THE OPTIMAL SEQUENCE OF STIMULI PRESENTATION FOR PROFILING AND PSYCHOPHYSIOLOGICAL DETECTION OF DECEPTION

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Abstract: *Described the study of changes in psychophysiological responses for different sequences of presented stimuli. Calculated the dependences of probabilities changes for psychophysiological responses direction of line-opposite questionnaire and complementary questionnaire. Correlation matrixes of psychophysiological responses for various questionnaires were calculated. Based on the obtained data was given the recommended sequence of stimuli presentation I-C-I-R-I during psychological detection of deception and profiling.*

Keywords: *vibraimage, psychophysiology of consciousness, detection of deception, stimuli, profiling, I-C-I-R-I.*

Modern psychophysiology suggests that the sequence of stimuli presentation is important for a correct analysis of the subsequent psychophysiological responses [Bauer, 2006; Alekseev, 2011]. Different researchers offer various forms of questionnaires that include questions of different significance for tested person [Bauer, 2006; Alekseev, 2011]. The most common in the world is the approach of Zone Comparison Test (ZCT) presenting, developed by Cleve Backster in 1961 [Backster, 1961; Bauer, 2006]. Indeed, if we consider the detection of deception from the measurement theory point of view, the method including comparison of responses to the relevant and control (comparison) question need be attributed to the methods of balanced transformation, which, in general, have higher accuracy than the measuring methods of direct transformation [Novitsky, 1975]. Currently, a number of standards for detection of deception have been developed [ASTM E2386-04, 2017]. While psychophysiological detection of deception (PDD) has a large number of supporters and opponents who are convinced that modern lie detection has no scientific substantiation and accuracy characteristics given by PDD supporters are not true, and the decision to detect lies is subjective and greatly depends on the personality of the examiner [Maschke, 2018; Alekseev, 2011]. It should be recognized that many of opponents arguments of lie detection look quite convincing, most part of scientific publications on lie detection are declarative and do not have statistical scientific evidence [Maschke, 2018, Bauer, 2006]. Despite this, the psychophysiological detection of deception successfully develops, the conclusions of polygraph examiners are accepted by the courts of many countries and bring practical results.

The purpose of this study is to consider the issue of PDD by the physiology of consciousness [Boring, 1933] and to determine statistical patterns upon presentation of various stimuli. I hope that this research will make PDD more scientifically and received results will increase the accuracy in practical PDD testing.

Psychophysiological response to stimuli. Some theory

Practically, all modern PDD developers and researchers are convinced that a lie is a rather complex psychophysiological state (PPS) [Ekman, 2016], having multiple physiological manifestations and can be detected when compared with normal PPS or upon presentation of comparison stimuli. The main axiom or hypothesis of PDD says that a more significant physiological response corresponds to a more significant stimulus presented to a testee [Ekman, 2016; Alekseev, 2011]. In this case, PDD task is reduced to determining the intensity of physiological signals (for a contact polygraph, these are heart rate HR, arterial pressure AP, galvanic skin response GSR, and breathing frequency BF), depending on the presented stimuli. The developers of the contact polygraph historically use the time dependences of these physiological signals, which were previously recorded by analog polygraphs, and now are recorded and processed using computer programs [Varlamov, 2010]. The proposed hypothesis looks relatively logical, since upon presentation of a significant stimulus human brain requires greater energy consumption. It increases body metabolism, which should lead to intensification of all physiological processes, including heart rate, blood pressure, an increase in sweating (reduction of electrical resistance of the skin) and an increase in the frequency of breathing to provide more oxygen to the brain.

However, studies conducted with the help of vibraimage technology have shown that psychophysiological response to the presented stimuli does not look exactly like PDD followers hypothesis [Minkin, Myasnikova, 2018; Choi, 2018] convinced. Let's start with the fact that these physiological processes truly reflect the energy processes occurring in the human body, but the work of sensory physiological systems is associated not only with energy consumption, but is primarily based on the exchange of information signals both within one physiological system and between different physiological systems [Minkin, 2018]. The time dependences of the signals used in the contact polygraph practically do not reflect the informational efficiency of signal transmission, but the informational efficiency of the exchange of physiological signals is the main indicator of the change in PDD [Minkin, 2018; New]. The intensity of psychophysiological response (PPR) is not identical only to energy metabolism; therefore, most PDD researchers make a mistake by putting an equal sign between the intensity of the PPR and its energy component. In addition, the developers of lie detectors do not take into account chronobiological and regulatory processes that constantly occur in the human body [Minkin, Blank, 2019]. The function of the human vestibular system is to provide mechanical balance of the whole organism. To implement this function, the vestibular system constantly receives sensory signals from all organs of the human body, including the autonomous maintenance of the human head in an upright state. Any change in the functioning of a person physiology including brain activity changes when there are relevant stimuli leads to changes in the work of the vestibular system. This effect was called the vestibular-emotional reflex [Minkin, Nikolaenko, 2008]. Moreover, these changes in the work of the vestibular system can characterize not only by energy processes in a human body, but also by information exchange efficiency [Minkin, Nikolaenko, 2017; Minkin, 2018].

In addition, the efficiency of information exchange in a human body can be determined by analyzing the correlation of the of various physiological systems operation [Minkin, 2018], which opens up the possibility of using the obtained results for any technology of psychophysiological detection, including the contact polygraph.

Method and participants

To analyze the PPS, we will look at the test results of the group of 210 high school students (aged 15–17 years) of St. Petersburg schools by VibraMI programs testing with the Gardner12T questionnaire [Minkin, Nikolaenko, 2017; VibraMI, 2019] and PsyAccent with the T12 questionnaire [PsyAccent, 2019] conducted in 2018 from September to December. Testing was conducted on a computer with IntelCore I7 processor, with Microsoft LifeCam Studio webcam with the image format of 640×480. The illuminance of the test subjects was within (500–700) lux, the head size during the test was at least 200 elements by horizontal line in frame, the image quality indicator in the VibraMI and PsyAccent programs exceeded 80%. The duration of each test was approximately 380 seconds.

Test results

The order of stimuli presentation in VibraMI [VibraMI, 2019] and PsyAccent [PsyAccent, 2019] programs is different. In VibraMI program pairs of opposite stimuli are presented, and in PsyAccent programs there are stimuli pairs of similar meaning. Otherwise, these programs are quite similar to each other, in both, 24 questions and pictures are sequantly presenting on the monitor screen. Testee are answering Yes, No, or missing the answer to the question if he could not choose the answer. From the normal physiology point of view, it can be considered that the only difference in the presented stimuli was in the order in which stimuli were presented, since the significance of stimuli in different programs should be approximately the same for a testee. In previous experiments with the VibraMI program, it was shown that if opposite stimuli were presented, a noticeable negative correlation was observed in the psychophysiological responses to neighboring questions with the average Pearson correlation level P = –0.45 [Minkin, Myasnikova, 2018]. The similar result confirmed in the course of new experiment, the correlation matrix of the psychophysiological responses to the 24 questions of the VibraMI program given in table 1.

The results in table 1 confirm the previously obtained data on the prevalence of negative correlation between neighboring questions for the linear opposition questionnaire. The average Pearson coefficient for performed tests using the VibraMI program for neighbor replies was P = –0.44. The correlation matrix of the psychophysiological responses to the 24 questions of the PsyAccent program given in Table 2 for the same people as in Table 1.

The results in table 2 are strikingly similar to the correlation matrix of table 1. The average value of the Pearson coefficient for the 210 tests performed by the PsyAccent program was P = –0.46. It turns out that the statistics of the psychophysiological

response of testees practically does not depend on the semantic content of stimuli-questions, but is determined primarily by the form of stimuli presentation [Minkin et al., 2019].

Table 1

Correlation matrix of 210 people psychophysiological responses tested by VibraMI questionnaire

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1		-0,45703																						
2	-0,45703		-0,4849																					
3		-0,4849		-0,40663																				
4			-0,40663		-0,45076																			
5				-0,45076		-0,4294																		
6					-0,4294		-0,43926																	
7						-0,43926		-0,4848																
8							-0,4848		-0,3372															
9								-0,3372		-0,52338														
10									-0,52338		-0,3722													
11										-0,3722		-0,46834												
12											-0,46834		-0,4149											
13												-0,4149		-0,5187										
14													-0,5187		-0,44842									
15														-0,44842		-0,34989								
16															-0,34989		-0,49213							
17																-0,49213		-0,44221						
18																	-0,44221		-0,47759					
19																		-0,47759		-0,31757				
20																			-0,31757		-0,47029			
21																				-0,47029		-0,46784		
22																					-0,46784		-0,31599	
23																						-0,31599		-0,26619
24																							-0,26619	

Table 2

Correlation matrix of 210 people psychophysiological responses tested by PsyAccent questionnaire

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1		-0,38277																						
2	-0,38277		-0,44639																					
3		-0,44639		-0,54147																				
4			-0,54147		-0,4069																			
5				-0,4069		-0,53241																		
6					-0,53241		-0,44862																	
7						-0,44862		-0,46365																
8							-0,46365		-0,46134															
9								-0,46134		-0,42592														
10									-0,42592		-0,46355													
11										-0,46355		-0,41459												
12											-0,41459		-0,42794											
13												-0,42794		-0,48078										
14													-0,48078		-0,44861									
15														-0,44861		-0,38785								
16															-0,38785		-0,46673							
17																-0,46673		-0,59772						
18																	-0,59772		-0,47366					
19																		-0,47366		-0,41611				
20																			-0,41611		-0,41791			
21																				-0,41791		-0,51536		
22																					-0,51536		-0,5415	
23																						-0,5415		-0,39433
24																							-0,39433	

PPS of testee varies relative to PPS center and does not depend much on whether a testee has a positive, negative or neutral attitude to the stimulus. Even if two negative stimuli are sequentially presented, PPR to the second negative stimulus will be positive, not negative, since the psychological adaptation of the organism and the internal mechanisms of physiological regulation are stronger than the conscious negative attitude to the presented stimulus. Similar PPR is observed when two positive stimuli for a testee are sequentially presented, the second positive stimulus is still perceived as negative. Vibraimage technology allows PPS changes capturing in the information-energy axes [Minkin, 2018]. Typical changes in PPS when conducting polls with oppositional stimuli from VibraMI program and complementary PsyAccent stimuli shown in figures 1 and 2, respectively.
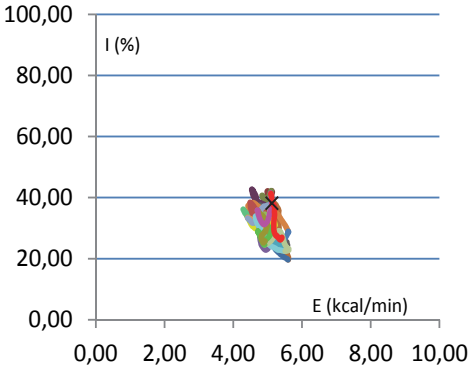
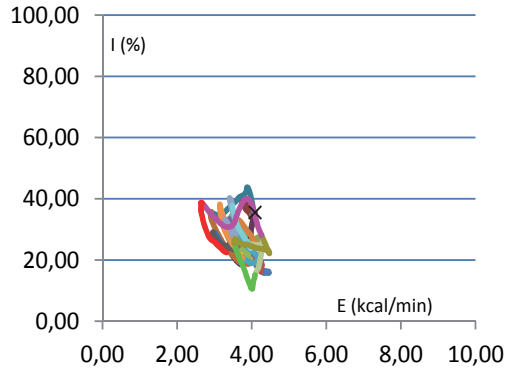**Fig. 1.** PPS changes by VibraMI testing

Fig. 2. PPS changes by PsyAccent testing

In the case of each specific test, the picture of PPS changes is not so ideal, but general statistical patterns (such as the inverse correlation between the information-energy parameters and oscillations around a common center) are clearly traced in figures 1 and 2. Lets consider not only changes in PPS upon presentation of stimuli, but also analyze the magnitude and direction of these changes depending on the value of the previous response. According to the available data, we will determine the probability of PPS direction changes depending on the previous response and deviation from the center, by setting the threshold value of the PPS, $/P/ = 0.12$ separating all psychophysiological responses in the performed experiment into two equal parts.

The probabilities of changes in the subsequent PPR with a large and small deviation of the PPR previous value for the tests performed by the VibraMI and PsyAcent programs are shown in figures 3 and 4, respectively.
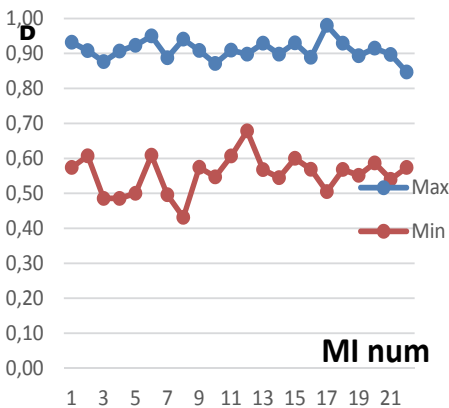

Fig. 3. Probability of PPS changes by VibraMI testing. Probability for Max and Min deviation from previous response
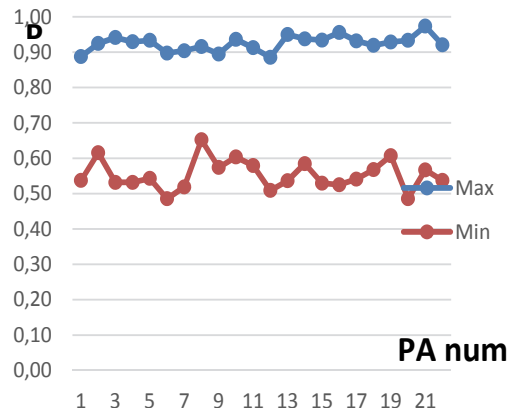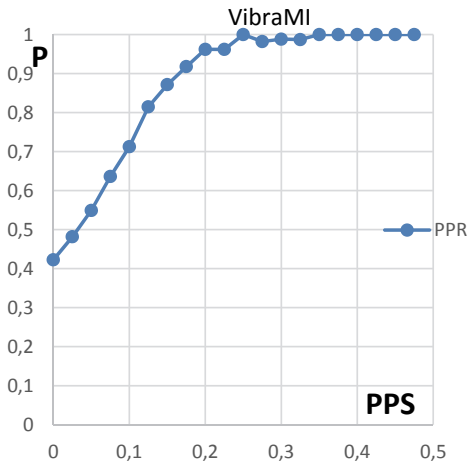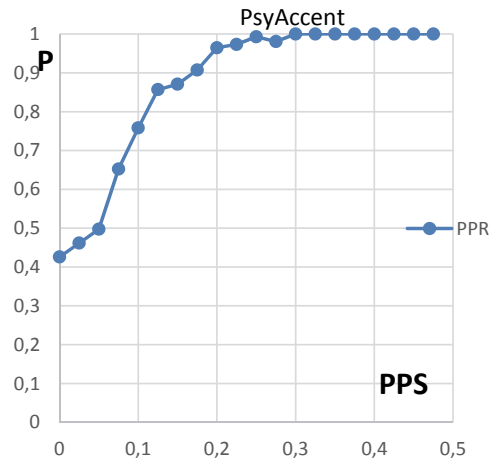

Fig. 4. Probability of PPS changes by PsyAccent testing. Probability for Max and Min deviation from previous response

The data obtained in figures 3 and 4 show that the probability of a subsequent change in the PPR depends little on the content of the question, but it significantly depends on the previous deviation of the PPR. Averaged probabilities of PPR changes based on the available data, construct the dependence of the probability of a change in the direction of the PPR on the previous value of PPR are given in figures 5 and 6.

Fig. 5. Probability of PPR direction changing depending on the previous value of the PPR by VibraMI program testing

Fig. 6. Probability of PPR direction changing depending on the previous value of the PPR by PsyAccent program testing

The data presented in figures 5 and 6 convincingly prove that the results of PPR direction changing for both programs are almost the same and with a significant PPR to the previous question (PPS > 0.2) the probability of changing the direction of the PPR is almost equal 1. That means with a significant PPR to the previous question, the magnitude of the subsequent response is less than the previous one, and this phenomenon does not depend on the type of presented questions.

Discussion

In my opinion, the main problem of modern PDD is the perception of the lie term as a separate and independent psychophysiological state [Ekman, 2016; Alekseev, 2011] and the concentration of PDD only on examples when the testee tells a lie. This local approach to the PPR problem does not allow to receive scientific evidence and validity of used methods. It results in a weak evidence base, since it is almost impossible to achieve significant motivation of testee when conducting statistical tests for lies, and the practical results of real suspects detection are poorly amenable to statistical evaluations, since each real crime is individual in nature. At the same time, specific methods of psychophysiological testing are based on the comparison of the PPR of testee for different stimuli [Bauer, 2006], therefore all theoretical and practical results obtained in the study of testee response to presented stimuli should

be relevant for PDD, which is only a particular case of psychophysiological responses manifestation. The proposed approach to PDD, as a particular manifestation of the physiology of consciousness, will allow to establish the correct testing methods that can be scientifically confirmed.

For a correct understanding of lie physiology, it is necessary to clearly and statistically proved to represent the normal psychophysiological responses of a testee upon presentation of stimuli, only a clear understanding of the norm will allow analyzing and correctly classifying deviations from it. Starting with Backster Zone Comparison Test (ZCT) method, the most of the used questions sequences are the following (or close to the data) variants of questions sequences [Baur, 2006; Varlamov, 2010]:

$$I\text{-}SR\text{-}SYM\text{-}C\text{-}R\text{-}C\text{-}R\text{-}SYM\text{-}C\text{-}R;$$
$$I\text{-}I\text{-}I\text{-}I\text{-}C\text{-}R\text{-}I\text{-}C\text{-}R\text{-}I\text{-}C\text{-}R\text{-}I\text{-}C\text{-}R;$$
$$I\text{-}SR\text{-}SYM\text{-}C\text{-}R\text{-}C\text{-}R\text{-}C\text{-}SYM;$$

Where I — Irrelevant;
      SR — Sacrifice Relevant;
      SYM — Symptomatic;
      C — Comparison;
      R — Relevant.

The main method of comparison questions processing is to compare the PPR for comparison-control (C) and relevant (R) questions, which, as we see from the given sequences, are placed in successive pairs. In this case, the declared principle of comparing responses implies that PPR should be compared to the presented stimuli. However, from the data in figures 3–6, it follows that the PPR for stimuli depends not so much on the stimulus as on the current deviation of the PPS from the zero (central) position. Thus, the presentation of the first comparison stimulus (C) shifts the test PPS from the center position, and the presentation of the control (R) stimulus with a high probability (more than 0.9) will turn the PPS in the opposite direction if the control question was really significant for the test. Therefore, the goal of ZCT is not achieved, or is achieved with low accuracy, since the mechanism of conscious physiological regulation prevents testee from identical perception of the two compared stimuli-comparison and relevant. To avoid this inequality in the perception of incentives, the sequence of presentation should be, for example, the following:

$$I\text{-}C\text{-}I\text{-}R\text{-}I\text{-}C\text{-}I\text{-}R\text{-}I\text{-}C\text{-}I\text{-}R\text{-}I$$

In this case, the insignificant questions established between the control and the significant ones will allow PPS to return to a position close to the center of the PPS, therefore the subsequent PPR of a testee will depend only on the presented stimuli, since the influence of the regulatory physiological mechanisms is close to zero on the PPS, which is approximately near the center, and equally likely to change in any direction (the probability of a change in direction is 50%). I foresee objections from the supporters of the classical polygraph, namely, that there is an opinion that an increase in the time between the presented stimuli should lead to the return of the PPS of a testee

to PPS center. However, conducted studies [Minkin, Myasnikova, 2018; Minkin et al., 2019] show that this is not always the case. PPR of a testee before presenting the next question in most cases continues the inertial movement in the same direction as when presenting the previous question [Minkin, Myasnikova, 2018; Minkin et al., 2019]. The return of the PPS to its initial state is determined by the brain activity period [Minkin, Blank, 2019], and not by an increase in the pause between questions, giving uncertainty in the results. In addition, the lack of presentation of stimuli for a long time leads to a greater change in the PPR than when a certain rhythm is set by the presented stimuli. The psychophysiology of consciousness [Minkin, Blank, 2019] relatively quickly adjusts the body to the proposed rhythm of presentation of stimuli, and the period of change in PPR corresponds to the period of presentation of stimuli after the presentation of the 2nd stimulus [Minkin, Myasnikova, 2018; Minkin, Blank, 2019].

Conclusions

This study have shown that the concept of norms for a psychophysiological responses to relative comparison stimuli makes PDD more objective and scientifically based. It is necessary to rely on the cybernetic approach to a person, as to a living system, operating not only with known physiological parameters and energy consumption, but also with the information efficiency of physiological processes. In this case, PDD should be considered as a special case of the physiology of consciousness.

Vibraimage technology proves that the information-energy approach and vector analysis of PPS changes has significant advantages over traditional temporal dependencies of physiological parameters to improve the accuracy of PDD and reduce testing and profiling time.At the same time, the vibraimage technology is based on the past experience of PDD, moving to a new level of physiological processes understanding and physiology regulation in a human body. The proposed sequence of stimuli presentation (I-C-I-R-I) can be implemented in various PDD systems, profiling and interviewing.

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