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JUNG WAS RIGHT. VIBRAIMAGE TECHNOLOGY PROVES THE DIFFERENT DIRECTIONS OF ENERGY DISTRIBUTION FOR EXTRAVERTED AND INTROVERTED PSYCHOPHYSIOLOGICAL STATES

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Abstract: *Jung hypothesis about the different directions of energy distribution for extraversion and introversion psychophysiological states was proved based on statistical processing of testing results of 161 and 91 first-year students of two technical universities, St. Petersburg, Russia. Multiple intelligences testing of students were provide by line-opposite presentation method with vibraimage technology processing. The experiments showed a prevailing negative correlation between the parameters of an introverted person's energy consumption and positive correlation for extraverted person. Analyzed different equations for psychophysiological state calculation. The article discusses the possibility of consolidating the obtained results for others psychophysiological tests.*

Keywords: *Psychophysiological response, Vibraimage technology, Multiple intelligences, Information exchange, Consumed energy, Introversion, Extraversion.*

Introduction

Though the fundamental works by Darwin and Sechenov (Darwin, 1872; Sechenov, 1965) still influence the development of the modern psychophysiology, in the last 150 years there has been made the minor progress in this field despite the significant achievements in the human-based Physical and Medical studies. The major cause of such a slow progress is that all the theoretical works anyhow focused on psychophysiological processes (Wiener, 1961; Bernstein, 1967 and Lorenz, 1966) were detached from the mainstream practical research (Backster, 1963; Baur, 2006; Cacioppo, 2007). The vibraimage technology (Minkin & Shtam, 2008; Minkin & Nikolaenko, 2008; Minkin & Nikolaenko, 2017; Minkin V. A., 2017) introduced in the late 20th century and quickly developing now, attempts to combine the theoretical issues of general psychophysiology with the practical results and studies. The main practical application of the vibraimage technology is the representation of the reflex head movements through the psychophysiological parameters on the basis of the vestibular-emotional reflex (Minkin & Nikolaenko, 2008). One of the trends of development of the vibraimage technology is the practical study of the human capabilities and construction of the multiple intelligences profile. The concept of multiple intelligences (MI) introduced by Gardner in 1983 (Gardner, 1983) allowed scientists to unite the theories of evolution and multiple intelligences into the common system, and thereby objectively evaluate various individual abilities. The extended theory of multiple intelligences proposed by Minkin and Nikolaenko (Minkin & Nikolaenko, 2017) is based on the application

of line-opposite questionnaires. The vibraimages are used to represent the changes in the psychophysiological state of a person being tested in the information-energy axes (Minkin, 2018). However, the most of the conclusions from the extended theory of multiple intelligences are just made on the basis of hypotheses and assumptions since the proof of each assumption requires the extensive analysis and many experiments. One of such assumptions is the negative relationship, found in the most of experiments, between the energy expenditure and information exchange among the physiological systems during the line-opposite surveys. The current study is intended to investigate this, the previously made, assumption (Minkin & Nikolaenko, 2017) in light of the testing results and their statistical analysis.

Carl Jung about 100 years ago suggested terms introversion and extraversion as one of main psychophysiological parameters (Jung, 1921) of human personality. Jung divided these PPSs primarily based on the movement of energy (Jung, 1921). Jung hypothesis supposed that energy consumption for extravert is directed out of a person and energy consumption for introvert is directed inside a person. For a long time such an assumption remained in the form of a hypothesis and all psychologists, including the most influential ones (Eysenck, 1952; Leonhard, 1999) used the terms extraversion and introversion rather freely, attributing their own meanings to these concepts and ignoring Jung's original assumption of a different direction of the energy flow in a person in an extraverted and introverted PPS.

The structure of the questionnaire for the MI testing developed in (Nikolaenko, 2018) implies the consequent presentation of questions of the conventionally opposite sense (in what follows we will omit the word "conventionally") to estimate the attribution of a person to each of the twelve types of MI. As the main measurable parameters characterizing individual psychophysiological responses, we use the parameters indicating the energy (consumed energy, E) and information (informational exchange efficiency coefficient, I) components of the psychophysiological response (Minkin & Nikolaenko, 2017; Minkin, 2018). Here, under the consumed energy, E, we mean the physical energy measured in natural units of physical quantities, e.g. joule or calorie. The information characteristic of a person is based on the classical concept of information introduced by Shannon and Wiener for cybernetic systems (Shannon, 1948; Wiener, 1961), and the information efficiency indicates the ratio of information transmitted into the physiological systems without loss, related to the total information flow within the physiological systems (Minkin, 2018). It is natural to assume that physical characteristics of the changes in these I-E parameters depend on the type of the posed questions and presented stimuli.

1. Theoretical background

In testing the multiple intelligences, a respondent is presented with 24 opposite questions-stimuli on the computer screen. The web camera installed on the same computer registers the psychophysiological response when processing the micro movements of the head with the use of the vibraimage technology (Minkin & Nikolaenko, 2017).

Negative correlation in the PPS changes between two neighboring questions-stimuli primarily reflects the fact that the transition from one question to another increases the information efficiency and decreases the consumed energy, or vice versa, the information efficiency decreases, and the consumed energy increases. Schematically, a typical changes in the PPS during the presentation of opposite questions-stimuli with an inverse correlation between information-energy parameters is shown in Fig. 1. The changes in the psychophysiological response when a dashed line depicts answering the first question, and a solid line shows answering the second question. This statistical dependence has a logical psychophysiological explanation: the presentation of significant stimuli increases the energy exchange and during the pause after the response, the PPS does not return to the initial state, but, possibly, slightly changes the original direction of the PPS motion. When the person is answering the next question, the PPS change occurs in the opposite direction while the negative correlation between the I-E parameters is preserved.

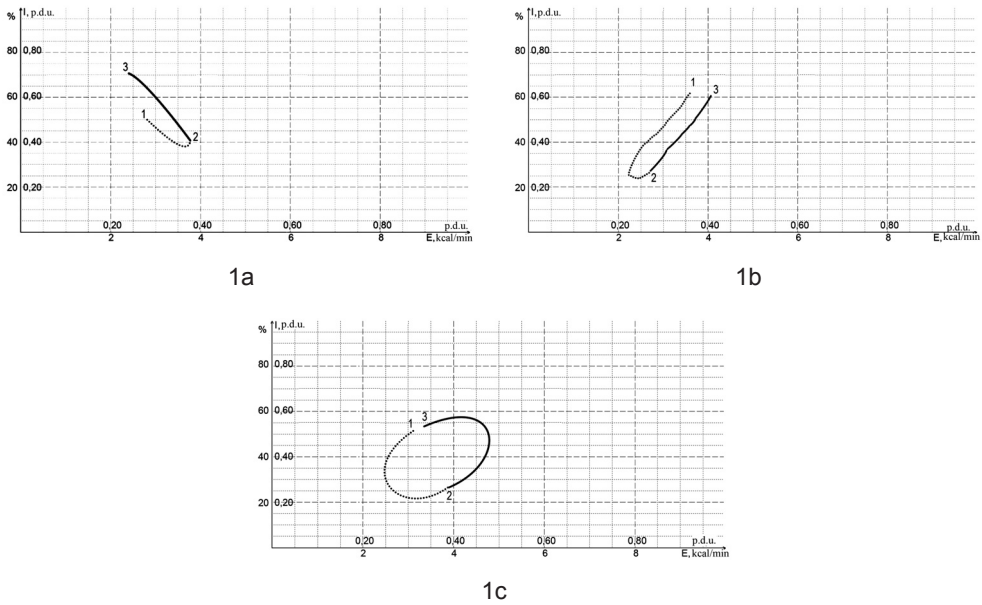


Fig. 1. Typical PPS changes during the MI testing:
1a — Negative I-E correlation, 1b — Positive correlation, 1c — No correlation

We intentionally show and examine the changes in the PPS just by presenting a pair of questions basing on the following considerations. The historical breakthrough and increasing accuracy in the psychophysiological detection of deception are mainly due to the Backster's concept of transition to comparative testing between close-in-time control and relevant questions (Backster, 1963; Baur, 2006). Practical testing shows that the fluctuation of the person’s PPS actually takes place with respect to a certain center of gravity of particular individual PPS. This point the most correctly reflects the average PPS of the person during the testing. Each presented stimulus tends to change

this average PPS value in a certain direction, and the more significant the stimulus is, the greater PPS change should be expected. Directions of the PPS changes are described in the form of hypotheses in (Minkin & Nikolaenko, 2017; Minkin, 2018). Presumably, opposite questions-stimuli should shift the PPS in opposite directions, and this change should also take place regardless of the correctness of the equations used for the calculation of the final PPS. In addition, the opposite questions-stimuli approach allows us to constantly keep close to the PPS conventional center of gravity. This point seems to be quite important since a significant shift from the PPS center of gravity due to the presentation of unidirectional stimuli will lead to a situation where the change in the PPS is not only determined by the next stimulus, but also by the desire of the physiological systems to return the body to the normal state, close to the PPS center of gravity. In this case, the response to the stimulus would be extremely noisy and obscured by the natural physiological reaction of the body, and therefore cannot be restored from the obtained dependence.

Fig. 1a shows an example with a correlation coefficient between the information-energy parameters close to minus 1. Certainly, not all the pairs of questions-stimuli and the corresponding psychophysiological responses have such clear graphical structure as shown in Fig. 1a.

As the next explicit example, let us consider another graph of the possible type of changes in PPS (shown in Fig. 1b), when the person is answering a pair of opposite questions-stimuli, and explain what psychophysiological patterns characterize this scenario. The graph in Fig. 1b shows that when the person is answering the first question-stimulus, the values of both the information and energy parameters fall, and during the answer to the second question-stimulus both of these parameters increase. Hence, the correlation between the information-energy parameters is positive and close to 1. Psychologically, this may be because the first question-stimulus is unpleasant for the individual (his or her information state worsens), but at the same time the question-stimulus does not cause the irritation and the consumed energy also decreases. When the tested person is answering the second question-stimulus, an opposite response is observed, this stimulus causes an improvement in the psychological and information state and, at the same time, causes more energy consumption.

The next example in Fig. 1c shows the dependence between the information-energy parameters during the answering the opposite questions-stimuli in the absence (or minimal) correlation between the specified parameters measured for the total time of presentation of each question-stimulus in the pair. In this case, when answering the first and second questions, the psychophysiological response of the person demonstrates the multidirectional movement that includes time intervals with both negative and positive correlation between the information-energy parameters, and the duration of these time intervals is approximately equal. Therefore the total correlation between I-E parameters during the presentation of each question in a pair is close to zero.

In the examples of graphical representation of the changes in the psychophysiological state (Figs. 1) as a result of answering the opposite questions-stimuli the return to the

initial state occurs. In practice, this does not always happen. On the contrary, the range of the I-E coordinates between the beginning of the first question and the end of the answer to the second question can be quite big. This means that when one only takes into account the state at the end of the question answer, the correlation between I-E parameters can be either positive or negative. However, in an ideal case (or at the large sample size), at presenting pairs of opposite questions-stimuli the range turns out to be significantly less than when pairs of differently directed questions are presented. In the case when neutral questions are additionally added it becomes even more difficult to reveal any general patterns. One of the problems in this case is the practical impossibility of providing a common statistical response of the parameters at answering the neutral questions by different persons. This problem is well known to specialists engaged in psychophysiological detection of deception (ASTM E2386, 2017; Varlamov, 2010).

2. Testing procedure

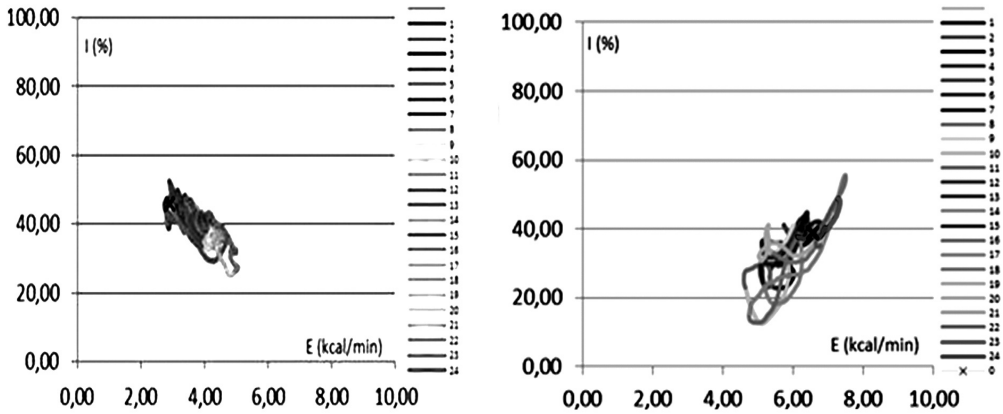
Two groups of first-year students of technical universities of St. Petersburg, Russia, were tested for multiple intelligences. The first group consisted of 161 technical students of the St. Petersburg State Electrotechnical University (LETI), the second group consisted of 93 economic students of the St. Petersburg State Technological University (SPSTU). The tested students were from 17 to 24 years old. An almost equal gender distribution was observed; with a slight predominance of males (60/40 in LETI and slightly higher in favor of females, 65/35 in PPSTU). The testing was conducted in the second half of 2017 with the use of the VibraMI software (VibraMI, 2018). The students have not been familiarized with the questions before the testing. In addition, they believed that the ongoing testing could affect the results of their academic performance, therefore, the presented questions and stimuli were significant for the examined students.

3. Analysis of correlation dependencies

Apart from constructing the multiple intelligences profile for each student, the VibraMI software detects and records a considerable amount of statistical characteristics and dependencies of the psychophysiological parameters obtained during the MI testing into Excel files. Automated processing of measured parameters saved in Excel files is performed by the statistical software VibraStatMI (VibraStatMI, 2018). The VibraStatMI software allows to determine the common patterns for the tested groups, including the correlation dependencies between different parameters. Current psychophysiological state of the person, P, is defined as an intersection point of two coordinates in the I-E axes (Minkin, 2018). Typical examples of the PPS change during the MI testing are shown in Figures 1.

Different colors of the graphs in Figures 1 highlight the PPS changes corresponding to the person's response to each of 24 questions-stimuli. The point corresponding to the initial psychophysiological state before the survey is marked by a cross. In spite

of the seemingly chaotic nature of the PPS changes during the MI testing, we will try to determine the general patterns common for the changes in the information and energy parameters. For this purpose, we calculate the correlation coefficient between the information and energy parameters registered during the time of presentation of each stimulus-based question. Since the I-E parameters are determined for each frame, during the time of one stimulus-based question presentation, which is approx. 20 seconds, we get about 600 measurement results of I-E parameters representing a definite relationship between the parameters of interest. The main direction of I-E dependence on the Fig. 2a is identical to the theoretical sample giving on Fig. 1a and indicates negative correlation between I-E parameters. The most part of tested students have this type of I-E dependence during said testing.



2a 2b

Fig. 2. Typical samples of psychophysiological responses:
2a — negative I-E correlation, 2b — positive I-E correlation

For comparison, the test results for a professor are given below. The professor was absolutely not afraid of the testing result, but rather showed interest and a positive attitude in obtaining the test results. It is possible to suppose that PPS of professor during said testing was extraverted, instead as students PPS was introverted during the same testing.

Fig. 3a shows the dependence of the changes in I-E parameters (correlation diagram) concerning every stimulus-question response during said testing for typical student, and Fig. 3b shows the correlation diagram for professor.

It is absolutely obvious that correlation diagram of student has significant negative correlation for the most part of PPS responses (Fig. 3a) and correlation diagram of professor (Fig. 3b) has significant positive I-E correlation.

Despite the fact that specific cases of MI testing show positive I-E correlations in responses to individual questions, the group-average correlation for certain questions is generally negative for each question. An example of such averaging over the testing group of 161 students is shown in Fig. 4.

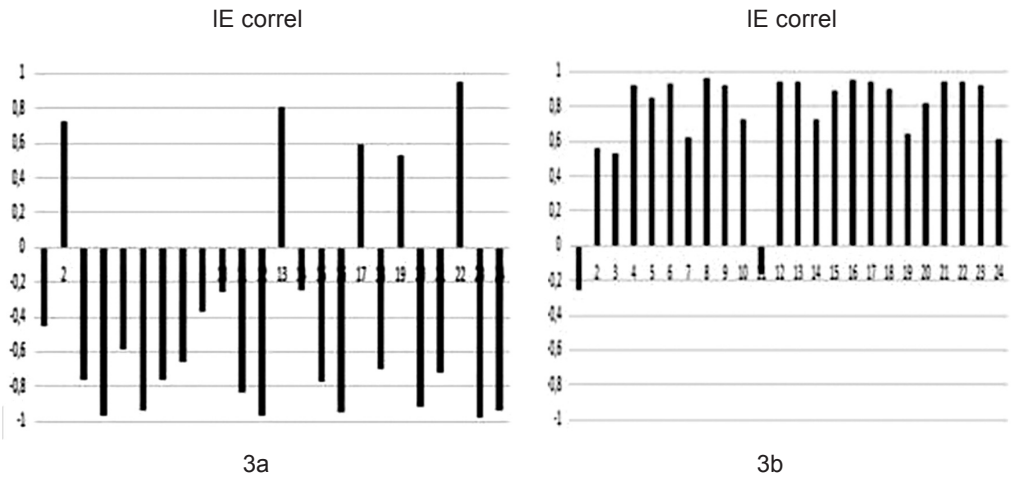


Fig. 3. Correlation coefficient between I-E parameters for the different individual testing: 3a more negative I-E correlation, 3b more positive I-E correlation

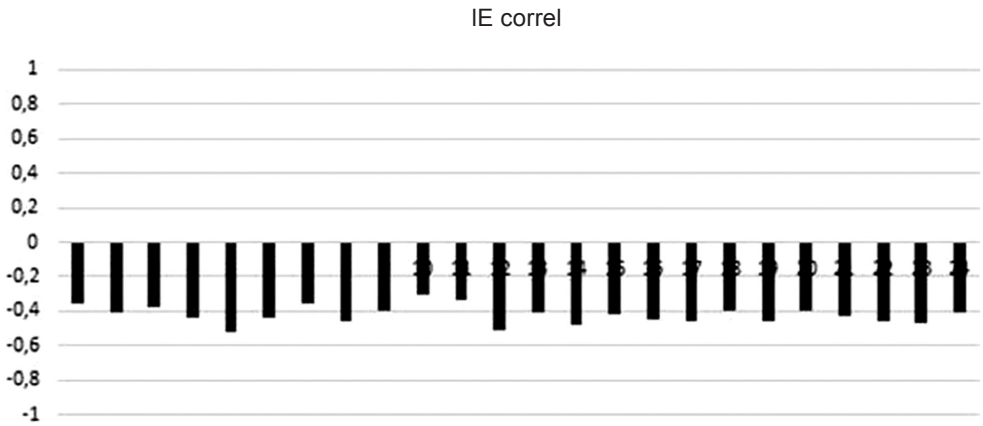


Fig. 4. The averaged correlation coefficients between I-E parameters for the 161 student testing

The result shown in Fig. 4 again corroborates that the negative correlation between I-E parameters is predominant in the answers to opposite questions-stimuli during the multiple intelligences testing of 161 student.

4. Discussion of the obtained results

The conclusions about the correlations of the psychophysiological responses can be considered consistent as our results practically coincide for two independent tested

groups of several hundred people. The study has revealed an additional rule: the more uniform the group structure is, the more pronounced the leading types of intelligences will be in the resulting MI profile of the group. For example, the subdivision of 161 students into unsuccessful students and successful students results in different prevailing intelligences types for these groups. On the horizontal axis are given 12 types of intelligences based on classification given in the article (Minkin V. A., Nikolaenko Y. N., 2017).

On the contrary, the uniting people with different abilities and life interests into the common tested group leads to the equalization of the general statistics and the uniform distribution of the types of multiple intelligences over a large group of different people. This result is quite important and can be used to check the adequacy of the questions-stimuli presented in testing. For example, if after checking a large sample it turns out that one type of MI is the leading, then the most likely this is due to the incorrect assignment of stimuli responsible for the leading type of intelligence. This effect was observed in the first version of the questionnaire where the natural intelligence (NL) was found predominant for the most of non-related groups. Only after correction of questions-stimuli aimed at revealing the natural intelligence, the relative importance of the natural intelligence in the MI profile returned to normal and was no longer the leading type in non-specific groups (Nikolaenko, 2018).

According to the previous algorithms of PPS calculation (Minkin V. A., Nikolaenko Y. N., 2017), the main effect on the testing person is made by the stimulus and the rest of the effects can be neglected. However, a certain correlation in pairs was noted only for closely spaced (nearby) responses. Consequently, a significant change in the PPS is influenced not only by the stimulus, but also by the remoteness of the current value of the PPS from the normal value corresponding to the integral or central state of the PPS. Thus, the change in PPS during testing is determined by two main valid factors: the stimulus presented and the equilibrium psychophysiological force aimed at returning the PPS to the normal (central) state (integral center). Therefore, the magnitude of the stimulus effect on the PPS is determined by the vector from the central state to the current one, rather than the vector that connects the current PPS to the previous one. In this case the practical task of determining the response to a stimulus is reduced to solving a problem from mechanics where two forces act on an ideal moving object. However, this seemingly good logical model of the change in PPS showed less significant results of the correlation in the response to the answers to neighboring questions. The case requires additional research and clarification of the causes of the results. The simplified model of the effect of two forces on the change in PPS (stimulus and regulation of physiological balance) may not take into account the additional physiological characteristics. The model differs from a real person as much as an ideal mechanical system differs from the real one, including the frictional force, the inertia of the object, and other additional factors.

If the prevailing inverse correlation between I-E parameters were not observed in the tested groups, the correlation diagrams calculated from equations (1) and (2) given in the monography (Minkin V. A., Nikolaenko Y. N., 2017) could differ

significantly. Now we will try to answer the question, “Why the correlation between I-E parameters was predominantly negative, although it is known that in some cases it can be close to zero or positive?” As mentioned above, this paper presents the results of testing the first-year students who were feared that the test results could lead to their expulsion from the university. Such psychological pressure during the testing process itself definitely affected the student’s PPS.

However, our experiments make it possible to explicitly distinguish two of these PPSs by the direction of the energy movement. In this case, a PPS should be called introverted if a negative correlation between the energy and information parameters of the subject is observed when responding to the opposite stimuli (positive and negative). Accordingly, a PPS should be called extraverted if a positive correlation between the energy and information parameters of the person is observed when responding to the opposite stimuli. In the tests conducted, the psychological pressure exerted on the students created the prerequisites for their generally introvert behavior, while their professor, interested in cooperation, showed himself as an extravert.

The next question is whether the conclusions drawn are applicable to other types of psychophysiological testing, for example, for lie detection, also remains open. The results allow to hope that the approach might be helpful in making psychophysiological detection of deception more scientifically grounded and practically applicable. It is certainly tempting to use the obtained results for various psychological and psychophysiological tests aimed at identifying potential personal qualities, for example, human variability (National Academies of Sciences, 2016), as well as for fixed or changeable questionnaires to verify loyalty or identify potential supporters of terrorism.

It cannot be ruled out that the method of assessing the PPS changes in information-energy coordinates can be the basis for any psychophysiological testing, and the direction of the PPS vector more objectively represents the subject's response to the stimulus than the relatively subjective positive or negative perception of the stimulus.

Conclusions

In spite of their apparent mathematical and theoretical abstractness, the above examples allow us to draw the specific practical conclusions:

1. The relationship between the information and energy personal characteristics found based on the vibraimage technology makes it possible to assess the changes in the individual PPS and determine the combination of the psychophysiological characteristics of a person.

2. The proposed methodology for determining the introversion/extraversion by monitoring direction of energy changes during the opposite questions-stimuli presentation will allow more objectively evaluate this parameter for each person.

3. The PPS changes of certain groups of persons during MI testing with the first presentation of significant line-opposite stimuli has a predominantly inverse correlation between the information-energy (I-E) parameters.

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