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MEETING PARK FORUM
HELSINKI, FINLAND

-CONFERENCE PROCEEDINGS-

BOOK 2
VOLUME 1

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DESIGN, TECHNOLOGY AND EMOTION MEASUREMENT

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ABSTRACT

Emotion is a complex field with growing attention from several other fields of research. Recent scientific discoveries in Neuroscience and Affective Computing are providing insights on the most hidden and unconscious mental processes. By measuring what people experience when using a product, designers can gather useful data that aids them understanding their needs and expectations [1]. Due to the contribution of this new knowledge, Design faces new challenges and great opportunities to evolve.

Although information on research methods for measuring emotions is readily accessible in books, scientific journals, websites, among others, no data was found in a coherent and comprehensive manner to manage all. As a result, this article is intended as a framework for three distinct methods for physiology measurement – Eye tracking, Galvanic Skin Response and Facial expression analysis, which resort to sophisticated sensor-based equipment to track specific functions of the human body, namely, pupil dilation, conductivity of the skin and facial behavior. These equipment are becoming affordable, less evasive and portable, making possible field experiments and remote research [2]. These methods were elected because they offer researchers unique paths to explore unconscious behavior. Thus, they are valuable to assess emotional states — prior studies found evidence of patterns in physiological responses for specific emotions [3].

In order to explore these issues, material from books and academic research was gathered and studied. Each method is described, some studies are pointed out and recommendations are given. The literature revealed that these methods provide valuable insights about bodily responses, but they have limitations and disadvantages. Furthermore, it requires technical expertise, knowledge about research planning and analysis of the acquired data sets. Nevertheless, published findings support that the true power of these methods unfolds as they are combined with each other.

The main purpose of this article is to briefly inform designers and researchers about specific techniques and equipment available for emotion measurement in order to aid them in making more informed decisions. In addition, it is aimed to encourage different approaches in Design research in order to develop better products and experiences. Future prospects for Design are also discussed.

Keywords: Design, Emotions, Eye Tracking, Galvanic Skin Response, Facial Expression Analysis.

INTRODUCTION

How can designers create pleasurable and meaningful experiences? How can designers understand what people want? Positive and negative emotions that people experience when using a product are viable entry points to understand their needs and expectations and can also provide insights about pleasure and enjoyment that products trigger [1]. Therefore, emotional measurement can generate useful data to improve and design better products.

Studying emotions is not simple though, they vary and have different intensities. Nonetheless, studies of emotional processes in human body and advances in the fields of Affective Computing and Neuroscience are enhancing the way researchers collect and analyze data. This has led to an increasing application of technological devices to several fields of research. The available equipment helps to demystify bodily processes that cannot be consciously controlled, opening new paths for designers to include other sciences into Design practice.

Hence, it is necessary to know the available methodologies and understand its potentialities and drawbacks to opt for the best solutions and take full advantage of them. Thoring *et al.* [2] provide a literature-based overview about technologies for emotion measurement and suggest a framework to serve as a guideline for researchers. They argue that one of the main advantages of using different technologies is the possibility for triangulation of different data sources.

Following this line of thought, it was decided to collect and explore information about three specific methods for physiology measurement: Eye tracking, Galvanic Skin Response and Facial expression analysis. They all provide important metrics to understand emotions.

Present research

The purpose of this article was to provide an overview for designers, students, researchers, and practitioners who are not specialists in these particular approaches. It was gather material from academic research and study, books, among other sources. The paper will first introduce some important concepts related to emotions and the brain. The next sections will approach three distinct methods that resort to technological equipment: it will be discussed what they are, what they measure, and some studies will be pointed out. Finally, the paper concludes with a general discussion and avenues for future research are mentioned.

THE EMOCIONAL BRAIN

In emotional situations the body acts and triggers responses automatically — the heart pounds, flutters, stops and drops; palms sweat; muscles tense and relax; blood boils; faces blush, flush, frown, and smile [4]. The autonomic nervous system (ANS) is one avenue for the brain to regulate the body internal environment — it carries the brain commands to the body internal organs and sends sensations back up to the brain [5]. More broadly, the autonomic nervous system can be separated in two subdivisions (figure 1):

- The sympathetic nervous system: associated with bodily indicators such as heart rate, breathing rate, sweating, digestion, hunger, pupil dilation, sexual arousal and responsible for motor action ("fight or flight") that tells the body to spend its energy resources;

- The parasympathetic nervous system: regulates slowly changing processes associated with "rest and digest".

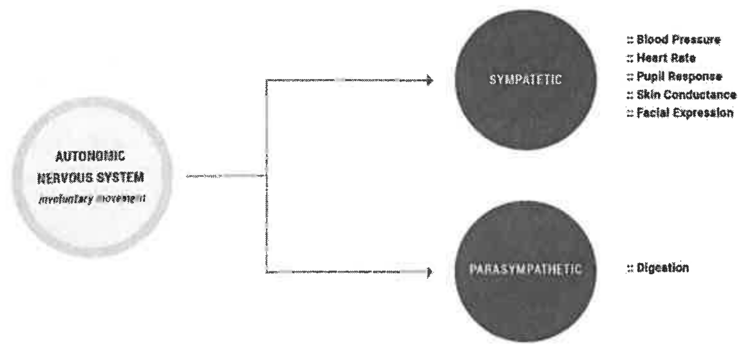

***Figure 1.** Components of ANS and bodily indicators.*

It is possible to study emotional processes in human brain and body through different technologies and approaches. The following sections describe three different methods that are being applied to measure emotions.

Eye tracking

Eye tracking holds out the promise of another window into the mind: the semi-magical ability to know what people are looking at [6]. This methodology – which has been applied to several fields of research e.g., human factors, cognitive psychology, marketing, human-computer interaction, among others – allows to detect what people see and where they look by tracking their eye movements and how long they fixate on a certain point, aiding researchers understand visual attention.

Commonly conducted with a device called an eye tracker (remote or wearable), eye tracking uses infrared light-emitting diodes and cameras to track and record where participant is looking, based on the relative position of the pupil center and corneal reflection [6].

A complete eye tracker system includes software that easily allow to produce visualizations of eye tracking data instantaneously. Usually, the most used visualizations are heatmaps (figure 2) and gaze plots that highlight where the person looked, the length of time and the gaze pattern their eyes followed. Using the words of Bojko [6]: "these visualizations are the eye candy of eye tracking".

***Figure 2.** Heatmap from a PhD student research project.*

Eye tracking has over a hundred metrics: the most used for analysis are fixation duration, dwell time and number of fixations. One of the measures that is useful for emotional measurement is the information about pupil diameter, since research suggests that pupil dilation is determined by emotional arousal [7].

This method is being applied in marketing studies to understand consumers´ visual attention behavior in different settings. But it also appears that researchers are taking different approaches: Cho [8] explored the visual behavior of people when glancing at a detached house and Agost *et al.* [9] studied the impact that context, through different decoration styles, had on the subjective impressions evoked by a particular ceramic floor.

Well, researchers do recognize that eye tracking reveals important information about how people see, but they know that it is not enough. The Achilles´ heel of eye tracking is that it does not reveal the reasons why people stare to visual stimuli. Hence, it is necessary to resort to other methods, seeking for more information to establish connections between data to better understand visual behavior.

Galvanic Skin Response

The skin is the largest organ of the human body and it is a rich source of information about what people are thinking and feeling. Sweating on hands and feet is triggered when arousal increases — physiological low conductivity is associated to emotional states such as calm relaxation or deactivating depression, whereas high conductivity relates to states that include hot anger or exuberant joy [10].

Also known as Skin Conductance (SC), Electrodermal Activiy (EDA), Electrodermal Response (EDR), and Psychogalvanic Reflex (PGR), Galvanic Skin Response (GSR) reflects subtle variations in the electrical characteristics of the skin. It is generally measured by applying two electrodes in the surface of the skin, using a conductive gel to improve the conductivity between the skin and the electrode. Phasic skin conductance measurements can be interpreted as a direct arousal response to stimuli, e.g., sounds and images. Generally, when an emotionally arousing stimulus event occurs, the variations in the phasic component are visible as rapid signal increases, named "peaks", also referred as Skin Conductance Responses (SCRs) — figure 3.

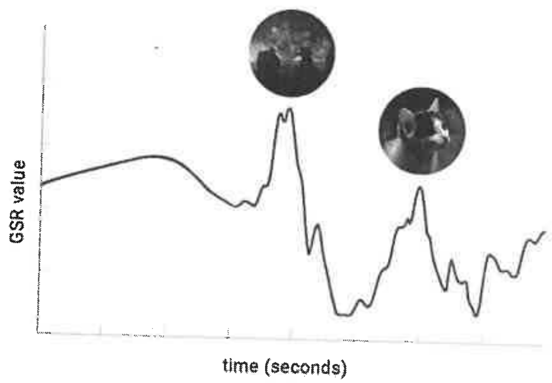

Figure 3. *GSR shows peaks in emotionally arousing content.*

However, GSR per se cannot determine if the arousal was due to positive or negative content — it only tells if a person is activated or not. Jeon [11] points out other downsides of this approach: physiological sensors are intrusive; mapping between sensing data and a specific emotional state is not robust and other practical issues observed in research, e.g. hairy skin, different size of body part and sweating in the summer.

Reported in practically all psychology, psychiatry, and psychophysiology research journals, GSR has been one of the most widely used response systems in the history of psychophysiology and it has been applied to several questions from basic research examining attention, information processing and emotion, to more applied clinical research examining predictors and/or correlates of normal and abnormal behavior [4].

Design studies are also embedding GSR and the results are positive. Trujillo *et al.* [12] explored how an Immersive Virtual Environment influence people´s emotions. The authors considered that GSR was an appropriate tool to quantify emotional states inside environments and it has potential for the development of emotional cartographic. From other perspective, Moreira *et al.* [13] used GSR to understand consumers' perception regarding car exterior designs and they encourage the use of more physiological measurements to interpret their attention or emotional nature.

Facial Expression Analysis

Human face can produce thousands of different facial behaviors and configurations through 20 structurally independent muscles, which may function independently of each other or as a group. Produced by muscle contractions, facial behaviors change the shape of features by producing appearance changes in wrinkle patterns, bulges of skin, dimpling, and other observable, rapid signs [14].

Affectiva's Affdex technology, Insights (nViso) and FaceReader (Noldus Information Technology) are some examples of commercial software for automated facial image analysis — a technique that is used to measure facial expression that has the advantage of not requiring sensors. These solutions resort to embedded cameras in laptops, tablets and mobile phones or stand-alone webcams and they are capable of recognizing facial expression patterns through the caption of video (online or offline) or images.

The implemented algorithms in the software have been developed based on Ekman and Friesen´s Facial Action Coding System (FACS). The latter is a measurement system that allows a modular construction of emotions based on the combination of Action Units (AU): each AU matches an individual face muscle or muscle group. As illustrated in figure 4, happiness results from a combination of AU 6 (Cheek Raiser) with AU 12 (Lip Corner Puller — commonly referred to a smile).

***Figure 4.** Happiness.*

Each analysis software differs by metrics but in general they all include outputs related to seven basic emotions (joy, anger, disgust, surprise, fear, sadness, contempt); valence; arousal; appearance (age, gender, ethnicity), face tracking and head angle estimation.

Automated facial image analysis is a powerful visual method to convey emotions but according to Hwang and Matsumoto [14] it is not easy to analyze emotions on faces across ethnicities because some ethnic groups have slightly different facial structures and baselines — Asian upper faces are less easy to detect the intensity and appearance changes of certain muscles in comparison with European upper faces due to the different bone and skin features. Moreover, the authors highlight other difficulties: training and the need for certifying developers; analyzing facial expressions frame by frame; setting up videos and using research methodologies to capture facial movements validity.

CONCLUSION

With a broader sense of the available technology and a brief knowledge on the procedures, it can be concluded that these methods offer solutions for a variety of scenarios: they allow to conduct experiments in research labs or real life.

This study also evidenced that the analysed approaches can help answering research questions about people and the mechanisms that underlie emotions, but they have limitations. Oddly, looking at the current state of literature in Design, it seems that these methods are underutilized. Some major reasons can be suggested: these methods are time-consuming; it is required knowledge and technical expertise; recruitment of participants could be challenging; lack of funds.

Despite of the potential of Eye tracking, GSR and Facial expression analysis, there are still questions to improve and to solve. Hwang and Matsumoto [14] mentioned that they do not believe in the existence of automated solutions that can access the complexity and sophistication of facial expressions. However, technology will keep evolving and better solutions will be created.

Indeed, researchers are developing more portable and less evasive devices along with software which offers easy access to data. For example, created by Empatica, the E4 wristband is an unobtrusive monitoring wearable research device that offers

real-time physiological data acquisition and software for in-depth analysis and visualization. As another example, the company Emotiv offer products to brain measuring that use a sensor technology that does not require extensive preparation and conductive materials.

At the same time, software management tools that explore the potential of combining multiple technologies, such as iMotions, are starting to emerge. Researchers argue that studies can be empowered by the use of multiple technologies and are combining methods or even creating new ones: Roza and Postolache [15] designed a mobile application for emotions' analysis using electrocardiography and GSR.

Eye tracking, GSR and Facial expression analysis provides insights that vary with emotional valence, i.e., emotions can be either positive or negative, but the technologies alone do not enable the identification of a specific emotion. We believe that the triangulation of emotional data from these three technologies will lead to the finding of patterns and detailed relationships between changes in physiological activity and the displayed emotion that will lead to a better understanding of what people feel — thus, improving product development process.

In addition, we consider that crossing information from related areas could also contribute with valuable information to improve emotion measurement. For instance, Wearable Technology is a category that is using biometrics, such as heart rate, to monitor emotions.

Understanding and predicting emotions is and will remain a challenging work. Designers and academicians have numerous opportunities to explore in future researches and a number of obstacles to overcome. The premise of this study is that knowledge is power, but its purpose was also to encourage designers leaving their comfort zones by searching other fields of research and instigate them to try more interdisciplinary scientific research to understand people's perception of products in order to create better experiences.

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