Three Generations of Vibraimage Systems. Developer Review

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Abstract: *Application fields, advantages and disadvantages for different generations of psychophysiological systems are analyzed on the sample of vibraimage systems. Block diagrams of three generations of vibraimage systems are considered. The substantiation of physical approach to personality characteristics decomposition into independent components to identify factor dependence is given. The instruments of personality characteristics decomposition into independent components as multifactorial stimuli are proposed. The development of the third generation systems for psychophysiological detection is predicted as the main trend for the next 20–50 years in psychophysiology developments. The goal of identifying person intentions in 60 seconds is formulated, the methods and means for achieving it are proposed.*

Keywords: *vibraimage, psychophysiology, metrology, direct conversion measuring instruments, measurement with feedback, adaptive measuring instruments, adaptive testing, visual stimuli, biometrics.*

Introduction

According to the established tradition, the first report at the conference is an overview of the general trends in vibraimage technology that have occurred over the past year (Minkin, 2018; 2019a; 2020b). In this paper, I will focus on the classification of vibraimage systems by the measurement method. It is known that all measurement methods are divided into direct and indirect (Novitsky, 1975; OIML V 2–200, 2007). In direct measurement methods, all information transmitting in one forward direction. In vibraimage systems analyzing the psychophysiological state (PPS) of a person, the movements of a subject head are converting using the number of measurement functions. Outside light transforms into a reflected light gradient, light-charge transformation is going on a photodetector matrix, charge transforms into an output analog signal, digitization of the output signal in going on a television camera, digital signal processes by a computer program into the parameters of psychophysiological state, for example, aggression or stress level.

Direct measurement methods are traditionally used in various psychophysiological studies. Usually the primary source of information is physiological signals, for example, EEG (Reuderink et al., 2013), facial expressions (Giannakakis et al., 2017), speech tonality, eye activity, temperature body, electromyogram (EMG), respiration rate, galvanic skin response, heart rate (HR), electrocardiogram (ECG), heart rate variability (HRV), blood pressure, photoplethysmogram (Giannakakis et al., 2019; Tao & Tan ed., 2009).

The method of balanced measurement (or indirect measuring function with feedback) in psychophysiology and psychology is usually associated with the presentation of visual,

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textual or audio stimuli that set a certain psychophysiological state or mood to a subject. The IAPS system provides the widest choice of visual stimuli, which includes about 1200 different images (Zhou et al., 2011), with known statistics of the effect to PPS. The other way of measurement stimulus effect on the PPS assessed by the dynamics of changes in various psychophysiological signals, such as GSR, EMG, EEG, and respiratory rate.

Adaptive methods of psychophysiological research (with stimuli adaptation to a subject) are widely represented in psychophysiological lie detection (Baur, 2006). The personality of a subject is especially important, and the stimuli of the basic testing are matched based on pre-testing, when the most significant questions are determined for a subject (Minkin & Nikolaenko, 2020).

The purpose of this review is to analyze the advantages and disadvantages of various vibraimage systems as measurement psychophysiological instruments, as well as to determine the optimal applications for each generation of vibraimage systems.

Vibraimage systems of the first generation. Direct measuring instruments

The first developed vibraimage systems were direct transformation, its structural diagram shown in Figure 1.

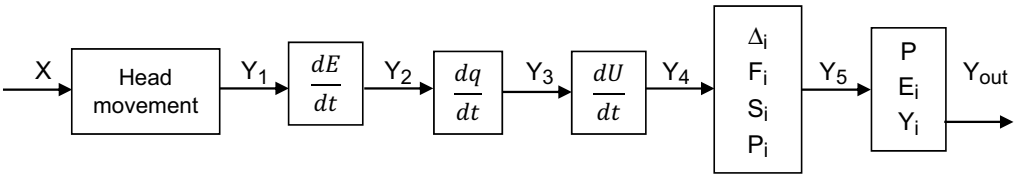

Fig. 1. *Block diagram of vibraimage system for direct measurements.*

X — PPS characteristics, Y_1 — change in the light flux depending on the contrast of the object and its motor activity, Y_2 — spatial transformation of the light flux using the optics of a television camera, Y_3 — charge conversion in the photodetector, Y_4 — analog-digital signal-to-digital conversion, Y_5 — primary parameters of vibraimage; Y_{out} — PPS characteristics measurement result

The physical measured quantity in vibraimage system is spatial-temporal movement of a head, which indicates the change in the reflected light flux arriving at each element of a matrix photodetector. Photodetector converts the light into electrical charge, and then into voltage, which is converted into a digital video image in a television camera. A computer program converts a digital image into two streams of analog and frequency vibraimage (Minkin & Shtam, 2000), then these streams are converted into primary parameters of vibraimage reflecting the amplitude, frequency, symmetry and mathematical parameters of head movement (Minkin, 2017; 2020). The resulting sensitivity of channels, in which the direct measurement method is used, is determined by the sensitivities of all its transformations. The resulting error is equally determined by the errors of all transformations (Novitsky, 1975). It should not be considered that vibraimage systems of the first generation or direct measurements are worse than vibraimage systems of the second or third generation, they are designed to solve various aims. The main task of the first generation of vibraimage

systems MED, PRO, HealthTest, VibraHT (Minkin, 2019a; Minkin et al., 2020) is to measure person's psychophysiological parameters for task free state, without external stimuli influence. Although, in some cases, is better to use neutral (irrelevant) stimuli to minimize the scatter of the PPS, since it has been proven that the absence of external stimuli leads to the maximum scatter of the PPS parameters in a random sample of subjects (Minkin, 2020a). Therefore, in the latest modification of the HealthTest and VibraHT programs, the Relax mode was developed with the display of nature pictures, doing possible to reduce the PPS dispersion for relatively long three-minute tests (Minkin et al., 2020).

The main application of the first generation of vibraimage systems were and remain security systems, when it is necessary to determine the current PPS of a subject within a short time (5–20 seconds), for example, at an airport to quickly identify aggressive, suspicious and potentially dangerous passengers (Minkin & Tseluiko, 2014).

Another relevant application of the first generation vibraimage systems is medical and psychophysiological diagnostics for the detection of various diseases, for example, COVID-19 (Blank M. A. et al., 2012; Minkin et al., 2020) or pre-shift psychophysiological control (Bobrov et al., 2020). It should be noted that if to identify bright emotional states is enough to have PPS measurement duration of several (5–20) seconds, then for medical and psychophysiological diagnostics, a longer measurement time is required, amounting to 60–180 seconds. This is need to measurement time exceeds the brain activity period (BAP), which can be more than 60 seconds (Minkin & Blank, 2019), and capturing only a part of this period significantly reduces the accuracy of determining the mean values and variability of the PPS parameters (Minkin, 2019b).

The second generation of vibraimage systems. Measurements with feedback

In some cases, information about task free psychophysiological state turns out to be insufficient. For example, to obtain data on a person's intentions, or to reveal hidden information, is necessary to present external stimuli. In this case, the response of PPS changes under the influence of external stimuli is fixed, i. e. realized feedback between stimulus presentation and PPS changes. The block diagram of vibraimage system with feedback shown in Figure 2.

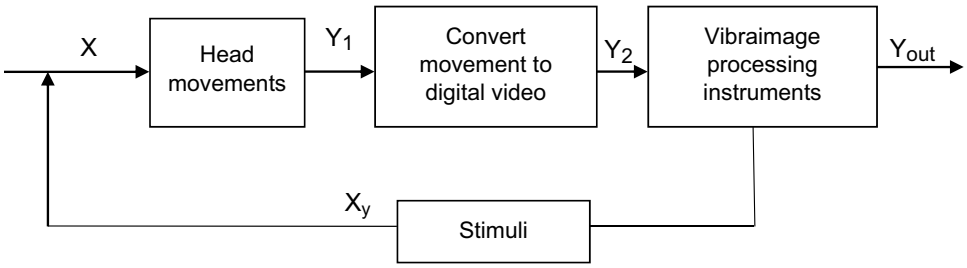

Fig. 2. *Block diagram of vibraimage system with feedback by stimuli presentation. Line of direct conversion of measured quantities is similar to Figure 1 and shown as integral conversion blocks*

Feedback is any signal transmission in the opposite direction, i. e. from exit to entrance (Novoseltsev, 1978). The visual and textual stimuli presented to a subject have influence and change the PPS parameters. The measured quantity in vibraimage system with controlled stimuli is not the PPS parameters themselves, but their changes when the stimuli are presented to a person. Such subtraction of parameters allows one to reduce the influence of primary PPS on the measured value (which can be different for many reasons) and to analyze only the necessary information, although, of course, it is not always possible to completely eliminate the influence of the primary PPS on the test results. Vibraimage programs of the second generation (VibraMI, PsyAccent, VibraLie) use visual, textual and audio stimuli to change the subject's state (Minkin & Nikolaenko, 2017). They are based on the approaches of stimuli presentation developed in classic psychophysiology, including high time interval between stimuli at least 15 seconds with a stimulus duration about 5 seconds (Minkin & Myasnikova & Nikolaenko, 2019). It was assumed that during the time after the stimulus presentation, the psychophysiological state of a subject returns to approximately the same position in which it was before the presentation of the previous stimulus. Most of the second generation of vibraimage programs were designed to be used in fairly comfortable conditions of personal psychological testing, for example, determining the abilities and multiple intelligences (MI) profile of a child or student, or conducting interviews when applying for a job. The average testing time was approximately 7 minutes and included 24 stimulus questions.

Of course, this is a significantly shorter testing time than traditional psychological surveys MMPI (Drayton, 2009), which includes more than 500 questions and last about 2 hours for one test, which makes vibraimage technology quite attractive for mass testing. Most psychophysiological testing with stimulus presentation is complex enough to perform, which limits the test results to a maximum of hundreds of subjects (Giannakakis et al., 2019) in one study or application. Studies involving hundreds and thousands of subjects using a single method were possible only by conducting psychological surveys without using physiological data (Schmalbach et al., 2020). However, the easy of vibraimage technology allows researching of more than 10 thousand subjects with measurements of dozens psychophysiological parameters (Minkin, 2020a) for every subject.

The third generation of vibraimage systems. Adaptive measurement tools

Now, I do not know any analogs of automatic adaptive psychophysiological systems of the third generation, except for vibraimage systems. A non-automatic analogue of adaptive systems is pretesting and basic testing for lie detection, carried out by a polygraph examiner for each individual case (Minkin & Nikolaenko, 2020).

Only vibraimage technology, due to its properties (contactless, friendly to use, processing a huge amount of information received at 30 Mb/s in real time), can quickly divide a personality into independent characteristics at the pretesting stage, determine and present the significant stimuli that are individual for each person on basic testing. Therefore, vibraimage system is adaptive to a subject and carry out a comprehensive processing of each component and personality as a whole. The structural diagram of the adaptive vibraimage system shown in Figure 3.

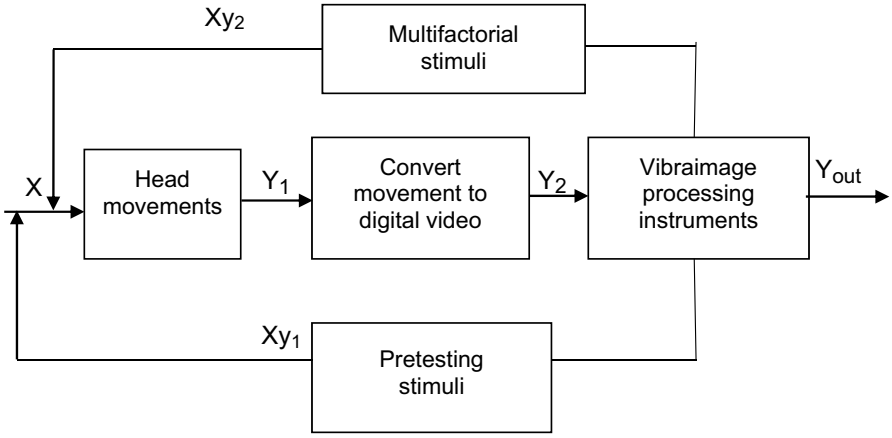

Fig. 3. *Block diagram of adaptive vibraimage system*

At the first time, the adaptive vibraimage system (VibraNLP) was presented at last year conference on vibraimage technology (Minkin & Nikolaenko, 2020). Current conference presents several studies of VibraNLP program (Minkin, 2021a; 2021b; Minkin & Blank, 2021). The adaptability of VibraNLP program lies in the fact that at the pretesting stage (12 questions-stimuli) the profile of a subject's multiple intelligences is determined and the most developed MI are identified or personality is divided into other characteristics. The questions and stimuli presented to a subject on the basic testing stage depend on the pretesting results. The most developed MI types are receiving the most significant stimuli related to the research factor. This makes possible to use insignificant stimuli as relatively neutral and increase the testing accuracy while reducing its duration due to the priority analysis of significant personality characteristics. The feedback of multifactorial stimuli after pretesting stimuli on Figure 3 shows process of multifactor stimuli individualization after processing of responses to pretesting stimuli.

Previous generations of vibraimage systems used classic psychophysiological rules (Cacioppo et al., 2007), however adaptive vibraimage system establishes its own rules and norms. The results presented on this conference (Minkin, 2021a; 2021b; Minkin & Blank, 2021) show adaptive systems achieve the same or higher detection accuracy during shorter testing time relative to classical psychophysiological systems.

It was proved before that after presentation of significant stimuli, the subject's PPS does not return to its previous position (Minkin & Myasnikova, 2018; Minkin & Myasnikova & Nikolaenko, 2019). Moreover, long pauses between questions allow a subject to better control his unconscious responses, and minimizing the time between stimulus questions allows to get more accurate unconscious response to the presented stimulus (Minkin, 2021a; 2021b; Minkin&Blank, 2021). This is also facilitated by the imposed rhythm of stimulus presentation, which period can be minimized to 5 seconds per stimulus. Moreover, the number of stimulus can be halved by combining opposite stimuli in one question, (if necessary) then the total number of questions will be 12–24, and the total testing time will be only 60–120 seconds like in different questionnaires of VibraNLP program (Minkin, 2021a; 2021b; Minkin & Blank, 2021). Such short testing time opens

up fundamentally new opportunities for using adaptive vibraimage systems in the field of security, including arriving at airports. Vibraimage systems of the first generation cope with the identification of potentially dangerous people during departure, which is quite understandable, since psychophysiological direct measurement systems determine the current psychophysiological state. If a passenger intends to commit a terrorist act or unlawful actions in flight, then his psychophysiological state before departure must differ from the PPS of ordinary passengers. However, if a passenger is not going to commit illegal actions during the flight, while he has the intention to commit illegal actions after arrival, then it becomes meaningless to control his current PPS before departure, since it will not differ from the PPS of ordinary passengers. It is also pointless to monitor the current PPS of potential terrorists after the flight; in order to identify potential violators, it is necessary to monitor their intentions, and not the current PPS.

Vibraimage systems of the second generation are capable of detecting the intentions of the subjects, but the achieved testing duration of about 7 minutes does not allow controlling 100% of passenger traffic at modern airports. The creation of automatic kiosks to control the hostile intents of arriving people (Nunamaker, 2011) becomes possible when the testing time is reduced to 1 minute, which is achievable with adaptive vibraimage systems of the third generation (Minkin, 2021a; 2021b; Minkin & Blank, 2021).

Discussion

The physical approach to a person as an object of psychophysiological research, laid down by Sechenov (Sechenov, 1952), Darwin (Darwin, 1872) and James (James, 1890) back in the 19th century, is also fundamental in the 21st century. In 2020, the Nobel Prize in Physics was awarded to Roger Penrose for his research on black holes in the field of astronomy, although, in my opinion, his research in the field of psychophysiology and consciousness (Penrose, 1994) deserves an equal award. The standard research approach in modern physics is the decomposition (dividing) of a general phenomenon into independent constituent components, for example, molecules into atoms, atoms into elementary particles, the white spectrum into color components. The study of each component of the spectrum separately allows better understanding and representing the properties of an object as a whole. Therefore, the theory of multiple intelligences proposed by Gardner (Gardner, 1983) for characterizing personality is such a physical analogue of personality decomposition into independent spectrum or independent personality characteristics. The main thing in Gardner's approach is precisely the independence of psychophysiological characteristics, and not their name and function (Gardner, 2009).

It seems to me such physical prism that separates personality characteristics and reveals the person's predisposition to the investigated factor are multifactorial stimuli (Nikolaenko, 2020) linguistically oriented both to the factor under study and to a certain type of multiple intelligences. Of course, it is quite difficult to achieve the same repeatability of results in psychophysiology as in physics, since the linguistic and associative binding of a stimulus to various factors is a new method and requires additional study and statistical confirmation.

A separate issue that also requires further study is the possibility of generating similar stimuli used at the stage of preliminary testing. On the one hand, the stimuli should be close enough in meaning so as not to evoke different associations; on the other hand, the stimuli

should be different in order to avoid the addictive effect and be relatively unexpected and new for the subject. A roughly similar approach is used in psychophysiological lie detection during the formation of significant stimuli (Baur, 2006), when significant stimuli have some differences among themselves upon repeated presentation.

Despite currently the apparent lack of practical statistical evidence of the effectiveness of adaptive (for a specific user) psychophysiological systems of the third generation, it seems to me that this path of development will prevail for psychophysiology for the next 20–50 years, since any study of a person as an object are quite long-term.

When we started to deal with biometric identification in the early 90 s of the last century and created the first chip scanner for fingerprint identification (Minkin et al., 1992; 1995), few people believed that the procedure of biometric identification would become a routine at many airports in the world. The problem of intentions identification (Minkin, 2002) is perhaps slightly more difficult than person identification, but it is the same physical problem and must have an objective solution.

Conclusion

Currently, the products created on vibraimage technology give scope for both practical users and researchers working in various fields, including safety, medicine, psychology, sports and other areas where measurement and assessment of the psychophysiological characteristics of a person is in demand.

Vibraimage systems of the 1st and 2nd generations working on the rules of classic psychophysiology moves psychophysiology from academic science to practical using and have high distribution in the world because show transparency, friendly and effectivity. The 3rd generation of vibraimage systems open new opportunity to psychophysiology and give new instrument to human study. Detection of the quantity relation between conscious and unconscious gives new possibilities to psychophysiological testing achieves higher accuracy for less time of measuring emotions, abilities and psychophysiological characteristics.

Until recently, the vibraimage technology was only a tool for obtaining psychophysiological information about a person, similar to other physiological signals. Now the accumulated knowledge forms new approaches in psychophysiology, which can be not only in demand as practical solutions, but also used as a methodology for others psychophysiological technologies.

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