



MEASURING EMOTIONAL USER EXPERIENCE WITH VIRTUAL AND TANGIBLE PRODUCTS

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Abstract: Emotional impressions that a product create in the consumers are crucial in deciding whether this product can be purchased and used or not. Therefore, emotional user experience and its measurement are very important for designing virtual and tangible products. The factors influencing user's affective states and emotional user experience with virtual and tangible products like visual, sound, kinaesthetic stimuli are presented and discussed. The mathematical models most appropriate for processing emotional user experience data are multivariate statistical models, fuzzy sets, neural networks and swarm optimization models. The tools for measuring emotional user experience like questionnaires, emotion cards, face recognition, eye tracking, EEG are presented and discussed. The approaches for measuring emotional user experience with products are reviewed. Special attention was paid to Kansei Engineering approach. Further research directions for measuring emotional user experience with virtual and tangible products oriented to their design are outlined. Very promising for measuring emotional user experience are the tools and approaches using user's brain waves.

Keywords: Emotional user experience, affective states, measurement methods, design, brain waves, virtual and tangible products.

1. Introduction

Designing products with attractive appearance for consumers requires knowledge on emotional user experience (eUX) that these products generate. For integration of "affective" states in product design the measurement of the impact of product's characteristics on consumers is needed. In this paper the emotional states of users during their interaction with products were observed and data measured, processed and analysed. Different approaches for measuring emotional state of users during their interaction with virtual and tangible products are reviewed.

First type of objects reviewed are tangible industrial products like packages 23,26, mobile phones 5, automated teller machines 8 or typeface design. Second type of objects reviewed are virtual products like MP3-player skins 7,8, commercial videos 21, sound stimuli 13, virtual computer games 31 or websites.

Our final goal is to identify the factors that have positive emotional impact on consumers during their contact with a product and to develop a methodology for creating emotional user experience product design.

2. Factors Influencing Emotional User Experience

When creating a new product, it is most likely to be preferred by user if it's attractive then it has an ugly appearance 10,22,26. But what makes the products attractive?

Neurological studies show that 90% of all incoming information into human brain is provided by the vision 29. But all what users see and determine their preferred products is actually a visual illusion. At any time users' brains interpret in their own way every detail that we see in the world around 33. So, we need to cause the brain to realize what the eyes see, as a product, that the user wants to have. For this purpose more than 20 design elements like moving or still images 4,23, videos 20,21, colours 10,26, graphic symbols, logos, words, fonts and another verbal elements 4, diagrams, charts, models 14 can be used as visual stimuli. They can evoke users' joy experience and cause pleasant emotions 33. User's brain rates as pleasing these visual elements which are harmonious, friendly, sexy or that make the user to want to hold (cf. Fig.1).



Fig.1. Visual elements associated with joy

The visual elements that influence user’s emotions can be successfully complemented by **sound stimuli** like sounds 24,25, music and acoustic surrounding 13,20. Sound stimuli creating positive emotions can be used by designers to create products leading the users to their purchase 7.

Another group of factors that stimulate users to buy and use the products are the **kinaesthetic stimuli** like touching, flavour and smell 15. The fragrance is a stimulus to which designers still view with suspicion, but it is the only factor that interacts directly with the user’s consciousness. The smell is capable to cause intolerable disgust or unique pleasure within milliseconds 37. The flavour of a product causing positive user experience can be different for specific users. Customers can determine what they prefer, but they often have difficulties to determine why 10 (cf. Fig.2).

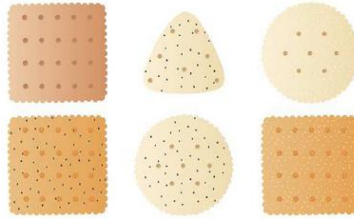


Fig.2. User experience study of interaction with crackers that varied in shape, flavour and topping 10

The user can interact directly with a product by **touching** it. This provides direct tangibility and produces sense of objectivity. The brain assumes that when user touches something, it becomes his property. Studies show that users who touch a product are more likely to buy it than if they just watch at it 37.

Upon measuring user experience with virtual products it is difficult to create a real sense of touch, smell and flavour. Recent research is increasingly measuring users’ behavior to study users by their virtual activities or by interaction with other users 31.

The research papers examined above show that the methods for measuring user experience are suitable to be used for tracking the impact of any design elements or combinations of elements on user. Choosing the right influencing factor can support conducting a successful measurement of user experience.

Biophysiological factors influencing emotional user experience are galvanic skin response, heart rate, speech. Research on emotional speech focuses on acoustic features like pitch (level, range and variability) and speaking rate. People express their feelings by the acoustic features and by the content of what they want to say (words, phrases and syntactic structures). The use of speech recognition techniques is helpful as the user’s tone and intonation depicts the emotional state of the user. **Motor behavioural** measurement methods are based on the fact that the body usually responds physically to an emotion (e.g. changes in muscle tension, coordination, strength, frequency). **Body gestures and movements** refer to the different positions of the body and their changes over a period of time can help to study emotional user experience. Detecting and recognising **biological signals** is an essential aspect of emotion recognition. For example, a sensor system measuring biosignals such as heart rate, skin conductivity, respiration, temperature, pulse, electrical activity in the muscles, etc. can be used for detection of various emotional states of user.

3. Modelling Emotional User Experience

In the following the most appropriate models for analysis of data gathered from user behaviour and experience with virtual and tangible products will be pointed out. When sample size is greater than 10 times the number of variables multivariate statistical models like multiple regression and discriminant analysis are applicable 14.

When sample size is limited computational intelligence optimization models 6 for eUX data like fuzzy systems, neural networks and swarm optimization models are recommended. Fuzzy systems mimic the way people think by defining and using fuzzy rules. There are many ways for determining fuzzy rules, combining the outputs of several fuzzy rules and defuzzifying the output. In eUX area often is difficult or impossible to define fuzzy rules. Artificial neural networks are better by means that they do not require to define fuzzy rules. They mimic the biological processes in human brain. Neural networks can be trained to learn the behavior of product users. Swarm Intelligence is a computational intelligence technique based on the collective behavior of animals in nature such as birds, fishes, bees, ants and wasps. It can be used for analysing behavior of product user by processing their eUX data.

4. Tools for Measuring Emotional User Experience

There are more than hundred different types of tools for collecting user experience data 34. Their choice depends on the stage of the product development, the purpose of this product, the place where the test is conducted, the number of participants and a lot of other factors.

Most often used tools are the **questionnaires**. They are suitable for the study of user experience with virtual products like MP3-player skins, web site design etc. and with tangible products like packages. For example, for study the interaction of users with virtual products data on the attitude of the subjects during the selection of MP3-player skin can be collected. Quite widely are used questionnaires to survey the interaction of users with tangible products. With their help are collected data on the main positive and negative buying emotions such as satisfaction, joy, pleasure, expectancy, excitement, desire, relax, interest, arousal, flatulency, appreciation, suspicion, vexation, boredom, guilty, displeasure or is investigated users' involvement level by contact with visual and verbal elements of a package 11. In some cases, questionnaires are combined with tools for self-report by a cartoon depiction of the emotional state 5. In combinations with focus groups, interviews, or other methods for thinking aloud, the questionnaires are also used for a detailed study of package design impact on users' behavior.

When the products tested are at the initial design phase and we are looking for dynamic study of users' opinion and emotion, convenient method of research is the **focus group**. It includes specialists, university students 20,31, or people with experience in the working area. A moderator leads the group conversations, seeks for attitudes, beliefs, desires, and reactions of users. The data obtained in this way is qualitative, and consists of experience, opinions, ideas 3. In some studies focus groups in combination with emotional self-reporting are used, in order to monitor the experiences when a human and computer interact 29,31.

In studies aimed at reducing the amount of text data collected focusing on emotional state of the user tools like **Emotion cards** are used (cf. Fig.3). They are self-reporting tools that can be used physically or digitally, e.g. contain number of words or combinations of pictures and words that dynamically describe users' emotion. The newest version of this tool is constructed as online report or mobile application. The subjects of the research must be able easy to find and quick to fill in paper or digital cards 34.

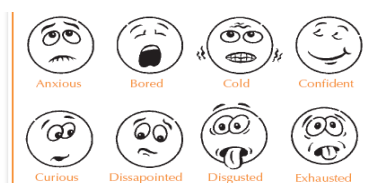


Fig.3. Part of Emotion cards for valuating users' emotional strength 35

Another tool for emotional user experience measurement and report is PrEmo. It excludes the use of words. For the description of the emotions simple animations are used (cf. Fig.4). PrEmo is applied cross-culturally with users of all ages, education and working spheres. Its self-report allows users to describe both negative and positive experience at the same time 39.

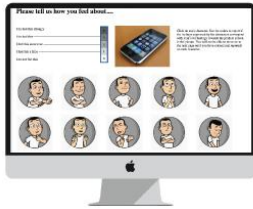
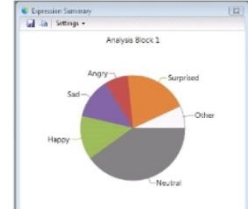


Fig.4. PrEmo tool – on the desktop and tablet 39



Fig.5. FaceReader™ tool



During the user experience survey the participants rarely remain still and expressionless. When the emotional expressions of the users are observed in detail, then may be noticed that the subjects can laugh, shout, face, smile, frown, disperse, or nervously crush his fingers. These are all **behaviours** that we can describe and measure 1.

The most expressive part of the human body is the face. An objective approach for studying users' preferences to different characteristics of a product as appearance, shape, flavor and topping 10 during users' interaction with tangible products is the **face recognition**. It can help to understand how important are different visual factors for generating positive emotions of buyers 20,23. For this purpose, increasingly mobile EEG devices are used. fMRI devices are used to investigate the behavioral, neural, and psychological properties of package design 26. **FaceReader** is a tool for recognition of user emotions by facial expressions (cf. Fig.5) into one of six categories: joy, anger, sadness, surprise, fear and disgust 23.

An alternative way analyse facial expressions is the use of **electromyogram** sensors, which measure the electrical activity in certain muscles of the person responsible for frowning or smiling 1.

Eye tracking method for measuring the user experience captures the location of the subjects' eyes on a fixed surface until the user receives visual stimuli. The position of the eyes is determined at regular intervals of time and then is superimposed like heat map or points on the image of incentives 2. The time that the users' eyes remain on specific area is determined as a percentage of the total time spent on study. Researchers must be able to monitor the participants if they are really engaged with a task 1.



Fig.6 Eye tracking tool 36



Fig.7 Specialized mobile EEG device 38

In some studies of user experience the tracking of **verbal behavior** of the participants is used. It is believed that thus data on both emotional and mental state of the subject can be obtained. The comments of the users until their interaction with the product are recorded and analysed and subsequently classified as positive, negative or neutral. For a thorough study of the sound data can be monitored features such as pitch, log energy, formant, mel-band energies, mel frequency cepstral coefficients and velocity/acceleration of pitch 12.

Increasingly, the user experience specialists started to study human emotions by **EEG** devices 20 or specialized devices that convert raw EEG data into affective states data which are convenient for processing and analysis 4,10,21 (cf. Fig.7). The electroencephalograph (EEG) measures the

voltage between electrodes on the scalp. Electrodes are placed at specific positions on the head of the user 17. In different studies their number ranges from 2 to over 100. The mobile EEG devices are used equally successfully in the laboratory and in field studies. With their help can be explored both virtual and tangible products 4,13,20. The further development of these tools continues, also research to find connection between brain response and users behavior with the aim to distinguish more precisely which design elements of the market products are related to user's positive emotions.

As a conclusion it could be stated that there are not strict rules for user experience measurement methods or tools selection. The choice depends on the characteristics of the products, on the development phase, on the capacity of researchers and the needs of these studies.

5. Approaches for Measuring eUX with Products

During the past decade many different approaches for measurement of user experience were developed. Discussed here approaches are used as stand-alone or combinations of them 8,21. The basic approaches for measuring user experience are of subjective nature which are based on observations of users data obtained from surveyed parties 16,30. The next step in the development of approaches for measuring user experience is the use of objective physiological and biometric data stand-alone and in combination with subjective approaches 16.

When the user interacts with virtual products an arousal-valence emotion model using data of the users' brain activity can be applied. By music and sound stimuli 16 or short videos 20 for predicting the consumers' choices in the online shopping emotional responses to marketing video media can be studied. The EEG-measurement can be combined with questionnaires in the study of the users' reaction during the visualization of short advertising movies.

One of the newest and emerging approaches for measuring emotional user experience is Kansei engineering (KE) 19. It translates user feelings and impressions into product design parameters. KE has been successfully applied to incorporate the emotional appeal in the product design ranging from physical consumer products like cars, household, food industry and services 4,9,26 to IT artifacts 24,28. For example, package KE tries to identify the Kansei value of packages that triggers and mediates desired emotional response. The KE process implements different techniques to link product emotions with product properties 5. Integrating the affective values in product design requires the introduction of suitable methods into companies' product design processes, which can capture and convert subjective and even unconscious feelings about a product into specific design elements 9,27,32. Checklist/questionnaires tool measuring the emotional impact of product on users can identify affective values and translate them into specific design solutions for product.

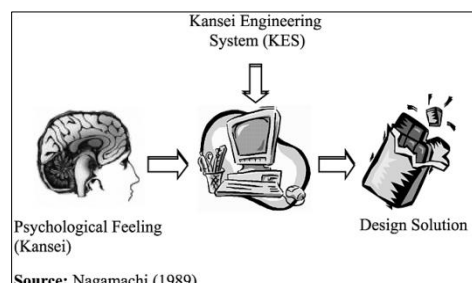


Fig.8. Kansei model 18

6. Conclusions

This paper showed that there are subjective, objective and combined approaches for measuring emotional user experience. They can be successfully applied as well with virtual, as with tangible products. The examined cases confirmed that the advanced measurement methods provide reliable data, suitable for processing and analysis. There are over one hundred different methods and tools to measure the user experience and they can be used - both individually and in



combination. The obtained data are available to be used as a prerequisite or recommendation to create products with attractive appearance for the consumers. This conducted overview will serve as a basis for further study of larger user experience measurement by interaction with a product in a particular branch of industry. Very promising further research direction for measuring emotional user experience with virtual and tangible products oriented to their design could be tools and approaches using user's brain waves.

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