulus according to individuals' goals, the implications of the stimulus according to individuals' goals, the potential coping of stimulus consequences and the normative significance of the stimulus according to individual values. In the UX

context, appraisals can be studied through the perception of products features such as *attractiveness* or *usability*.

- The physiological component refers to modifications of biological rhythms triggered by the emotions such as heartbeat or sweating.
- The expressive component is linked to nonverbal communications and to facial expressions.
- The motivational component refers to the importance of emotion in behaviors. Thus, emotions are action readiness that represent individual willingness to change or to maintain the relationship with an emotional stimulus [10]. In that view, UX of products trigger action readiness such as approach or avoidance modes.
- Finally, the subjective feeling component corresponds to a conscious access to the previous modifications that leads to a verbal expression [11]. The conceptualization of subjective feeling can be set apart in two different views: using categorical labels such as Ekman's six basic ones (*happiness*, *surprise*, *fear*, *anger*, *disgust*, and *sadness* [12]) or using dimensional continua such as *pleasure*, *arousal* and *dominance* [13].

Those five components compose emotions. Each can be studied independently but they influence each other [7]. Thus, contrarily to emotions' conceptions that take into account only one component, emotions are complex phenomena. This statement involves identifying how to measure them in UX studies.

B. How to Measure Emotions in UX Studies?

Because emotion components are heterogeneous, different methodologies are required to measure them. Some methodologies fit with UX studies but others are less adapted. For instance, anticipated uses of products are generally not intense enough to trigger measurable changes of electrophysiological signals. Therefore, self-assessment measures are mostly used in UX studies.

Self-reported measures are simple tools to use, and they enable users to access the subjective component of emotions. Verbal measures (i.e. measures with emotional words such as surveys) are commonly used thanks to their simplicity and their ease of completion. They can be categorical if they ask to select an emotion among a list [14], [15], or they can be dimensional with items that measure emotional stats on a continuum [16].

In order to highlight emotion as a multi-componential phenomenon, an UX study investigating the cognitive component, the subjective component and the motivational component of emotions triggered by an innovative human-computer interaction was performed.

II. Case Study: Evaluating Emotions in the UX of Hand-Gesture Interactions

To assess emotional components in UX, an experiment was designed in which participants were asked to use a classic computer mouse (control group) or a hand-gesture interaction device (experimental group) to perform some tasks.

Hand-gesture interaction devices are new technologies that accurately detect and capture users' hands movements. Thus, they allow users to control computers with their hands [17]. The main advantage of these interactions is to free users from the constraints of a surface, they can explore a 3D space to control computer applications [18]. Consequently, such innovative interactions provide a new experience to users and thus trigger emotions. The cognitive schemes related to simple actions they used to do are revolutionized [19]. Consequently, the expected hypothesis was that hand-gesture interaction devices are likely to trigger stronger and more valenced (i.e. positive or negative) emotions than classic interaction devices [20].

A. Material

To test these hypotheses two hand-gesture interaction devices were compared to a classic one. The first one is a prototype from the Isorg Company named the Magic Pad. It is made of 100 optical sensors that calculate the radiant light energy in a 20 cm height. When users move their hand over the sensors, the shadow produced is interpreted as motion vectors (Fig. 1).

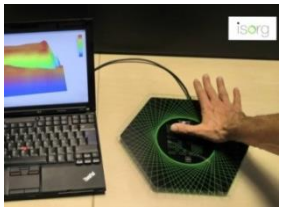

Fig. 1. The ISORG's Magic Pad, the spectrograph displays correspond the sensors activity.

The second hand-gesture interaction device is the Leap Motion controller (Fig. 2).

Fig. 2. The Leap Motion controller detects hands with infrared cameras. Then, hands are virtually modeled to control the computer.

The Leap Motion controller is made of infrared cameras that detect hands movements thanks to recognition algorithms. When users put their hands above the cameras, they are virtually modeled and they allow users to interact with the computer.

B. Self-Reported Measures of Emotion Components

Cognitive appraisals triggered by the interactions were evaluated with three 4-item scales measuring their perceived innovativeness [21], their perceived attractiveness [22], and their perceived originality [23]. Subjective feelings were measured with a dimensional scale made of 6 differential semantic items [24] and the motivational component were measure with an explicit approach-avoidance scale [25].

C. Procedure

Participants were divided in two tasks, which have both experimental and control conditions. A first group of participants used a skill-based application (Task 1, N = 104; 92 females and 12 males, M_{age} = 21.1). Participants had to control a horizontal bar with their hands (experimental groups) or with their cursor (control group). A ball is balanced on this bar and coins appear randomly. The task was to get the coins with the ball as fast as possible without having the ball fall from the bar.

The second group of participants used a mapping application (Task 2, N = 105; 86 females and 19 males, M_{age} = 20.3). The application is configured to display the plan and the satellite view of the map at a 1:200 resolution. Participants could freely navigate in a 2D space corresponding to Cardinal points and they could zoom in or zoom out. The task of the participants was to find specific locations in a city.

In the final phase, participants were asked to fill out a form and were thanked for their participation. Overall, the experiment lasted 30 minutes.

This study meets the French ethical criteria for experiment with humans. No personal data were collected except age and gender. The participants were volunteers and they were debriefed after the experiment.

D. Results

As expected, a group effect is shown in each measured component of emotions. Hand-gesture interaction devices are perceived as being more innovative (Task 1: t_{103} = 9.50, p < .01; Task 2: t_{102} = 10.12, p < .01), more original (Task 1: t_{103} = 9.73, p < .01; Task 2: t_{102} = 9.82, p <.01) than the control device. They was perceived as more attractive only in with the skill-based game (Task 1: t_{103} = 6.83, p < .01; Task 2: *ns.*).

Regarding the subjective component, hand-gestures interactions trigger more positive (Task 1: t_{103} = 3.07, p < .01; Task 2: *ns.*) and more intense experiences (Task 1: t_{103} = 2.36, p < .05; Task 2: *ns.*) than the control interaction, but only with the skill-based game.

Finally, for the motivational component of emotions, hand-gesture interactions trigger more explicit approach (Task 1: t_{103} = 5.03, p < .01; Task 2: *ns.*) and less explicit avoidance (Task 1: t_{103} = -2.42, p < .05; Task 2: *ns.*) than the control device but, once again, only with the skill-based game.

E. Discussion

Overall, the results validate the hypothesis of more valenced and more intense emotions triggered by innovative products. The results show that using a skill-based game with a hand-gesture interaction device will trigger more positive and intense emotions than a classic device such as a computer mouse on the cognitive, the subjective and the motivational components of emotions. However, it seems that the skill-based game is more inductive than the mapping application. This result could be due to the limited interaction in two dimensions of the mapping application which would decrease the effect of the interaction innovativeness. Another explanation is related to users' motivations. In the experimental condition, users are not self-motivated to achieve a goal, but rather submitted to the experimental demand. Then, because they were amused by the skill-based game, they were more elicited than with the mapping application.

However, the results of this study highlight the existence of differentiated components that make up the emotional phenomenon in the skill-based game. These components are independent but they are the different facets of the same emotional phenomenon. Thus, it is important to know that reducing emotions to only one component in UX studies is measuring only one of its facets.

In addition, these results highlight the interest of self-reported measures of emotions. Self-reported measures can differentiate the emotional states of the participants according the tasks. They also reveal cognitions and motivations related to the emotional phenomenon. Nevertheless, even if self-reported measures are useful, they have two main biases that concern the subjectivity of users' answers. Indeed, because there is a delay between the emotion and its measure, participants must remember what they have felt. Thus this measure is not as precise as instant measures. The participant could also be complacent and respond to what experimenters were expecting. The second bias of self-reported measures is related to the words used in surveys. Surveys are forced-choice procedures that request annotators to assign one label out of a set of possible labels defined by the experimenters. However, an important bias of these procedures is the meaning of these words. A common example is that participants used to fail to distinguish surprise and fear in Ekman's basic emotional categories.

Taking into account the potential biases of users' self-reported measures of emotion, the second part of this project is to use Affective Computing solutions to overcome them. In this perspective, the developments of the works are oriented in two particular directions : self-annotations and nonverbal measures [26].

III. Development of Emotion Assessement Tools

Two tools were created in order to overcome the flaws of self-reported measures in UX studies. The first, Oudjat, aims to reduce the subjectivity of users' answers with a video of self-annotated emotions. It allows users to watch their own expressions and attitudes to choose the correct answer. The second, EmoLyse, is a nonverbal self-report tool that aims to measure the motivational component of emotions.

A. Oudjat: Verbal Self-Annotation of Emotions

The self-annotation procedure consists in recording the UX of users and after to ask them to recognize the emotions felt [27]. This procedure is relevant to evaluate and to measure behaviors, emotions and perceptions [28]. It also reduces the subjectivity of self-reports because it helps users remember their emotions and they transcribe their answers to objective clues such as facial expressions, body posture and speech. However, the available tools seem to be torn between usability and configurability. Some tools allow very precise annotations but they are hard to use by naïve participants (e.g. Nvivo [29] or Anvil [30]). Other tools are easy to use but they cannot be configured according experiment requirements (e.g. Gtrace [31] or Carma [32] are specific for dimension annotations).

Considering advantages and weaknesses of existing annotation tools and keeping in mind the different specifications needed for annotation experiments, Oudjat has been designed to be both easy to use by naïve users and easy to configure by experimenters.

Oudjat is an open-source annotation software which integrates experimental options that might be required by annotation experiments [33]. It provides an interface to configure the experiment such as language, dependent variables, independent variables and stimuli selection (Fig. 3).

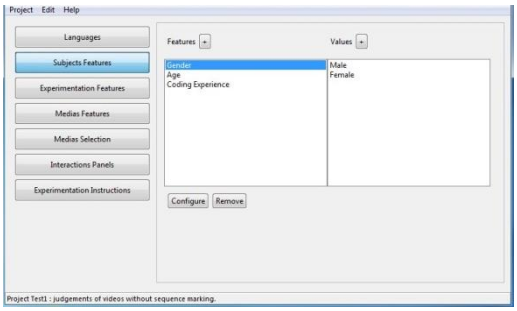

Fig. 3. Oudjat's configuration interface. The experimenter can easily set up all the experiment criteria such as languages, dependent and independent variables, type of annotator responses (e.g. buttons, scales, free labeling) and instructions.

After defining the configuration of the experiment, Oudjat generates a simple annotation interface for users which displays only instructions, answers and recordings (Fig. 4).

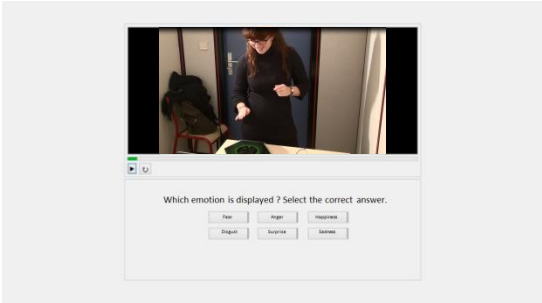

Fig. 4 . Oudjat's annotation interface. The interface displays only the relevant information to users: their own video, the task and the emotions to assess.

The self-annotation procedure is a special case of Oudjat possibilities. In this case, experimenters could set up their experiment and afterward import the recordings. Then, users are recorded and they had to watch their own UX in order to recognize their own emotions. Therefore Oudjat could be a relevant solution to overcome the bias of users/annotators subjectivity in self-reports. Users can easily use it to report their emotions based on objective observations.

However, despite its advantages, the self-annotation procedure is still a verbal measure of emotion based on a forced-choice procedure. It does not resolve the second bias previously highlighted because the choice of the word displayed will partially determine users' answers. Consequently, to overcome this bias the second perspective is to propose a nonverbal measure of emotions named EmoLyse.

B. EmoLyse: Nonverbal Self-Annotation of the Motivational Component of Emotions

Nonverbal self-reports are a possible alternative to measure emotions without using surveys rather than presenting emotional words, these tools display illustrations of avatars experiencing an emotion. The participants' task is to select the avatar corresponding to their emotion. As verbal self-reported measures, these can be either dimensional like the Self-Assessment Manikin or SAM [34], [35] and the AffectButton [36] or categorical like the PrEmo tool [37].

The emotional measure of nonverbal self-reports is less explicit than verbal ones. With figurative representations of avatars, it is possible to accurately assess the emotion felt. Nevertheless, the existing nonverbal tools mainly evaluate the subjective component of emotions with dimensions or with categories. But it is possible to measure emotion through other components such as shown in the previous study. Among the potential components, the motivational component appears to be particularly relevant to measure.

Emotion's primary function is to assist individuals to reach their goals by taking into account contextual factors of the situation. Emotions would "motivate" human behavior. Thus to Frijda [10], emotions reveal states of action readiness that are states in which individuals are willing to change or maintain their relationship with a stimulus (e.g. with someone or with a product). For example, the main action readinesses are states of approach and avoidance [38]. The approach action readiness is triggered by pleasant stimulations and it eases the relationship whereas the avoidance action readiness is triggered by unpleasant stimulations, and hampers the relationship [39]. Therefore, the motivational component appears to be an essential measure in UX studies because the UX evaluates the relationship (i.e. the interaction) between users and their products.

However, tools evaluating the motivational component of emotion are underrepresented in nonverbal self-report measures. Some devices were designed to evaluate approach-avoidance states (e.g. joysticks and sliders) but there are little figurative tools to measure action readiness. Therefore, the objective of this research is to develop and validate a tool which would assess the motivational component of emotions triggered by UX. EmoLyse is derived from the Simon Test and from sliders (Fig. 5).

Fig. 5. Representation of user interactions with EmoLyse. The app displays an avatar and a picture of previously tested products. Users were asked to choose the avatar's posture corresponding to the emotion felt during the actual use of the product. If users felt avoidance feelings, they are expected to choose a position displaying avoidance. If they felt approach feelings, they will choose a position close to the product with corresponding body and arms inclinations.

It is a browser-based application in which an avatar is manipulated to represents specific body postures. According to

users' feelings, they can tactilely represent postures of approach or avoidance with the products previous use.

Approach and avoidance measures represented by the avatar's posture are made accordingly to three indicators: the distance to the object, the inclination of the torso and the inclination of the arms. The distance to the object is used to basically represent users' approach or avoidance tendencies. The inclination of the torso is an indicator of users' involvement. Finally the inclination of the arms reflects users' will to get the product. At the moment, the beta version of EmoLyse is on the verge of being finalized and it needs to be tested to ensure that body posture indicators appropriately reflect the expected measure.

IV. Conclusion & Perspectives

It now seems evident that emotional measures are decisive in UX studies. Emotions are a clue indicator of a product's potential commercial success. However, understanding what emotions are is still a stake in UX studies. Words as *satisfaction* or *hedonism* are used to analyze emotions whereas they do not reflect the complexity of emotions. Indeed, emotions are made of five independent components. They can be measured with classic self-reports (except for the physiological component) but they have two major biases. The first bias is the subjective part of self-reported measure of emotions. The second bias is the selection of emotional words in forced-choice surveys.

To overcome these biases, Affective Computing solutions were developed through dedicated tools. The first tool was created to assist self-annotation procedures in UX studies. It allows users to watch their recorded UX and to recognize their emotions. This tool, named Oudjat, is easy to configure and to use for annotations. The second tool was create to perform nonverbal self-reports. EmoLyse aims to evaluate the motivational component of emotions through the measuring of approach and avoidance. It allows users to represent avatar's postures corresponding to what they felt.

The development of tools and applications show that the questions of "what are emotions?" and "how to measure them?" remain issues that are not yet resolved. The use of traditional surveys is still widely used but new measurement prospects using Affective Computing can be studied.

Considering the future perspectives of these studies, measuring users' action-readiness is a possible way of improvement which must be considered. Thus, Oudjat and EmoLyse could provide study tracks. For example, Oudjat could be set up for action readiness annotations. These annotations could be compared to classic categorical annotation. The second track concerns the nonverbal self-reports. EmoLyse is a basic tool which consists in moving the avatar forward or backward and to roughly modify its posture. Assessing body postures in UX studies appears to be particularly relevant. The literature in the embodiment field [40] and works on emotion expressions thought postures [41]–[43] have now revealed that individuals' postures in natural situations reflects their thoughts and their emotions. The Affective Computing has rightly used these finding to model virtual avatar in order to accurately interact with humans [44], [45]. Affective computing could be of valuable help to measure emotions in UX studies in order to refine more possibilities and create a richer interaction with users. More particularly, it could be possible to combine the existing nonverbal self-reports to simultaneously assess many components. For example, a tool such as EmoLyse could be combined with PrEmo to represent not only action readiness postures but also categorical emotion representations.

Oudjat and EmoLyse are open-source software. Oudjat can be downloaded from https://dynemo.upmf-grenoble.fr/tools/ and EmoLyse from https://github.com/Emolyse/. With the development of these tools, the perspective is to open new opportunities for Affective Computing in UX studies.

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