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Psychophysiological Techniques for Measuring Emotion in Social Science

Abstract

This article briefly presents 6 techniques of measuring emotion: functional magnetic resonance imaging (fMRI), electroencephalography (EEG), electromyography (EMG), galvanic skin response (GSR), Facial Action Coding System (FACS) and infrared thermography (IRT). A note on each technique points out the dimension of emotion (valence or arousal) that is measured with a given technique, and informs on its previous use in sociology, as well as its major advantages and disadvantages. Limitations common to all techniques are discussed in the concluding section.

Key words: sociology of emotions, emotion measurement, research on emotion, measuring techniques, physiological indicators

Introduction

The history of research on emotions in social science is rather short. 'Fathers' of sociology, August Comte, Emile Durkheim, Georg Simmel or Max Weber, granted, to be sure, to the concept of *emotion* a relatively high position in their theoretical systems (Shilling 2012, p. 188–205), but psychologists have always had much greater experience in studying this field than sociologists. For the latter emotions have been for many years a subject of secondary interest, too often forgotten or underestimated. It is only over the last forty years that theoretical systems that stressed the importance of emotions have appeared again. Unfortunately, the number of new *sociological* studies dealing with emotions is gradually declining (Turner, Stets 2006, p. 25), with the majority of these contributions being focused on theoretical analysis rather than the practice of empirical research.

Historically, while sociology has been preoccupied mainly with theorising on emotions, leaving aside the question of how to investigate this important phenomenon (Lively 2014, p. 1), psychology has taken over some of the sociologists' duties and got involved in the study of emotions also in the context of *social interaction*. Psychologists have invented tools and research techniques allowing the *measurement* of the affective states of a human being. In addition, the dynamically developing *neuroscience* aided in the research on emotions, making it more effective and reliable. The so-called 'neuroscience turn' occurred in economy, philosophy, anthropology, law, and in the aforementioned psychology. However, it did not yet happen in sociology (Scheve 2003, p. 3). The reason for this lies in the sociologists' concern over the impact of reductionism and biological determinism. The debate on *sociobiology*, which took place in the 1970s, did not lead to the emergence of a new paradigm in social science. An explanation of why things have gone so is beyond the scope of this article. Nonetheless, the consequences of a revival of naturalism have been far-reaching. Sociologists can no longer ignore the influence of biological factors on emotions. They have to acknowledge that their claim that emotions have social origin is losing its prominent status within sociological theorising. Indeed, social researchers are becoming more and more aware that further research on both theoretical and empirical aspect of emotions cannot do without *physiological* factors and indicators to be taken into account along with the social and cultural variable (Stets 2010, p. 266).

The implementation of techniques widely used in medicine, criminology and cognitive science provides social science with a huge opportunity to gain more extensive and deeper knowledge of emotions and to empirically verify certain hypotheses, which, due to the lack of adequate tools, have so far been shrouded in doubt. Modern science has to consolidate and use its resources effectively. For this reason, I found it useful to present to fellow sociologists certain research techniques applied in other sciences, the techniques which have already been used with success in sociological studies of human emotionality. In this paper, a description of each technique employed in the area of emotion research is presented with some examples of its use in sociology, followed by an account of its major drawbacks, advantages, and dangers involved. The focus is solely on *measurement.* It would require writing another more extensive article to provide an overview of general models, theories, methods and results of empirical studies in this area.

Dimensions of emotions and measurement techniques

Before proceeding to an overview of techniques, we recall the distinction between two dimensions, *valence* and *arousal*, that the researchers studying emotions have identified (Lottridge, Chignell, Jovicic 2011, p. 201). Valence, the dimension which is more difficult to measure, pertains to the quality of experienced affect that is described in terms of a position on a bipolar continuum extending from *positive* emotions on one end, and *negative* on the other end. Research on emotions usually makes use of the so-called *Big Six*, a catalogue of six emotions considered basic: happiness, sadness, anger, fear, disgust, and the sixth one as to which the researchers' views differ (Scherer 2004, p. 677).

The arousal dimension describes the *strength* of an experienced affect varying from very strong to unnoticeable. Detecting the exact strength of the emotional state of a test participant is possible but far more difficult than ascertaining if it is positive or negative. Differentiating between the dimensions of measurement is vital because most research techniques provide information about only one of them.

In the sections of this paper that follow, six techniques used in emotion research are described one by one. Many other relevant measurement techniques tools have been skipped, however; these include: positron emission tomography (PET), magnetoencephalography (MEG), near infrared spectroscopy (NIRS), transcranial magnetic stimulation (TCMS), or reading emotion from the tone of voice or pulse. The reason for the omission was the priority given by the author to the techniques which have already been used in social studies, as well as to those which are feasible, or easy to implement, from the technical, financial, and teleological point of view.

Functional magnetic resonance imaging

Functional magnetic resonance imaging (fMRI) apparatus is a highly-specialized device, which proved suitable for measuring valence of experienced emotions. Its functioning relies on the observation and measurement of the BOLD effect (blood-oxygen-level dependent contrast), which consists in the increase of oxygen saturation in certain parts of the brain in response to stimulation. The increased demand for oxygen (and glucose) that arises with the increased activity of neurons in a given area, is being satisfied by an inflow (visible in the magnetic field) of blood to that area.

The use of fMRI, among other things, allowed for the identification of *mirror neurons*, or the areas of the brain which are being activated when a person performs a goal-oriented activity or observes such activities being performed by others. Intensive studies revealed the importance of this area for primary socialization, understanding other people's emotions, or empathy; a connection between dysfunctions of this area and autism was also found (Iacoboni, Dapretto 2006, p. 942; Iacoboni 2009).

Immordino-Yang and Damasio (2007) conducted a study on patients with brain damage. Using fMRI, they proved that emotions play a substantial role in the decision-making process and learning. Patients with lesion of a particular part of the frontal lobe, while maintaining the ability to think logically, could not predict the consequences of their decisions and appeared unable to learn on their mistakes. Another often quoted research in which social science interweaves with neuroimaging, is the one devoted to pinpointing the areas of the brain, responsible for focusing one's attention during interactions. The results of that study contributed to a better understanding of the structure of human interaction process (Redcay et al. 2010).

Without doubt, fMRI is a powerful diagnostic tool. Operated by competent personnel, it can provide invaluable data on human cognitive processes and the anatomical foundations of social existence. It is characterized by non-invasiveness and high spatial resolution, which guarantees a quality image with a high level of detail.

Major drawbacks of using fMRI in social science are the high running costs (about 1000–1500 PLN per test) and the need for close cooperation with the personnel operating the apparatus. Another limitation, which significantly decreases the usability of the device, is the fact that the person undergoing a test needs to remain still in a tube-shaped structure. This obviously precludes the observation of interaction in natural conditions. In some cases, the disqualifying factor is the relatively low time resolution – in order to see the changes on the screen, one has to wait for about 1–2 seconds. In this case, grasping the dynamic, momentary or ephemeral affective states may be impossible.

For these reasons, the technique is unlikely to be used extensively in sociological investigations. Nevertheless, I decided to include this technique in my account because it has become an invaluable tool for psychological studies still having a great impact on the social sciences.

Electroencephalography

Electroencephalography (EEG) can be employed, depending on the research assumptions, to determine the valence and/or arousal of experienced emotions.[1] It is an imaging technique for the electrical activity generated by brain structures. A set of electrodes is attached to the head (scalp) of the test participant. When neurons are activated, an electrical current flows through them and the activity is recorded on the device. The weak signals are amplified and written into the computer memory (Teplan 2002, p. 1).

EEG has been used to understand and anticipate antisocial behaviours. Many papers suggest that aggressive individuals, likely to commit offences, are characterized by abnormal readings. Raine, Venables, and Williams (1990) concluded that antisocial behaviour observed at the age of 24 could have been predicted on the basis of lower frequencies found in the readings obtained from the measurement of 15 year-olds. The same line of argument was put forward by Barratt et al. (1997). They claim that that lower values of the brain response to stimulation distinguish the individuals with antisocial inclinations from the rest of society.[2] Of course these findings do not imply that human behaviour is determined solely by biology but they encourage social scientists to explore new possibilities of analysing deviance.

By far the biggest advantage of using EEG is its large time resolution, measured in milliseconds (Teplan, 2002, p. 4). It allows for even momentary emotions to be captured. Unfortunately, in the context of sociological research on emotion, EEG has many disadvantages. Undoubtedly, the biggest one is the nuisance of the measurement process. The test participant has to sit still, without blinking and keeping facial expression fixed because a slightest muscle contraction can influence the results (Bahari, Janghorbani 2013, p. 228). The necessity of background noise control and the cumbersome equipment rule out the possibility of performing tests outside the laboratory. Other difficulties are connected with low spatial resolution, which means

[1] We distinguish two types of analysis: EEG, which is a test to detect problems in the electrical activity of the brain, and ERP (Event-Related Potentials), which is a stereotyped electrophysiological response to a stimulus, for instance, situation, object or thoughts.

[2] ERP (event-related potentials) studies conducted with the use EEG under the so-called oddball paradigm have shown that the participants whose P300 amplitude (caused by a stimulus engaging attention and eliciting an orienting response) was lower were characterized by higher susceptibility to deviation. Since the P300 wave is generated mainly in the parietal lobe, the weakening of its amplitude can be associated with aggressive behaviour, indecisiveness and non-compliance with social rules.

that only relatively large areas of active neurons leave traces in the recorded data, the recording being limited to cerebral cortex with no representation of subcortical structures (Teplan 2002, p. 7). Furthermore, the recognisability of emotions with algorithms is relatively low. Best results so far, with 83.33% recognition of 6 basic emotions (according to Ekman) were achieved by Panagiotis and Leontios (2010).

Electromyography

Electromyography (EMG) is a diagnostic technique based on measuring electrical activity that appears as a result of muscle contraction. By placing the electrodes at the right points on the participant's face, it is possible to assess the valence of experienced emotions. Tone of the muscle responsible for frowning (Latin *musculus corrugator supercilii*) increases inversely with the decrease on the valence scale, which means that the test participant is experiencing negative emotions. In contrast, positive affective state is indicated by the activity of the *zygomaticus major muscle*. The tone of this muscle increases proportionally to the increase on the valence scale (Brown, Schwartz 1980; van den Broek et al. 2006, p. 4). A later study (Larsen, Norris, Cacioppo 2003, p. 777) shows that experiencing positive emotions corresponds not only to the increase in the activity of the zygomaticus major muscle but also to the decrease of the tone of the muscle responsible for frowning. The relation also works the other way – negative emotions are correlated with the decrease in the readings of zygomaticus major muscle.

Until now EMG has been used mainly in experiments and quasi-experiments. It is useful in the assessment of emotional response to a stimulus and in investigating the influence of independent variables on dependent variables. In this context, the technique was used in the study of the emotional response to text, image and sound (Larsen, Norris, Cacioppo 2003, p. 783), and video (van den Broek et al., 2006). Equally positive results were achieved during the analysis of affective states connected with human interaction mediated for instance by Internet communicators and with technology per se (Calvo, Member, Mello 2010; Mandryk, Atkins 2007).

A signal, recorded in the form of a frequency (Hz), is sent to an amplifier via cables and later to the computer (Larsen, Norris, Cacioppo 2003, p. 778). The quantitative data obtained clearly indicates any alterations of the affective state of the test participants over time. With the use of a correct database, EMG allows not only to assess whether the emotions experienced are positive or negative, but enable us to recognize exactly the type of emotion (Petrantonakis 2010, p. 190). Similar to other methods mentioned, this one is also characterized by automated measurement and result interpretation.

Like any other technique, the one in question has its drawbacks too. When you use EMG, you must remember that the measurements of positive and negative emotions are conducted independently. In general, the correlation between muscle tone and experienced emotions is stronger in the muscle responsible for frowning than in zygomaticus major muscle (Larsen, Norris, Cacioppo 2003). In other words, it is easier to detect negative than positive emotions. Substantial difficulties stem from the fact that EMG can only be used in laboratory conditions, which eliminates the possibility of observing emotions in their natural environment. The necessity of connecting the electrodes to the participants' faces also needs to be taken into consideration, as it may significantly reduce comfort and produce negative emotions, leading to biased research results.

Galvanic Skin Response

Galvanometer is a device for measuring human skin conductivity. Conductivity increases abruptly during mental activity, such as solving mathematical problems, and stays on a relatively low level during rest. Sudden emotional arousal is one of the factors triggering galvanic reactions (Picard, Scheirer 2001, p. 1). The measuring of conductivity and resistance relies on the Ohm law, according to which the intensity of an electrical current is proportional to the voltage between two ends of a conductor, in this case two electrodes (Dawson, Schell, Filion 2007, p. 204). D'Mello, Dowell, and Graesser (2013) indicate that studying the galvanic response of human skin (GSR) is the fastest and most reliable way of measuring the intensity of human emotions. Electrodes can be placed at various points of the body, but the best results are achieved by measuring the electric potential of feet and hands. For obvious reasons, the latter possibility is used more frequently. Wires are usually connected to two fingers of the non-dominant hand (Boucsein et al., 2012).

An attempt to create a responsive user interface is an example of using GSR as a technique for collecting data on emotional arousal of the participants. The data was later used to stimulate them by triggering the correct algorithms (Villon, Lisetti 2006). Other researchers (Wang, Prendinger, Igarashi 2004) achieved satisfactory results with GSR by measuring the strength of emotional arousal during the interaction between two individuals, mediated by an Internet communicator.

GSR is a cheap method. The purchase of an affordable apparatus allows for an unlimited number of tests and the equipment requires only one person to operate. Portable GSR devices have been in development for some time. One of them is the *Galvactivator* – an ergonomic measuring device resembling a glove (Picard, Scheirer 2001). It enables doing research outside the laboratory, so studying the level of emotional arousal in natural conditions becomes possible. It is equally important that many individuals can be tested simultaneously if an adequate number of devices is available.

Some authors (Cacioppo, Tassinary 1990, p. 17; Ward, Marsden 2003, p. 210) point out that the results of a test for an individual may depend to a significant degree on the number and default level of activity of the individual's sweat glands. These characteristics vary across individuals, which requires that the measuring devices are calibrated before each test in order to set the so-called zero level for each subject. Some researchers report that better results can be achieved by measuring conductivity rather than electric resistance. Age and sex of tested individuals also matter – older participants achieve lower results; women's reaction to unpleasant stimuli is stronger, whereas men are more sensitive to erotic arousal. External variables, which are likely to affect measurement results, include body temperature, and temperature and humidity in the room in which the test is carried out (Boucsein et al. 2012, p. 1030). Administering medications in the course of a GSR test brings into the measurement process another heterogeneous set of factors which may distort results. A potential weakness of this technique, however not always crucial, is a relatively low time resolution of 1–3 seconds (Dawson et al. 2007, p. 211).

Facial Action Coding System

Facial Action Coding System (FACS) is a technique of reading emotions from the face. In the 1970s, Paul Ekman[3] established a number of Action Units (AU) conceived of as a kind of measurement units. Each of them is related to a change in the tone of face muscles, which are attributed to particular emotions, e.g., raising the corner of the mouth and eyebrows is interpreted as smile, a sign of happiness. AU are located mainly on eyebrows, nose and mouth.

Many observation patterns, similar to FACS have been established. One of the most popular is the Facial Animation Parameters (FAPs). A breakthrough in the development of FACS occurred in the last decade of the 20th century, when the first algorithms automating the decoding process were created (Bettadapura 2012, p. 1–7). The test procedure is simple – a video camera, aided by appropriate software, has to be pointed (assuming the appropriate angle and distance) at the face of a person whose emotions currently experienced are going to be recognized and named by the computer system (Sánchez et al. 2011, p. 1272). Depending on the software used and the type of emotion to be detected, the accuracy of the technique oscillates between 70% and 100% (Bettadapura 2012, p. 10; Karpouzis et al. 2007, p. 7).

At present, recognizing emotions from the face has become very popular in the commercial world (in this way companies and corporations study emotional reactions to new products or solutions) and in science. Because of its high usability, the method is still being developed. Although it has many varieties now, all of them are based on the work of Paul Ekman. The educational value of his legacy is priceless, as he was able to describe (see Ekman et al. 1987) universal emotions for particular cultures. Ekman and Cordaro (2011) proposed a list of *basic emotions* and investigated their characteristics. Ekman's book (1985, revised edition 2009) is a kind of manual for all who want to learn about the situations in which the other speaker is not telling the truth. Studies conducted by other researchers using FACS (Tsai, Chentsova-Dutton 2003) proved that Americans of Scandinavian and Irish descent express emotions differently, e.g., the first group was characterized by lower expressiveness in reference to happiness and love. The differences detected in those studies support the results of previous theoretical work. What is more, these empirical findings show that cultural differences are more visible for positive than negative emotions (Matsumoto et al. 1998).

Reading emotions with the use of a video camera equipped with necessary software is a cheap technique that enables carrying out an unlimited number of tests at any time and place. Once a video camera has been set up correctly, no additional actions are requited from the researcher, which makes this technique simple and

[3] Paul Ekman, considered the founder of FACS, continued the research initiated by Carl-Herman Hjortsjö.

effective. The biggest advantage of FACS, however, is full automation, making the presence of a researcher unnecessary for data collection. The test participant can be placed in another room or building, or even continent. There are no contraindications for the test not to be carried out remotely and in a fully automated manner, like the tests conducted for commercial purposes. Moreover, the right choice of equipment and its proper placement make it possible to study entire groups in various environments.

The choice of an appropriate database on the basis of which the software interprets the movement of each point as a sign of a particular emotion is important from both theoretical and methodological point of view (Karpouzis et al. 2007, p. 2). The problem lies in the number of different databases available and their incomparability. At present, the most popular are MMI Facial Expression database and the Cohn-Kanade database (Pantic et al. 2005; Sánchez et al., 2011, p. 1276).

Despite relatively high effectiveness of the technique, not every emotion can be recognized easily. Happiness, surprise and disgust are easier for the software to read from the face because these emotions find expression largely in evident AU of the mouth. Detecting anger is more difficult, which emotion for that reason is often confused with other affects. Covering the face, especially lips (e.g. with a scarf, facial hair, makeup), considerably decreases the chance of a correct reading, even by 50% (Bettadapura 2012, p. 10–22).

Infrared thermography

Infrared thermography (IRT) is a technique designed for detecting and recording temperature displacement on the surface of an object through the measurement of the infrared radiation emitted by the object. In emotion research, the test object is the human face. A video camera, pointed at the test participant's face, creates a colourful image, in which brighter colours indicate high temperature and darker shades represent lower temperature. It is worth mentioning that an infrared video camera reads the temperature of each pixel individually (Clay-Warner, Robinson 2014, p. 3). In essence, the theoretical basis of this technique stems from the aforementioned FACS and EMG (Robinson et al., 2012, p. 14). Like in the cases previously described, micro-expression, connected with experiencing positive or negative emotions, plays here a key role too. Latest research (Jarlier et al. 2011) indicated that interpreting thermographic data in terms of AU brings promising results. Although the technique has been used mainly to recognize emotions, it also performs remarkably well in establishing their level of arousal (Clay-Warner, Robinson, 2014, p. 5).

The research by Robinson et al. (2012) was the first one in which the effectiveness of infrared thermography in recognizing emotion was empirically proven. The results indicate that the temperature of the human face is different when experiencing positive and negative affects. The biggest differences were visible in the temperature of the cheeks and forehead. In the same year, another team of researchers (Wesley et al. 2012) compared the effectiveness of two techniques for detecting emotions with algorithms based on AU – using a thermal imaging video camera and a regular one – in different environmental conditions. As expected by the authors, tampering with the temperature negatively influenced the results of the infrared test. At the same time, switching off the light in the test room decreased the effectiveness of regular video cameras, while the effectiveness of IRT remained at a steady level. As indicated by the research of the Pavlidis, Eberhardt, and Levine (2002), IRT can be used not only for recognizing emotion by face analysis. The researchers found that the temperature measured with this instrument around the eyes of a person, in 83 percent of cased provided a correct prediction of whether the person was telling the truth. After lying, this area of the face got significantly hotter, indicating guilt.

The advantages of IRT are similar to those of FACS, namely: low costs, automation and the possibility of group remote testing. Robinson et al. (2012, p. 15, 36) point to the possibility of conducting interaction tests in a dynamically-changing environment under any light conditions, even in complete darkness. However, the authors of most research incorporating IRT claim that the best results can be achieved by employing another measuring technique (techniques).

As mentioned above, the biggest drawback of the IRT technique is the necessity to maintain a relatively steady temperature in the test room (the same applies to humidity). The result of the test can be also affected by anything that covers the face, even partially (hair on the face or covering it, any kind of glasses, scarves or hats). It is also highly unadvisable for the test participant to move excessively and change the distance from the video camera (Clay-Warner, Robinson, 2014, p. 5), although these disadvantages depend on the software used, which is constantly being improved.

Conclusions

All the techniques presented above using different mechanisms and ways of data collection share a few significant limitations. All of them arise from methodological assumptions and the imperfection of measuring devices. First of all, each technique is suitable for studying a limited number of emotions only. The researchers generally agree that the number of possible emotional states corresponds to the number of possible models of assessment, which makes it virtually endless (Scherer 2000, p. 149). For pragmatic reasons, even those who criticise the conception of basic emotions have to resort to it, for otherwise any analysis would be inconclusive or incomplete.

Another common setback is the inability to study mixed emotions. A particular emotional state experienced by an individual can be a combination of different or even contradictory states (Davidson 2003, p. 1; Panksepp, Watt 2011, p. 3). Very often we cannot discriminate between two emotions, for instance, uncertainty and frustration, nor can we devise an indicator for the case, which happens fairly often, where an individual experiences anger and happiness at the same time.

The third limitation (not applicable to the last two techniques described) goes together with the biggest advantage of the measurement based on physiological indicators – relying on a reading which is independent from the person's will because of being regulated by the autonomous nervous system (Westerink, Broek, Schut 2008, p. 151). It may be risky to rely solely on these techniques, without asking the participants themselves to describe their emotional states. For that reason, the use of psychophysiological techniques is often complemented by taking self-reports from the subjects.

The techniques described in this paper, in spite of their weaknesses and limitations, have been used for many years and they enjoyed growing credit due to being constantly developed and improved. Since their introducing to psychology they have been widely recognized in the world of science and gained strong and extensive methodological underpinning. Sociology of emotions – if it aims at becoming a truly empirical science – may only benefit from vast research experience and knowledge accrued over time in the disciplines that deal with the biophysical aspect of human existence. For social scientists, who are interested in studying social interactions and relations, the techniques such as FACS or IRT can be useful, first of all, in so far as they enable testing entire groups during the course of interaction in laboratory and naturals settings.

References

Bahari F., Janghorbani A. (2013). *EEG–Based Emotion Recognition Using Recurrence Plot Analysis and K Nearest Neighbour Classifier.* Conference paper: Biomedical Engineering, p. 228–233.

Barratt E.S., Stanford M.S., Kent T.A., Felthous A. (1997). *Neuropsychological and Cognitive Psychophysiological Substrates of Impulsive Aggression.* Biological Psychiatry, 41, p. 1045–1061.

Bettadapura V. (2012). *Face Expression Recognition and Analysis: The State of the Art.* [online] http://arxiv.org/ftp/arxiv/papers/1203/1203.6722.pdf, access: April 20, 2015.

Boucsein W., Fowles D.C., Grimnes S., Ben-Shakhar G., Roth W.T., Dawson M.E., Filion D.L. (2012). *Publication Recommendations for Electrodermal Measurements.* Psychophysiology 49, p. 1017–1034.

Brown S.L., Schwartz G.E. (1980). *Relationships Between Facial Electromyography and Subjective Experience During Affective Imagery.* Biological Psychology, 11, p. 49–62.

Cacioppo J.T., Tassinary L.G. (1990). *Inferring Psychological Significance from Physiological Signals.* American Psychologist, 45, p. 16–28.

Calvo R.A, Member S., Mello S.D. (2010). *Affect Detection: an Interdisciplinary Review of Models, Methods, and Their Application to Learning Environments.* IEEE Transactions on Affective Computing, 1, p. 1–23.

Clay-Warner J., Robinson D.T. (2015). *Infrared Thermography as a Measure of Emotion Response*. Emotion Review, 7, p. 157–162.

Davidson R.J. (2003). *Seven Sins in the Study of Emotion: Correctives from Affective Neuroscience*. Brain and Cognition, 52, p. 129–132.

Dawson M.I., Schell A.M., Filion D.L. (2007). *The Electrodermal System*. In: J.T. Cacioppo, L.G. Tassinary, G.G. Berntson (eds.). *Handbook of Psychophysiology.* New York: Cambridge University Press, p. 159–181.

D'Mello S.K., Dowell N., Graesser A. (2013). *Unimodal and multimodal human perception of naturalistic non-basic affective states during human–computer interactions*, Affective Computing, IEEE Transactions, 4(4), p. 452–465.

Ekman P. (2009). *Telling Lies: Clues to Deceit in the Marketplace, Politics, and Marriage*. New York-London: W.W. Norton & Company.

Ekman P., Cordaro D. (2011). *What is Meant by Calling Emotions Basic.* Emotion Review, 3, p. 364–370.

Ekman P., Friesen W.V., O'Sullivan M., Chan A., Diacoyanni-Tarlatzis I., Heider K., Ricci-Bitti S.E. (1987). *Universals and Cultural Differences in the Judgments of Facial Expressions of Emotion.* Journal of Personality and Social Psychology, 53, p. 712–717.

Iacoboni M. (2009). *Imitation, Empathy, and Mirror Neurons.* Annual Review of Psychology 60, p. 653–670.

Iacoboni M., Dapretto M. (2006). *The Mirror Neuron System and the Consequences of Its Dysfunction.* Nature Reviews. Neuroscience 7, p. 942–951.

Immordino-Yang M.H., Damasio A. (2007). *We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education.* Mind, Brain, and Education, 1, p. 3–10.

Jarlier S., Grandjean D., Delplanque S., N'Diaye K., Cayeux I., Velazco M.I., Scherer K.R. (2011). *Thermal Analysis of Facial Muscles Contractions.* IEEE Transactions on Affective Computing, 2, p. 2–9.

Karpouzis K., Caridakis G., Kessous L., Amir N., Raouzaiou A., Malatesta L., Kollias S. (2007). *Modelling Naturalistic Affective States via Facial, Vocal, and Bodily Expressions Recognition*. In: T.S. Huang, A. Nijholt, M. Pantic, A. Pentland (eds.) *Artificial Intelligence for Human Computing.* Berlin: Springer Berlin Heidelberg.

Larsen J.T., Norris C.J., Cacioppo J.T. (2003). *Effects of Positive and Negative Affect on Electromyographic Activity over Zygomaticus Major and Corrugator Supercilii.* Psychophysiology, 40, p. 776–785.

Lively K.J. (2014). *Comment on 'Methodological Innovations from the Sociology of Emotions – Methodological Advances'.* Emotion Review, 7, p. 2014–2015.

Lottridge D., Chignell M., Jovicic A. (2011). *Affective Interaction: Understanding, Evaluating, and Designing for Human Emotion.* Reviews of Human Factors and Ergonomics, 7, p. 197–217.

Mandryk R.L., Atkins M.S. (2007). *A Fuzzy Physiological Approach for Continuously Modelling Emotion during Interaction with Play Technologies.* International Journal of Human Computer Studies, 65, p. 329–347.

Matsumoto D., Takeuchi S., Andayani S., Kouznetsova N., Krupp D. (1998). *The Contribution of Individualism vs. Collectivism to Cross-national Differences in Display Rules.* Asian Journal of Social Psychology, 1, p. 147–165.

Panagiotis C.P., Leontios J.H. (2010). *Emotion Recognition from EEG Using Higher Order Crossings.* IEEE Transactions on Information Technology in Biomedicine, 14, p. 186–197.

Panksepp J., Watt D. (2011). *What is Basic about Basic Emotions? Lasting Lessons from Affective Neuroscience.* Emotion Review, 3, p. 387–396.

Pantic M., Valstar M., Rademaker R., Maat L. (2005), *Web-based Database for Facial Expression Analysis.* Conference paper: Multimedia and Expo.

Pavlidis I., Eberhardt N.L., Levine J.A. (2002). *Seeing through the Face of Deception.* Nature, 415 (6867), p. 35.

Petrantonakis S.C. (2010). *Emotion Recognition from EEG Using Higher Order Crossings.* IEEE Transactions on Information Technology in Biomedicine, 14, p. 186–197.

Picard R.W., Scheirer J. (2001) *The Galvactivator: A Glove That Senses and Communicates Skin Conductivity.* Conference paper: 9th International Conference on Human–Computer Interaction.

Raine A., Venables S., Williams M. (1990). *Autonomic Orienting Responses in 15-year Old Male Subjects and Criminal Behaviour at Age 24.* American Journal of Psychiatry, 147, p. 933–937.

Redcay E., Dodell-Feder D., Pearrow M.J., Mavros S.L., Kleiner M., Gabrieli J.D.E., Saxe R. (2010). *Live Face-to-Face Interaction during fMRI: A New Tool for Social Cognitive Neuroscience*. NeuroImage, 50, p. 1639–1647.

Robinson D.T., Clay-Warner J., Moore C.D., Everett T., Watts A., Tucker T., Thai C. (2012). *Toward an Unobtrusive Measure of Emotion during Interaction: Thermal Imaging Techniques.* Advances in Group Processes, 29, p. 255–266.

Sánchez A., Ruiz J.V., Moreno A.B., Montemayor A.S., Hernández J., Pantrigo J.J. (2011). *Differential Optical Flow Applied to Automatic Facial Expression Recognition.* Neurocomputing, 74, p. 1272–1282.

Scherer K.R. (2004). *Ways to Study the Nature and Frequency of Our Daily Emotions: Reply to the Commentaries on 'Emotions in everyday life'.* Social Science Information, 43, p. 667–689.

Scherer K.R. (2000). *Psychological Models of Emotion*. In: J. Borod (ed.), *The Neuropsychology of Emotion*, New York: Oxford University Press, p. 137–162.

Scheve C. von (2003). *Sociology of Neuroscience or Neurosociology*? Advances in Medical Sociology, 12, p. 255–278.

Shilling C. (2012). *Dwie tradycje w socjologii emocji*. In: M. Rajtar, J. Straczuk (ed.). *Emocje w kulturze.* Warszawa: Wydawnictwa Uniwersytetu Warszawskiego, p. 181–210.

Stets J.E. (2010). *Future Directions in the Sociology of Emotions*, Emotion Review, 2, p. 265–268.

Teplan M. (2002) *Fundamentals of EEG Measurement.* Measurement Science Review, 2, p. 1–11.

Tsai J.L., Chentsova-Dutton Y. (2003). *Variation among European Americans in Emotional Facial Expression.* Journal of Cross-Cultural Psychology, 34, p. 650–657.

Turner J.H., Stets J.E. (2006) *Sociological Theories of Human Emotions.* Annual Review of Sociology, 32, p. 25–52.

Van den Broek E.L., Schut M.H., Westerink J.H D.M., van Herk J., Tuinenbreijer K. (2006). *Computing Emotion Awareness through Facial Electromyography*. In: T.S. Huang, N. Sebe, M.S. Lew, V. Pavlović, M. Kölsch, A. Galata, B. Kisačanin (eds.), *Computer Vision in Human - Computer Interaction.* Graz: Springer Berlin Heidelberg, p. 53–63.

Villon O., Lisetti C. (2006). *Toward Building Adaptive User's Psycho-physiological Maps of Emotions Using Bio-sensors*, 29th Annual Conference on Artificial Intelligence.

Wang H., Prendinger H., Igarashi T. (2004). *Communicating Emotions in Online Chat Using Physiological Sensors and Animated Text.* Extended abstracts of the 2004 Conference on Human Factors and Computing Systems.

Ward R., Marsden S. (2003). *Physiological Responses to Different Web Page Designs.* International Journal of Human-Computer Studies, 59, p. 199–212.

Wesley A., Buddharaju P., Pienta R., Pavlidis I. (2012). *A Comparative Analysis of Thermal and Visual Modalities for Automated Facial Expression Recognition*. In: G. Bebis, R. Boyle, B. Parvin, D. Koracin, C. Fowlkes, S. Wang, M-H. Choi, S. Mantler, J. Schulze, D. Acevedo, K. Mueller, M. Papka (eds.), *Advances in Visual Computing*, vol. 2, Rethymnon: Springer Berlin Heidelberg, p. 51–60.

Westerink J.H.D.M., Van den Broek E.L., Schut M.H. (2008). *Computing Emotion Awareness through Galvanic Skin Response and Facial Electromyography*. In: J.H.D.M. Westerink, M. Ouwerkerk, T.J.M. Overbeek, W.F. Pasveer, B. de Ruyter (eds.), *Probing Experience.* Netherlands: Springer Netherlands, p. 149–162.

Psychofizjologiczne techniki pomiaru emocji w nauce społecznej

W artykule tym przedstawiono w skrócie 6 technik pomiaru emocji: obrazowanie funkcjonalnego rezonansu magnetycznego (fMRI), elektroencefalografię (EEG), elektromiografię (EMG), reakcję skórno-galwaniczną (GSR), system kodowania ruchów twarzy (FACS) oraz termografię podczerwieni (IRT). Dla każdej techniki podano wymiar emocji (walencję lub pobudzenie), który mierzy dana technika, oraz informacje o jej wcześniejszym użyciu w socjologii, jak również przedstawiono jej główne zalety i wady. W zakończeniu omówiono ograniczenia wspólne dla wszystkich technik.

Słowa kluczowe: socjologia emocji, pomiar emocji, badanie emocji, techniki pomiarowe, wskaźniki, fizjologiczne