Chapter 3

Physiological Measurement as a (Controversial) Research Method

Bartłomiej Pierański

Abstract: The chapter presents the essence and specificity of physiological measurements that can only be performed using an appropriate apparatus. It is the only way to obtain physiological data which cannot be directly observed by humans (e.g. brainwaves, eye fixations) and advantageous due to its objectivity, continuity and non-invasiveness of the measurement. One must, however, remember that physiological measurements include a very frequent necessity to create unnatural test conditions (e.g. full immobilisation of the examined person) and can pose difficulties in the interpretation of data. The correct interpretation of data requires specialist knowledge, which very often goes beyond economics or management. The chapter also classifies the methods of physiological measurements, taking the human nervous system structure as a point of reference.

Keywords: neuromarketing, eye-tracking, physiological measurement, electrodermal activity

Introduction

Observation of human physiological reactions gives rise to many controversies, mainly due to the increased optimism manifested in declarations concerning the possibility of reaching the phenomena that have not been directly observable so far (e.g. emotions). Also, the method of interpreting the gargantuan amount of data is not fully determined. Furthermore, due to very restrictive requirements that are necessary to carry

out certain measurements (e.g. full immobilisation of the examined person), it is not always possible to observe a person in the conditions which are considered natural, both for the person and the situation.

This is the reason for the limited use of methods that are based on physiological measurements in analysing consumer behaviour (including in-store environment). As a consequence, the diagnosis of how the environment influences the consumer behaviour is made mainly on the basis of survey methods. In addition, the limited use of physiological methods is also due to the poor knowledge thereof. Therefore, the purpose of this chapter is to present the essence of physiological measurements as a research method, with its advantages and disadvantages. It also focuses on difficulty and ambiguity in the interpretation of data, collected using complex apparatus, describing the functioning of particular organs in the human body (especially the brain). Interpretation becomes extremely difficult when the empirical material collected must be referred to consumer behaviour. This chapter concludes with an overview of physiological measurement methods. The structure of the human nervous system was used as the basis for classification.

The essence and specificity of physiological measurements

Physiological measurements are mainly used in biology and medicine (Littlefield, 2009), in order to become familiar, diagnose and treat human diseases. They are, however, becoming adopted by social sciences for the so called biological bases of behaviour, triggered by the nervous system (Plassmann et al., 2012). Such measurements are also used in the study of in-store behaviour, albeit to a relatively limited extent as movements, breathing and perspiration (among other things) constitute an important source of data that can be used in the analysis of consumer behaviour (Schwartzkopf, 2015).

In the context of consumer behaviour research, physiological measurements are considered as a non-survey method of collecting data from primary sources (Kaczmarczyk, 2014, p. 61)¹, helping to broaden the scope of observable consumer behaviour manifestations. Reactions to the appearing stimuli (behaviour) can also be observed through the prism of physiological changes taking place in the human body. The non-survey nature of the physiological measurements means that they are not based on conscious and declarative answers as one would obtain from a survey. Physiological measurements, therefore, are considered more objective as they very often concern issues which people are unaware of (e.g. eye fixations), or other problems an individual does not want to or is not able to communicate (O'Connel et al., 2011).

¹ The type of stimulus used during the measurement process constitutes the criterion for the division of research methods into survey and non-survey ones. In case of survey methods, data is collected by asking questions in oral and written form. In non-survey methods, on the other hand, the questions are not the main stimulus for data collection. Apart from the physiological measurements, the methods of collecting data from non-survey primary sources include, among other things, monitoring, organoleptic and ethnographic methods (Kaczmarczyk, 2014).

The fundamental issue related to the analysis of physiological measurement methods is that they can only be performed with the use of the appropriate apparatuses (Steward, Furse 1982; Ober et al., 2009) due to unobservable elements such as brain-waves and eye fixations. Reiterating the importance of the apparatus in physiological measurements is Rószkiewicz (2002, p. 36) who credits it with possibility to record facts that create reality. This reliance on the apparatus seems to be a source of both advantages and disadvantages of physiological measurements.

Irrespective of the above, it should be stated that technological advancements have led to the development of new devices such as the magnetic tomograph and improvement of existing ones such as eye-trackers. Additionally, developments in the area of computer science is now enabling researchers to visualise the data gathered and enhance their analysis. These technological changes, combined with a relative decrease in the acquisition costs of at least some of the devices (Gregor, Wdowiak, 2016), have led to the employment of physiological measurements in many areas, including the area of consumer behaviour observation, as referred to above.

Advantages and disadvantages of physiological measurements

Observation of consumer physiological responses, based on the appropriate apparatus, has three major advantages: objectivity, continuity and the non-invasiveness of measurement. Such measurements provide an obvious advantage over respondent statements that are of a specific nature, susceptible to subjective distortions and are always made at a specific point in time. The objectivity of physiological measurements, can be understood in two ways as they relate to the behaviour of both the researcher and of the examined person. The researcher in such a study has limited influence on how the apparatus operates or the results obtained as the operation of the apparatus is not dependent on the state of consciousness of the entity performing the measurements (Urbański as cited in Sosnowski, Zimmer 1993). The lack of an appropriate apparatus however might require the researcher to undertake manual recording of specific behaviours. Such recordings as per Hintze et al. (2002) opens the study to the risk of “bending” observations to match research hypotheses, or changes concerning the method of recording the occurring phenomena, caused by fatigue or weariness of a person conducting the experiment.

The objectivity related to the use of the apparatus in the process of obtaining data on the physiological reactions of the consumer is also affected by the modification of the researcher's role. During the data acquisition process, the objectivity concerns the correct preparation of the apparatus and monitoring of its operation (Johnson, Pennypacker, 1993). Thus, active data acquisition by the researcher, which is susceptible to distortion, is replaced by an appropriate device that carry out measurements by mechanical means. On the other hand, the use of an apparatus in observation eliminates the need for the researcher to be present at the test and/or follow the observed person, which undoubtedly influences the modification of the behaviour of the subject (Hintze

et al., 2002). In view of the above, it would be possible to consider the recording of data – while conducting observations using the apparatus – as non-interfering with the respondents' behaviour (thus, making the behaviour more objective), if it was not for the fact that the use of apparatus makes the participants always aware of the fact that observations are being conducted. As a consequence, it should be assumed that it has a modifying effect on their behaviour. It's also important to note that the behaviour modifications in such instances would not be significant as the only aspects of behavior that can be changed are those of which the examined person is aware of and able to control. Reiterating the same is Steward and Furse (1982) who produced that subjects taking part in physiological measurements are not subject to active influence, such as camouflage or hiding natural reactions.

As it was mentioned above, another advantage of using the measuring apparatus in the process of observation is the continuity of measurements, e.g.: a specific type of physiological reactions accompanying the examined person from the moment he/she enters the store (sales area) up to the moment he/she leaves it (Larsen et al., 2017). This continuity of measurements enables the analysis of the dynamics of the occurring processes and the detection of speedy processes, thanks to which they can be analysed at very short intervals (Sosnowski, Zimmer, 1993).

Another advantage of conducting physiological measurements with an apparatus is its non-invasiveness. Such measurements are performed on the surface of the skin and are not painful. This non-invasiveness also ensure that the physiological processes are not disturbed by the apparatus used (Sosnowski, Zimmer, 1993), e.g. eye-tracking does not change the eye motor activity.

Nevertheless, the measurement of physiological processes with the apparatus is not free from faults. Such faults are mainly related to the specific nature of conducting the research and require unnatural conditions to be created. These may include the complete immobilisation of the examined person, usually in a lying position (e.g. the brain study using functional MRI (fMRI) or positron-emission tomography (PET)), or forcing a relatively stable sitting position at a certain distance from the stimulus (e.g. recording facial expressions), or, the creation of uncomfortable conditions for the examination (e.g. the need to wear a EEG cap, or a mask combined with a respirometer). All these factors create the impression that conducting observations on physiological reactions of consumers in normal market conditions seems to be limited and can only be overcome by combining measurements within the scope of the research procedure. It is assumed that only a comprehensive analysis of data obtained from various organs can provide a full and comprehensive answer in the research on consumer behaviour (Smyczek, Turek, 2011). In addition, the apparatus prolongs the time of conducting the research as it requires preparation and can be conducted on one person only over a certain time horizon (Ohme, 2006). Such tests can also be a heavy financial burden on account of the costs in acquisition and maintenance of the apparatus (despite a continuous decrease in the price of apparatuses).

Problem of (correct) data interpretation

What seems to be the greatest deficiency of the physiological measurements is the difficulty of the correct interpretation of data obtained with the apparatus. Undoubtedly, the empirical material obtained in this way is extensive (Bremer, 2013) and requires specialist knowledge, which very often goes beyond economy and management, for interpretation. Such knowledge (from neurologists perhaps) is especially important when conducting physiological measurements of brain functions (Diterhaft, Woźniak, 2017). One must, however, also keep in mind that the better we understand the brain, the more insufficient our knowledge of this organ becomes (Rožek, 2011, p. 77). One example could be recent discoveries, in which specific mental processes or emotions were found to be not governed by individual brain areas. On the contrary, the brain activates various parts during its work, which cooperate with each other forming macro connections (Binder, 2018, p. 30).

As per the above, it is clear that the conclusions drawn from the analysis of physiological data should not be overestimated and should be looked at with a greater distance. This also applies to the interpretation of data in behaviour diagnosis, within the context of specific market situations (Ariely, Berns 2010). What does not raise any doubts is that such apparatuses allow us to obtain data on the processes taking place in the body. For example, data from electrodermal activity measurements indicates the secretion activity of the eccrine sweat glands. The data from electroencephalography indicate the bioelectrical brain activity, whereas data from the functional magnetic resonance imaging provide us with a picture of oxygen demand in certain areas of the brain. Such methods make it possible to determine the physiological body response to various stimuli (Szymusiak, 2012).

It seems, however, that it is insufficient to treat physiological measurements as a measure of purely biological processes occurring in the body (under the influence of external stimuli), especially when it comes to brain activity analysis. Therefore, the essence of the problem comes down to answering the question – what are, apart from the described indicators of biological processes, the data collected from the physiological reaction observations? The analysis of literature leads to the conclusion that although it is not directly expressed, some researchers treat the data gathered from physiological measurement as indicators of emotions and thoughts (Szymusiak, 2012). This may result from overinterpretation of findings concerning the functions of the brain (Reimann et al., 2011). As an example, it is stated that the analysis of physiological reactions enables the confirmation of the existence of certain phenomena and even their measurement (Reimann et al., 2011), which until now have been discussed only in probabilistic categories (emotions), thus enabling the possible reconceptualization of these phenomena and identification of the processes taking place at more fundamental (neural) level. Taking the above into consideration, a deeper understanding of the consumer makes it possible to verify the existing theories on his/her behaviour as well as to create new ones (Shiv et al., 2005). In the same vein, it is pointed out that the tests based on physiological measurements enable the identification of phenomena which the examined persons are unaware of, and are significant reasons for their behaviour

(Falk et. al., 2012). It is a quite common assertion that the apparatus for the study of the brain offers the possibility of 'insight' into the unconscious processes (Kowalski, 2009).

These arguments cannot be fully accepted as the results of research in tests concerning the brain function, put the analysed issue in a different light (Steward, Furse, 1982; Lee et al., 2007). The unquestionable achievement of neurology is the construction of a brain map, as only about 10% of the human brain has been explored (Rożek, 2011, p. 75). A number of experimental studies made it possible to identify the specific areas of the (known) brain that got activated in specific situations. For example (Sudziński, 2009; Rożek, 2011):

- a. it is assumed that focus of attention, solving new problems and innovation are accompanied by the increased activity in prefrontal and parietal cortex,
- b. spatial imagination as well as mathematical and analytical reasoning correlate with increased activity of the temporal lobes,
- c. while when feeling emotions the amygdaloid nucleus is activated.

Nevertheless, it is emphasised that these are the so called behavioural correlates. Therefore, the analysis of reactions occurring in the brain does not identify the causes of a particular behaviour pattern. It only makes it possible to indicate the co-existence of specific brain region excitation with the stimuli (Ohme, 2006). However, even the mere fact of identifying such correlations raises several controversies. First of all, there is a question whether a specific region of the brain always correlates with only one particular behaviour pattern (Mruk, Jankowiak-Kaczmarek, 2017, p. 83). The tests conducted negate such an assumption (Aron et al., 2007). For example, it turns out that the brain region known as an 'insula' is activated when one has to pay a price which is perceived as high, but it also regulates the process of overcoming a habit such as nicotine addiction (Knutson et al., 2007). Similarly, the amygdaloid nucleus is activated during excitement and during learning (Paton et al., 2006). Notwithstanding the questionable interpretive unambiguity of the correlations discussed, the new findings concerning brain function (the above-mentioned macro connections) seem to completely undermine the reasonableness of linking specific brain areas with particular behaviour patterns. According to the critics of that approach, it is not the particular brain areas themselves but the mutual communication between the brain regions that constitutes the essence of mental processes (Dobbs, 2005). Furthermore, attention is also drawn to some malpractice linked to the use of such correlations. Methodically, they were determined in the following system: stimulus – brain cells response. Therefore, by exposing the examined person to the stimulus of predetermined characteristics (e.g. high level of emotional charge (anger), or an intellectually demanding task), the brain regions which were activated were searched for. Then, knowing the stimulus nature and the correlating brain area, it was concluded in which processes (of what nature) this region is involved (Poldrack, 2006). Meanwhile, knowledge gained in this way constitutes a source of conclusions concerning different, opposite course, which are considered to be not fully justified. Based on the brain reaction (activation of a specific area), conclusions are made concerning the nature of the stimulus presented to the examined person (Reimann, 2011). Such an action is methodically doubtful (Poldrack, 2006), due to the aforementioned multifunctional nature of the individual brain areas (Plassmann et

al., 2012). Similarly, it is not legitimate to claim that physiological measurements enable detection of unconscious processes. What is indicated is the current stream of research in neurology, focused on the search for the neuronal activity that can be associated with either conscious information processing or unconscious information processing (neural correlate of consciousness). However, there are no clear solutions as regard this issue (Lamme, 2003).

Bearing on the above mentioned findings in mind, it is difficult to justify the statements, appearing in the literature, on the unusual diagnostic power of physiological measurements related mainly to brain function. It seems that the key argument in favour of treating the results of empirical measurements as inference indicators of hidden existence is the lack of diagnosis, and thus the lack of understanding of the emergence phenomenon mechanism. This phenomenon is to explain how the observable, electro-chemical reactions occurring in the brain result in intangible and volatile phenomena, such as thoughts or emotions (Ohme, 2017, p. 55).

Classification of the physiological measurement methods

The structure of the nervous system can be treated as the basis for the physiological measurements classification (String, Turkish, 2011). In other words, when discussing the possibility of physiological measurements, human body should be treated as a certain network of integrated tissues and organs. The nervous system plays here a superior and integrating role in terms of functionality (String, Turkish, 2011) and can be divided into two main parts: the central system and the peripheral system. The central system contains all the neurons of the encephalon and spinal cord, whereas the peripheral nervous system consists of nerves connecting the central nervous system with other parts of the body. The peripheral nervous system, therefore, performs a transmission function, supporting the exchange of information between the brain and the rest of the body. The peripheral nervous system is divided into somatic and autonomic system. A human being is able to influence the somatic system to some extent, as it regulates the physiological functions of the body, which are partially controlled by human (e.g. eye movement, facial expressions). On the other hand, the autonomic system is characterized by the fully automated operation that is beyond any control, and very often outside of any conscious awareness of the human (Bercik, Rybanka, 2017).

Taking into account the structure of the nervous system, the physiological measurements can be divided into two groups: measurements of brain functioning (formed by the central system) and measurements of human body functioning (directly related to the functioning of the peripheral system). A more detailed division of the physiological measurements based on the structure of the nervous system is presented in Figure 1.

Measurements of brain activity are divided into direct and indirect ones. The first group of measurements is based on the fundamental principle of the nervous system – the brain in particular – which releases a continuous electrical discharge of neurons. Therefore, the direct methods are based on detection and recording (imaging) of the electrical activity of neurons. These measurements include:

Figure 1. Classification of the physiological measurements methods according to the nervous system structure

Source: own elaboration based on: Bercik and Rybanska, 2017, p. 85.

- a. Electroencephalography (EEG), which is one of the most popular and commonly used methods of measuring brain functions (Gregor, Wdowiak, 2016). It is based on two aspects. The first of them as per Bremer (2013) is the analysis of the so called rhythms (also known as waves), in tact with which the electric discharges of neurons occur. Identification of their character makes it possible to determine the state of the brain. Thus, a slow discharge rhythm is a characteristic of a state of relaxation (alpha rhythm), faster discharges indicate a state of excitement (beta rhythm), while delta waves are those found during a period of sleep. The analysis of EEG rhythms enables the detection of some neurological diseases, e.g: ADHD or epilepsy (Ligęza, 2018, p. 21). In addition to the rhythm analysis, the electroencephalography also examines the event related potentials (ERP). They represent the changes in EEG, the source of which are specific incidents (stimuli) occurring in the environment of the examined person. ERP is used in research on paying attention to stimuli or their recognition. One of the advantages of EEG is a time precision at a very high level,

allowing to record changes in electrical activity with an accuracy of 1 ms (Ohme et al., 2011, Rossiter et al., 2001). Additional advantages include a relatively low cost of the research, in comparison to other methods used for the analysis of the brain activity. Moreover, thanks to the use of a cap with built-in electrodes to be put on the head of the examined person, it is possible to conduct tests which require the participants to move as freely as possible (Gregor, Wdowiak, 2016). This method is also non-invasive as the electrodes adhere to the scalp and makes it possible to provide a very approximate location of the brain regions where electron activity changes occur. The EEG is used to analyse the process of processing information provided on websites (Bremer, 2013). Using the possibility of applying EEG measurements in mobile conditions, such equipment is also used to study the consumer behaviour within the in-store environment. However, taking into account the aforementioned low spatial precision of the technique, the results of such research are also quite vague. One of the few examples is the research conducted by Bagdziunaite and colleagues (2014), in which the level of analysis reached only the activation of cerebral hemispheres. It was assumed that higher activation of the left hemisphere in relation to the right hemisphere means positive attitude towards the product (*approach motivation*), whereas the opposite situation means negative attitude (*avoidance motivation*).

- b. Magnetoencephalography (MEG), in which changes in the magnetic field associated with the activity of neurons are recorded using detectors placed in the area of the skull of an examined person (Gregor, Wdowiak, 2016). Despite the high spatial precision of this method, it requires extremely high costs associated with the purchase and maintenance of the apparatus. In addition, MEG tests require isolation of the room where they are carried out. Due to these inconveniences, this method is not used on the wide scale.

The other type of methods for analysing the brain function is not based on measuring the electrical activity of neurons, but on their demand for energy required by the activity. Therefore, these are the methods that indirectly measure the brain function by focusing on blood flow analysis, in accordance with the assumption that more active parts of the brain require more oxygen or glucose supplied with blood. Within this group of methods, the functional magnetic resonance imaging (fMRI) is mainly used. In contrast to EEG, this method is characterized by very high spatial precision. This is possible thanks to haemoglobins magnetic properties in its transport of oxygen. It turns out that in magnetic resonance, the component's behaviour characteristics differ (the magnetic properties are different) when the blood is being transported and when it is not. The comparison of the image of oxygen-rich haemoglobin with oxygen-poor haemoglobin enables the accurate indication of the brain regions with high oxygen demand (Lizęga, 2018, p. 22), even if such structures are deeply positioned (Bercea, 2012). Therefore, fMRI allows the identification of the brain areas that are activated for specific tasks, especially that brain cells use oxygen ten times faster than other organs when working (Duch, 2008). Thanks to this method, the areas that are active while feeling emotions, learning new skills or making decisions have been identified (Wang et al., 2008; Plassmann et al., 2011). Nevertheless, this method has a number of disadvantages

which significantly limit its use in research on consumer behaviour. First of all, the relationship between oxygen demand and neurons activity is not fully explained. It is possible that this demand may be a result of other factors that are not directly related to the increased work of specific parts of the brain. There are two reasons for this. The first condition is the fact that the brain at rest consumes as much energy as the brain in the activation state (Binder, 2018, p. 30). In turn, the second premise is based on the research, according to which neurons activate within a few milliseconds after the stimulus is presented, while the increase in oxygen demand and thus the increase in blood flow occurs only after 2–6 seconds (Szymusiak, 2012). A significant time delay of measurement is another disadvantage of this method (Morin, 2011; Kenning, 2007). Bearing in mind the above, this method proves to be of little use in diagnosis of the dynamics of brain function changes. In addition, the requirements that must be met in order to perform magnetic resonance create very unnatural test conditions: the examined person must be immobilised (especially head) and then placed in the lying position (on the back) in a cylinder that emits noises of a high intensity (magnetic resonance). Moreover, the specificity of the measurement performed using that method required multiple repetition of the same stimulus for the same person. It inevitably prolongs the process of data collection. As a result, it is very difficult to create appropriate research conditions that at least to a small extent would reflect everyday shopping conditions (Riedl et al., 2010). Therefore, it is difficult to generalise the research results obtained in this way, and consequently, predict the behaviour of people in the ordinary environment (Bremer, 2013). Moreover, very high cost of this method intensifies limitations in its application with regard to the analysis of consumer behaviour (Gregor, Wdowiak, 2016). There are also opinions that this method is too primitive for the tasks that it should be able to tackle. And since this does not lower the researchers' expectations, it triggers the aforementioned tendency to over-interpret the results obtained (Uttal, 2003).

Intermediate brain activity testing also includes a very sensitive method called positron-emission tomography (PET). Nevertheless, its specificity requires the administration of radioactive substances to the examined persons which significantly limits its usefulness. The half life period of these substances is so short that it coincides with the test period. Nevertheless, these are hazardous substances, thus the tests carried out using this method are considered to be invasive. Awareness that they will be required to take such substance constitutes a significant psychological barrier to people who are to be examined (Kenning et al., 2007) and may impede the acquisition of a sufficient number of participants (Jaśkowski, 2004). If one combines the above with the high costs of apparatus acquisition and maintenance as well as high cost of isotopes, the research method appears so complicated that its usage is limited primarily to medical tests (Szymusiak, 2012).

As it was already mentioned, the physiological measurements do not only cover the brain activity regulated by the central nervous system, but they also concern the body activity directly influenced by the peripheral nervous system. Those measurements indicate the consequences of brain activity observable in different parts (physiological systems) of the body. The body activity is regulated by two nervous systems (two parts

of the peripheral system): somatic and automatic system. The activities regulated by the somatic system can be controlled by humans to a limited extent. The following measurements are carried out in their scope:

- a. Eye movement measurement – a collection of research techniques used for the measurement, recording and analysis of data on the position and movement of the eye in a given period of time. Eye-tracking is based on psycho-physiological processes related to the visual perception of the environment (Rojna, 2003). The most popular technique for recording eye movement is “corneal reflex examination” and uses the reflection of light from the cornea (the so called Purkinje effect). That technique is based on a continuous lighting of the cornea and then on determining the position of the beam of light being reflected. The lights reflection off the cornea is analysed and identified as the movement of the eyeball (Wedel, Pieters, 2006).
- b. Measurements of facial expressions (changes in facial expressions) – changes in facial expression can be observable and unobservable (Dimberg, 2000). It is assumed that changes occurring on the face, communicate the existence of specific emotions (both positive and negative) in a correct way. In case of the observable changes, cameras record the examined person face for forty-four possible combinations of facial muscle movements (Ekman, Friesen, 2003). The images from the cameras are then analysed by software designed for that purpose. Necessarily, this type of measurements require that the examined person does not move (it concerns the head in particular), so that the distance from the camera remains unchanged. In turn, measurement of the unobservable changes of facial expressions that last several milliseconds (microexpression) is called electromyography. It consists in attaching electrodes to appropriate places on the face and measuring muscle contractions, which are essentially their bioelectrical signals. Measurement of both observable and unobservable changes of facial expression, due to its specificity makes the examined person focused on the research process despite its impracticality in data collection in non-laboratory conditions (Szymusiak, 2012).
- c. Voice verification- consists of the measurement of the volume of speech, the pace of spoken words (speed of speech), the meaning of spoken words (logic of speech), and microvibrations (Klebba, 1985; Haddad et al., 2002). These measurements are good indicators of emotional stimulation (Backhaus et al., 1985) and is one of the simplest measurements to carry out, due to its use of conventional recording equipment, which may remain unrevealed for the examined person. The analysis of the recorded voices, however, must be carried out using specialised software (Klebba, 1985). Although this method is suitable for detecting the emotional stimulation, physiological mechanism that leads to changes in the characteristics of statements made under the influence of emotions is not clearly recognized (Nighswonger, Martin, 1981).
- d. Measurements of response time – by comparing the response time of the examined person to specific stimuli, it is possible to determine how such stimuli are received (positive or negative). The test makes it possible to determine the attitude of the examined subject or person – in line with the principle that the faster the reaction to the stimulus presented, the more positive attitude. A great advantage of this

method is the possibility to conduct the test on persons who remain unaware of the attitudes towards specific stimuli (Barcea, 2012).

The last group of measurements being analysed is related to the functioning of the autonomic nervous system. As mentioned above, the activities of the body regulated by the autonomic nervous system remain beyond the human body control. They take place automatically and out of consciousness. This system activity can be analysed by means of the following measurements:

- a. Measurement of secretion activity of the eccrine sweat glands – this activity affects the electrodermal reaction (EDA) and is related to changes in the skin conductance, which is a derivative of perspiration by the eccrine sweat glands. By measuring this activity it is possible to identify the emotional stimulation. Electrodermal activity can be recorded as a reaction to a short-term stimulus (phase reaction) or a chronic stimulus (tonic reaction). Due to the significant accumulation of sweat glands on hands and feet, these body parts are the main area of the physiological measurements focus.
- b. Measurement of respiratory processes intensity (respirometry) – in this case, the respiratory frequency (rhythm) as well as inspiration and expiration depth are subject to measurement. It is assumed that respiratory processes can be an important indicator for determining the emotional states. For example, quick and deep breathing is associated with enthusiasm, while shallow breaths can be a sign of fear or even panic. In general, emotional stimulation increases the respiratory frequency, making it irregular (Bercik, Rybanska, 2017) and is measured by a device known as a respirometer. In order to perform the test properly, it is required to place the appropriate mask on the examined person face (including nose and mouth). The mask is connected with the measuring equipment and is usually conducted in laboratory conditions due to their specificity.
- c. The measurement of the cardiovascular system activity – measuring the frequency and regularity of heart contractions (Sosnowski, Zimmer, 1993, p. 222) enable the determination of excitement. It has also been noted that the heart rate decreases when people focus on analysing information in their environment. When one does not pay attention to such information, the heart rate increases. This system activity is measured by means of an electrocardiograph or a heart rate monitor.

Conclusions

Physiological measurements, as a research method are increasingly used in social sciences, including economics. The main reason for this is the technological progress, thanks to which the equipment used for physiological measurements become easier to operate, more accurate and, what is equally important, less costly. Nevertheless, regardless of the level of technological advancement of the apparatus used, the issue of correct interpretation of data obtained remains unchanged. This undoubtedly requires an interdisciplinary approach and needs scientific achievements in consumer behaviour to be combined with knowledge of physiology, neurology, psychology, engineer-

ing or computer science. Such a multilateral approach, however, can be an obstacle to the correct use of methods discussed and needs to be overcome as they provide an opportunity to acquire knowledge that would be difficult to obtain otherwise.

References

1. Ariely D., Berns G.S. (2010). *Neuromarketing: the hope and hype of neuromarketing in business*. Nature Reviews. Neuroscience, 11(4), 284–292.
2. Aron A., Badre D., Brett M., Cacioppo J., Chambers C., Cools R. et al. (2007). *Letter: Politics and the brain*. New York Times.
3. Backhaus K., Meyer M., Stockert A. (1985). *Using voice analysis for analysing bargaining processes in industrial marketing*. Journal of Business Research, 13(5), pp. 435–446.
4. Bagdziunaite D., Nassri K., Clement J., Ramsøy T.Z. (2014). *An added value of neuroscientific tools to understand consumers' in-store behaviour*. (43rd EMAC Conference, Valencia, June 3–6), downloaded from <http://www.emac2014.eu/>.
5. Bercea M.D. (2012). *Anatomy of methodologies for measuring consumer behavior in neuromarketing research*. Conference Paper. Downloaded from <http://www.lcbr-archives.com/media/files/12emc023.pdf>
6. Berčík J., Rybanská J. (2017). *Methods used in neuromarketing*. [In:] Horska E., Berčík J. (Eds.), *Neuromarketing in food retailing*. Wageningen Academic Publishers, Wageningen, pp. 83–102.
7. Binder M. (2018). *Psychoodejście. Jak i po co podglądamy mózg*. Polityka, 31(11), pp. 26–31.
8. Bremer J. (2013). *Czym jest neuromarketing*. British Computer Society, Teoretické štúdie, Communication Today, 18, pp. 18–45.
9. Dimberg U., Thunberg M., Elmeheed, K. (2000). *Unconscious facial reactions to emotional facial expressions*. Psychological Science, 11(1), pp. 86–89.
10. Diterhaft A., Woźniak M. (2017). *Sytuacja i możliwości wykorzystania badań neuromarketingowych na rynku polskim*. Zeszyty Naukowe Wyższej szkoły Bankowej w Poznaniu, 75(4), pp. 193–204.
11. Dobbs D. (2005). *Współczesna frenologia?* Świat Nauki. Special edition, 16, pp. 23–29.
12. Duch W. (2008). *Perspektywy neuromarketingu*. [In:] Mruk H., Sznajder M. (Eds.), *Neuromarketing. Interdyscyplinarne spojrzenie na klienta*. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu, Poznań.
13. Ekman P., Friesen W.V. (2003). *Unmasking the face*. Malor Books Cambridge, MA.
14. Falk E.B., Berkman E.T., Lieberman M.D. (2012). *Effects from neural responses to population behavior: Neural focus group predicts population-level media*. Psychological Science, 23(5), pp. 439–445.
15. Gregor B., Wdowiak Ł. (2016). *Istota oraz metody badań neuromarketingowych*. Prace Naukowe Uniwersytetu Ekonomicznego, 459, pp. 50–61.
16. Haddad D., Walter S., Ratley R., Smith M. (2002). *Investigation and Evaluation of Voice Stress Analysis Technology, Final Report*. National Institute of Justice, NCJRS 193832. <http://www.ncjrs.gov/pdffiles1/nij/193832.pdf>.

17. Hintze J.M., Volpe R.J., Shapiro E.S. (2002). *Best practices in the systematic direct observation of student behavior*. Best Practices in School Psychology IV, 63, pp. 993–1006.
18. Jaśkowski P. (2004). *Zarys psychofizjologii*. Wyższa Szkoła Finansów i Zarządzania, Warszawa.
19. Johnston J.M., Pennypacker H.S., Green G. (1993). *Strategies and tactics of behavioural research*. Lawrence Erlbaum, Hillsdale, NJ.
20. Kaczmarczyk S. (2014). *Klasyfikacja metod zbierania danych ze źródeł pierwotnych w badaniach marketingowych*. Metody ilościowe w badaniach marketingowych, 195, pp. 55–64.
21. Kenning P., Plassmann H., Ahlert D. (2007). *Applications of functional magnetic resonance imaging for market research*. Qualitative Market Research. International Journal, 10(2), pp. 135–152.
22. Klebba J.M. (1985). *Physiological measures of research: A review of brain activity, electrodermal response, pupil dilation, and voice analysis methods and studies*. Current Issues & Research in Advertising, 8(1), pp. 53–76.
23. Knutson B., Rick S., Wimmer G.E., Prelec D., Loewenstein G. (2007). *Neural Predictors of Purchases*. Neuron, 53(1), pp. 147–156. doi:10.1016/j.neuron.2006.11.010
24. Kowalski J. (2009). *Neuromarketing jako wrota do podświadomości konsumenta*. [In:] Kozielski R. (Ed.) *Nowe media – konkurencja z wyobraźnią. W poszukiwaniu nowych metod komunikacji z klientem*. Raport z warsztatów strategicznych. Uniwersytet Łódzki, Mikołajki, p. 20–21.
25. Lamme V. (2003). *Why visual attention and awareness are different*. Trends in Cognitive Sciences, 7(1), pp. 12–18.
26. Larsen N. M., Sigurdsson V., Breivik J. (2017). *The use of observational technology to study in-store behavior: consumer choice, video surveillance and retail analytics*. Behavioral economics in consumer behavior analysis, pp. 1–29, doi: 10.1007/s40614-017-0121-x.
27. Lee N., Broderick A.J., Chamberlain L. (2007). *What is “neuromarketing”? A discussion and agenda for future research*. International Journal of Psychophysiology, 63, pp. 199–204.
28. Littlefield M. (2009). *Constructing the organ of deceit: The rhetoric of fMRI and brain fingerprint in post-9/11 America*. Science, Technology & Human, 34(3), pp. 365–392, doi:10.1177/0162243908328756.
29. Ligęza T. (2018). *Przyrządy do narządu, Poradnik Psychologiczny*. Jak i po co podglądamy mózg. Polityka 31(11), pp. 18–24.
30. Morin Ch. (2011). *Neuromarketing: The New Science of Consumer Behavior*. Society, 48(2), pp. 131–135.
31. Mruk H., Jankowiak-Kaczmarek A. (2017). *Wiedza o konsumentach z perspektywy ekonomii behawioralnej*. [In:] Bartosik-Purgat M. (Ed.), *Zachowanie konsumenta. Globalizacja. Nowe Technologie. Aktualne trendy. Otoczenie społeczno-kulturowe*. Wydawnictwo Naukowe PWN S.A., Warsaw, p. 79–98).
32. Nighswonger N.J., Martin C.R. (1981). *On using voice analysis in marketing research*. Journal of Marketing Research, 18(3), pp. 350–355.
33. Plassmann H., Ramsøy T.Z., Milosavljevic M. (2012). *Branding the brain: A critical review and outlook*. Journal of Consumer Psychology, 22(1), pp. 18–36.
34. Ober J., Dylak J., Gryniewicz W., Przedpelska-Ober E. (2009). *Sakkadometria – nowe możliwości oceny stanu czynnościowego ośrodkowego układu nerwowego*. Nauka 4, pp. 109–135.
35. O’Connell A.F., Nichols J.D., Karanth K.U. (2011). *Camera Traps in Animal Ecology. Methods and Analyses*. Springer.

36. Ohme R. (2006). *Kontrowersje wokół neuromarketingu*. Downloaded from: <https://wiadomosci.Onet.pl/kiosk/kontrowersje-wokol-neuromarketingu/kmj1s>.
37. Ohme R. (2017). *Emo sapiens. Harmonia emocji i rozumu*. Bukowy Las, Wrocław.
38. Ohme R., Matukin M., Pacula-Lesniak B. (2011). *Biometric measures for interactive advertising research*. Journal of Interactive Advertising, 11(2), pp. 60–72.
39. Paton J.J., Belova M.A., Morrison S.E., Salzman C.D. (2006). *The primate amygdala represents the positive and negative value of visual stimuli during learning*. Nature, 439, pp. 865–870.
40. Poldrack R.A. (2006). *Can cognitive processes be inferred from neuroimaging data?* Trends in Cognitive Sciences, 10(2), pp. 59–63.
41. Riedl R., Hubert M., Kenning P. (2010). *Are there neural gender differences in online trust? An fMRI study on the perceived trustworthiness of eBay offers*. Society for Information Management and The Management Information Systems Research, 34(2), pp. 397–428.
42. Reimann M., Schilke O., Weber B., Neuhaus C., Zaichkowsky J. (2011). *Functional magnetic resonance imaging in consumer research: A review and application*. Psychology & Marketing, 28(6), pp. 608–637 doi:10.1002/mar.20403.
43. Rossiter J.R., Silberstein R.B., Harris P.G., Nield G. (2001). *Brain-imaging detection of visual scene encoding in long-term memory for TV commercials*. Journal of Advertising Research, 41(2), pp. 13–21. doi:10.2501/JAR-41-2-13-21.
44. Rożek T. (2011). *Nauka po prostu*. Demart S.A., Warszawa.
45. Rószkiewicz M. (2002). *Metody ilościowe w badaniach marketingowych*. Wydawnictwo Naukowe PWN, Warsaw.
46. Schwartzkopf S. (2015). *Measurement devices and the psychophysiology of consumer behaviour: A posthuman genealogy of neuromarketing*. BioSocieties, 10(4), pp. 465–482. doi:10.1057/biosoc.2015.3.
47. Shiv B., Bechara A., Levin I., Alba J.W., Bettman J.R., Dube L., McGraw A.P. (2005). *Decision neuroscience*. Marketing Letters, 16(3–4), pp. 375–386.
48. Smyczek S., Turek A. (2011). *Możliwość zastosowania diagnostyki medycznej w badaniach zachowań konsumentów*. [In:] Mazurek-Łopacińska K., Sobocińska M. (Eds.), *Badania marketingowe w zarządzaniu przedsiębiorstwem*. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 237, Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław, pp. 65–74.
49. Sosnowski T., Zimmer K. (1993). *Metody psychofizjologiczne w badaniach psychologicznych*. Wydawnictwo Naukowe PWN, Warsaw.
50. Stewart D.W., Furse D.H. (1982). *Applying psychophysiological measures to marketing and advertising research problems*. Journal of Current Issues and Research in Advertising 5(1), pp. 1–38. doi:10.1080/01633392.1982.10505319.
51. Studziński J. (2009). *Z marką do mózgu*. [In:] Kozielski R. (Ed.), *Branding. Nowe możliwości. Nowe rozwiązania*. Raport z warsztatów strategicznych, Uniwersytet Łódzki, pp. 15–16.
52. Szymusiak H. (2012). *Neurobiologiczne techniki stosowane w biznesie*. Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań.
53. Urbański M. (1993). *Podstawy pomiarów w psychofizjologii*. [In:] *Metody psychofizjologiczne w badaniach psychologicznych*. Wydawnictwo Naukowe PWN, Warsaw, pp. 42–100.
54. Uttal D. (2003). *On the relation between play and symbolic thought. The Case of Mathematics manipulatives*. [In:] Saracho O.N., Spodek B. (Eds.). *Contemporary Perspectives in Early Childhood Education*. Age Publishing Inc., pp. 97–114.

55. Wang Y.J., Minor M.S. (2008). *Validity, reliability and applicability of psychophysiological techniques in marketing research*. Psychology & Marketing, 25(2), pp. 197–232.
56. Wedel M., Pieters R. (2006). *Eye-tracking for visual marketing*. Foundations and Trends in Marketing, 1(4), pp. 231–320.