SIMPLE MEASUREMENT OF USER RESPONSE

Melanie Steiner and Dieter Meiller
Ostbayerische Technische Hochschule (OTH) Amberg-Weiden
Kaiser-Wilhelm-Ring 23, 92224, Amberg, Germany

ABSTRACT

This article deals with the measurement of human reactions for the evaluation of the user experience, the user experience when using software. The basic question behind this is how our increasingly activating systems can be evaluated even better in terms of the user. We can think of applications with augmented reality, mixed reality or virtual reality approaches, as well as those that use AI algorithms and thus change noticeably for the user with each use, or even for special approaches such as persuasive design. From the perspective of the user experience concept, the human being is the focus of consideration. Accordingly, knowledge of his behavior, his reactions, his emotions, is essential for the development and improvement of digital products. Here, not only proven methods such as usability testing, observation, questioning, etc. are used, but also reactions of the human body are considered in the context of evaluating a human-machine interaction. The article presents 10 methods from the multitude of possible procedures with a short description. It discusses their applicability in terms of user experience evaluation and clusters the methods by type for a good overview.

KEYWORDS

User Experience, Measurement of Human Reactions, Software Engineering, Evaluation, Electrical Activity

1. INTRODUCTION

Contemporary software development follows the principles of the user experience concept and uses the human-centered design process (HCD) for this purpose. The methods used in the evaluation phase range from usability tests, observation and surveys to psychophysical methods such as eye tracking. In recent years, however, many other evaluation methods have been gaining ground that have been used for decades in medicine and psychology to make body reactions measurable and interpretable in a proven manner. However, the measurement of body reactions for the evaluation of people or the customer journey have already become firmly established in neuromarketing.

The background of this development is the improvement and simplification of the measurement systems for body reactions. For this purpose, the handling of hardware and software has also been adapted for layman use. There are also many offers of measurement systems that can be used 24 hours a day and in a mobile context (e.g. pulse watch).

Another important aspect is the simple access to the relevant measurement methods. If we think of pulse measurement, for example, simple wearables for home use are now available to everyone from pharmacies, retailers and the Internet without any great effort or queries to the doctor. The costs are very low compared to professional devices used for clinical diagnostics.

Also, for laboratory tests (e.g. urine tests) more and more simple offers for everyone are offered in the meantime. These can be performed at home with instructions and then sent to a laboratory for evaluation. The results are then often made available in digital and visually appealing form. Such tests are generally not suitable for medical diagnostics. However, they can be used in an evaluation context, as they can clearly show trends in user responses.

Despite this strong simplification such systems and tests supply useful results which can be used in the context of the software evaluation. Depending on the research question and study design, however, careful consideration should be given to which systems and tests are used. Also, with regard to a study design that is to work with several different body reactions and the results to be obtained from them, is now associated with feasible effort. For the latter, multi-measurement systems are the obvious choice.

2. STRAIGHTFORWARD MEASUREMENT OF HUMAN REACTIONS

Numerous methods can be used to measure human reactions. The first step is therefore to formulate the specific question and the survey scope in detail. Particularly for use in software evaluation, methods and procedures are usually required that require little effort on the part of the users and also for the study design.

Another aspect for the use of simple systems is their mobile suitability. Systems designed for everyone often offer quite good quality here, because the results from such measurements are offered as a basis for subsequent medical diagnostics.

To minimize barriers to participation in a User Experience (UX) study, the type of procedure also plays a significant role. In the following, 10 procedures are briefly described that are helpful for measuring body reactions. In this context, information is also given on whether the respective procedures are available as invasive (with needle) or as noninvasive methods.

2.1 Procedures of Measuring Body Response

The following 10 procedures for measuring body responses may be useful in analyzing human-computer interaction:

Table 1.

Procedure	Invasive / noninvasive procedure	Effort
Blood pressure (BP)	noninvasive	low
Blood glucose (BG)	invasive, less invasive	high
Blood oxigen saturation (BOS)	invasive, noninvasive	low
Electrocardiography (ECG)	noninvasive	middle
Electrodermal Activity (EDA)	noninvasive	low
Electroenzyphalography (EEG)	invasive, noninvasive	high
Electrocardiography (ECG)	nonivasive	middle
Elektromyography (EMG)	invasive, noninvasive	low
Electrooculography (EOG)	noninvasive	low
Pulse	noninvasive	low

2.2 Measuring the Blood Without or With Less Invasive Procedures

The measurement of pulse or blood pressure (BP) is widespread, uncomplicated, and therefore very common. The use of a finger clip electrode, wearables as a pulse volume wristband, in the form of a watch, or even as an arm cuff for measurement on the upper arm is also possible around user experience context. Wristbands and watches mostly use the photometric method by sending green light into the tissue. The light intensity of the reflected light portion serves as the basis for measuring fluctuations. When measuring blood pressure, the systolic blood pressure (SBP) as well as the diastolic blood pressure (DBP) are given as standard. Some devices also offer the value of the arterial medium pressure (AMP). Pulse pressure (pulse amplitude), the difference between SBP and DBP, is also a parameter that even mid-priced systems provide. The main determinants of these measurements are both cardiac function and vascular function (Weber 2010, p. 9-10).

The blood glucose level (BG) is also of interest for application in the UX context (nervousness, anxiety, etc. in the case of hypoglycemia). Here, a first distinction can be made between the classic invasive method of blood glucose measurement and methods without pricking for blood collection. There are measuring devices which, in combination with an enzyme-soaked test strip, make the applied blood measurable. Here, the blood glucose content is determined either photometrically, by light measurement, or by measuring the electrical conductivity (amperonic) in mmol/l (minimol per liter, used internationally). In Continuous Glucose Monitoring (CGM), a small sensor is implemented in the subfatty tissue. This then measures the sugar content of the tissue fluid at regular intervals. The data is usually transmitted to a cell phone app, which provides documentation, evaluation, visualization and age. Another technological procedure is flash glucose monitoring

(FGM). Here, too, a sensor is placed that provides data. However, an alert function is not implemented here (Schmeisl 2015, p. 21-32).

Blood oxygen saturation (BOS) is another option that is of particular interest for applications involving a lot of movement. In a diagnostic context, oxygen saturation is often determined by analyzing the blood. The focus is on the arterial oxygen saturation (SaO2) and the venous oxygen saturation (SvO2). However, simple pulse oximeters make the measurement easily tradable as a noninvasive method. Pulse oximetric oxygen saturation can be determined using photometric methods (SpO2) (Machetanz 2017). Electrodes and measuring devices are available for the finger, the forearm or, for example, integrated into wearables such as wristbands and watches.

2.3 Methods of Derivation of Electrical Activity

An Electrocardiograhpy (ECG) is a very proven method that derives electrical impulses of the heartbeat. The first considerations in this regard go back to Carlo Matteucci who was able to prove the connection of cardiac activity with electrical processes in pigeon experiments as early as 1843 (Diepgen et al. 1960, p. 64). Usually, special ECG electrodes are used for this purpose, which are placed at predefined locations close to the heart. Measurement by means of a chest strap is widely used. Here the heart rate, or more precisely the R-pulses, are measured by means of skin electrodes implemented in the belt. Manufacturers of special wearables already offer these electrodes implemented in clothing and wireless, so that they can also serve for mobile use (ECG T-shirt, Ambiotex GmbH, co-developed by the Technical University of Brandenburg, Germany). However, there are also variants of optical ECG measurement that are available as wristbands or watches and can be well integrated for use in the context of a software evaluation.

One method that is already well established and used in evaluation is electrooculography (EOG). This noninvasive method measures the change in resting retinal potential or eye movements. Electrodes are placed above and below or to the side of the eye. They measure the change in voltage between the front and back of the retina. The method can also be used with the eyes closed and provides results. For example, they are available for the UX context as wearable EOG glasses (Bulling 2008). Even though it seems to be the case, this method is rarely used in today's mobile eye trackers and can be applied as an alternative or combined method. Mobile head-mounted eye trackers usually rely on the corneal reflex method and thus the reflection of light sources on the cornea, as well as their distance to the pupil. Simple systems suitable for evaluation measure electrical resistance by means of 3 electrodes, with one electrode serving as a reference electrode.

A noninvasive method that can be used for evaluation is also the measurement of electrodermal activity (EDA) of the skin. In general, this includes all electrical phenomena that can be measured on the skin (Brown 1967). Such changes have been demonstrated since the 1940s, for example, during sleep. Changes of potentials between 2 measuring points reflect the phasic (active) electrical changes of a skin resistance curve. They can occur as a reaction to a specific stimulus, but can also have unspecific causes. The EDA gives an indication of the excitation of the sympathetic nervous system. The tonic (passive) activity of the skin can also be measured. It shows the activity of the sweat glands. Simple measurement systems provide dual electrodes that are placed on the user's fingers during use, for example. It is usually measured in microsiemens (μS), with a range of 0-25 μS providing sufficiently qualitative results for the UX context (Biosignalsplux 2023).Electromyography (EMG) is the appropriate imaging technique to measure the electrical activity of muscles and to draw conclusions about the reactions of users. Here, the changes in electrical membrane potentials of a muscle or muscle group are measured. It can be performed invasively or intramuscularly (iEMG, use of needle electrodes) as well as non-invasively. The latter variant is particularly suitable for evaluation.

The last method presented here is electroencephalography, or EEG for short. It measures the electrical activity of the brain and is a highly interesting method that is not only used in clinical diagnostics, but also in brain-computer interfaces. However, it is considered to be rather laborious, as it usually involves working with a system of 10-20 or 30-40 fixed in an EEG cap. Nevertheless, there are now EEG systems that use much fewer electrodes and simple adjustment using a rubber band on the head. Also, EEGs can be used in a UX context with low to moderate movement. However, too much movement of the head leads to artifact formation. EEG can be used as a non-invasive procedure, or with needle electrodes as an invasive procedure. It offers the possibility to provide qualitative measurement results over longer periods of time.

3. CONCLUSION

There is a wealth of methods from the medical and psychological fields that are also of great interest for the context of user experience evaluation. If a study design is created, the effort for a first overview of possible methods that can be considered for the study context is often very large and therefore there are still barriers to the use of body signal measurement. During the literature review, methods are described in detail and often in technical terms. The emphasis is on ease of use with acceptable quality of results. However, the presented review shows that there are now many technical solutions for home use. Depending on the use case, these are also suitable for UX evaluation and can be used there as a single or multi-system. They are suitable as in combination of proven methods such as the interview survey, the survey with questionnaires or an observation during the usability test.

REFERENCES

Beck, K. and Ralph, J., 1994, Patterns Generates Architectures. *Proceedings of European Conference of Object-Oriented Programming.* Bologna, Italy, pp. 139-149.

Berger, H., 1929, Uber das Elektrenkephalogramm des Menschen. *Psychiatrie. und. Nervenkrankheiten*. Vol. 87, pp. 527–570.

Brown C. C., 1967, A proposed standard nomenclature for psychophysiologic measures. Psychophysiology 4, pp. 260–264.

Biosignalsplux, 2023, Electrodermal Activity (EDA) Sensor Datasheet, https://support.pluxbiosignals.com/wp-content/uploads/2021/11/Electrodermal_Activity_EDA_Datasheet.pdf, retrived 23.05.2023.

Bulling A., Roggen D., Tröster G. 2008, It's in Your Eyes – Towards Context-Awareness and Mobile HCI Using Wearable EOG Goggles. In: UbiComp 2008. Proceedings of the 10th International Conference on Ubiquitous Computing. September 21–24, 2008, Seoul, Korea. Association for Computing Machinery, New York NY 2008, ISBN 978-1-60558-136-1, S. 84–93, doi:10.1145/1409635.1409647.

Diepgen P., Goerke H., 1960 Aschoff/Diepgen/Goerke: Kurze Übersichtstabelle zur Geschichte der Medizin. 7., neubearbeitete Auflage. Springer, Berlin/Göttingen/Heidelberg, pp. 64.

Machetanz L., 2017, Sauerstoffsättigung, 8. Dezember 2017, https://www.netdoktor.de/laborwerte/sauerstoffsaettigung/ reviewed 23.05.2023.

Weber, T., 2010, Journal of Hypertension 2010, *Grundlagen: Zentraler Blutdruck,Pulswellenreflexion, Pulswellengeschwindigkeit*, Vol. 14 (2), pp. 9-13.