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# Validity of cardiometric performance data: an integral part of complex assessment of training session effectiveness

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## Aims

The paper offers some results from our experimental studies to determine validity of a complex performance fingerprint: the Baevsky stress index used to assess effectiveness of training programs: training sessions targeted at formation of phsychosomatic self-regulation skills and visual & verbal practical training course aimed at development of emotional intelligence.

## Materials and methods

In order to determine the criterion-related validity of cardiometric assessments of training results, we have organized training sessions addressing scheduled staged formation of the self-regulation skills.

Before the training sessions and after them, our training participants have been instructed to perform a set of three tasks, covering the following:

– to imagine a calming video clip;

– to imagine some TV news reporting various dramatic incidents, emergencies, calamities etc.

– to generate self-relaxation, to perform the task to get relaxed and initiated or induced an emotional balance.

During the execution of the above mentioned test tasks, we have recorded synchronously an electrocardiogram (ECG) and a rheogram (Rheo) of every tested individual with the use of PC-assisted hemodynamic analyzers CARDIOCODE.

In order to estimate the construct validity, test simulation & training equipment sessions for operators, who have shown differing levels in their training and actual experience in the operation of complex machinery and equipment systems, have been conducted. Each operator has been offered some variants of images of a control panel related to one of the equipment item serviced by them: the images have appeared on the screen of portable eyetracker GP-3.

In order to assess the content validity of the measured cardiometric parameters as fingerprints of the available training effect, if any, we have investigated the affective-cognitive processes, which have appeared during the visual and verbal practical training of the examined individuals to develop their emotional intelligence.

## Results and conclusions

Upon completion of our scientific investigations we have obtained the experimental confirmation of the validity of the applicability of a complex cardiometric fingerprint, like the Baevsky stress index, in order to assess the applicability and effectiveness of the training courses. Thus we have shown by the example of the psychosomatic self-regulation that it is just the Baevsky stress index that may be properly exploited in assessing the fact that the desired skills to control its own emotional state by a trainee have been effectively formed as the designed outcome of this training type. Discussing an example illustrating the execution by the complex machinery operators of the specific training test tasks, we have pioneered in demonstrating that the Baevsky stress index can be best applied in estimating the degree of interiorization of the formed skill and the robustness of the integration of the latter into the human individual life experience. Upon treating one more exemplary case of the visual-verbal practical testing to develop emotional intelligence, we have shown that there is a possibility to trace the availability of the training effect according to the variations in the Baevsky stress index values, while performing the above test tasks in the training course.

## Keywords

Cardiometry, Cardiocode, Validity, Training, Training effectiveness

## Imprint

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## Introduction

Successful applications of instrumental cardiometry in assessments of functional states in a human organism encourage researchers and practitioners to utilize it on a regular basis as an advanced monitoring and control tool capable of tracing processes of any interventions in the performance of the human body and mind [2]. As cardiometric equipment base is improved, a variety of techniques for an analysis of heart rhythm variability is finding ever increasing use, and that relates specifically to the Baevsky stress index methodology [17].

Therefore, using the above cardiometric index as a means for monitoring and control of data and processes a well as for an assessment of effectiveness of various types of training sessions seems to be absolutely reasonable. However, in doing so, it is required to conduct some additional investigations, which should address an estimation of validity of the applications of this sort of performance indicators in parallel with other types of assessments of effectiveness of trainings. So, it has been just our research work seeking how to solve this validation problem.

## Materials and methods

It is common knowledge that the most important criteria for suitability and applicability of measuring instrumentation are the following types of validity: the criterion(-related) validity, the construct validity and the content validity [1, 13]. It is a generally accepted practice that a mandatory procedure for an evaluation of soundness of any diagnostics method or technique must involve the requirement to test the said types of validity.

In order to determine the criterion-related validity of cardiometric assessments of training results, we have organized training sessions addressing scheduled staged formation of the self-regulation skills, which have met stage one in autogenic training and which have been conducted according to an original technique described extensively in papers [3, 5-11, 15, 16]. Before the training sessions and after them, our training participants (the total cohort of this group has included 101 individuals) have been offered to perform a set of three tasks, which have covered the following:

- to imagine a calming video clip;
- to imagine some TV news reporting various dramatic incidents, emergencies, calamities etc.
- to generate self-relaxation, to perform the task to get relaxed and initiated or induced an emotional balance.

During the execution of the above mentioned tasks and tests, we have recorded synchronously an electrocardiogram (ECG) and a rheogram (Rheo) of every tested individual with the use of PC-assisted hemodynamic analyzers CARDIOCODE, the theoretical concept of which and the principle of its operation are described in detail in [14, 19-21]. Upon recording the curves with the Cardiocode instrumentation, the original Cardiocode software has been applied to process the recordings according to a special algorithm and compute the respective values of the Baevsky stress index for every examinee.

In order to estimate the construct validity, test simulation & training equipment sessions for operators, who have shown differing levels in their training and actual experience in the operation of complex machinery and equipment systems, have been conducted. Each operator has been offered some variants of images of a control panel related to one of the equipment item serviced by them: the images have appeared on the screen of portable eyetracker GP-3. The variants of the images have contained different combinations of indicating signals, by tracing of which the tested operator should to visually fix the procedure of the proper actions related to the control components of the equipment item. In parallel to the visual testing procedure, we have recorded cardiometric parameters of each examined individual with the use of hemodynamic analyzer Cardiocode. Upon completion of recording, for every episode/situation presented on the screen, the respective values of the Baevsky stress index (SI) have been computed.

In order to assess the content validity of the measured cardiometric parameters as fingerprints of the available training effect, if any, we have investigated the affective-cognitive processes, which have appeared during the visual and verbal practical training of the examined individuals to develop their emotional intelligence. During the practical training sessions, each trainee has been presented multi-component images, exhibiting facial expressions of various emotions, at a time interval of 20 seconds. To provide current control of the behavior of the tested individual, we have applied the effect of a deficit-burden stimulation, which has been detailed in our recent papers [1-8, 11]. In our experimental studies, we have used either the words to nominate certain emotions (joy, sadness etc.) or pictorial representations of this sort of emotions by emoji as deficit-burden stimuli: the words have been

Table 1. Main statistics SI parameters before vs. after psychosomatic self-regulation training

| Test task No. | Mean | | Standard deviation | | Median | | Asymmetry | | Excess | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test |
| 1 | 269 | 229 | 260 | 176 | 209 | 204 | 3,5 | 2,2 | 19 | 11 |
| 2 | 466 | 338 | 433 | 271 | 327 | 270 | 2,4 | 1,3 | 9 | 4 |
| 3 | 265 | 241 | 251 | 190 | 203 | 177 | 2,4 | 1,5 | 11 | 5 |

located in the center of the screen. Around such a deficit-burden stimulus, responsible for initiation of a certain direction for a searching activity in a test subject, there have been placed photos of children and adults represented both genders.

At stage one of the training courses, each stimulus has comprised paired photo pictures of the same human individuals, who have experienced diametrically opposed emotions, and one of the emotions in this case has been referred to as a deficit-burden stimulus. All stimuli utilized at the above stage have been collected into single-type groups, and each of these groups has included four unchanged sets of photos depicted human faces and two sets to express one of the respective diametrically opposite emotions. It can be illustrated by the example as follows: the pair of emotions joy – sadness has been referred to a set of the words "sadness" and "joy", alternatively displayed in the center of the screen, furnished with the respective emoji to express the emotions. The groups of the stimuli have differed from each other in the number of the photos located around a deficit-laden stimulus: the number of the photos depicted human individuals has varied from 4 to 24.

At stage two of the training courses, we have employed verbal expressions of the emotions only as deficit-laden stimulation. At this stage, in addition to the paired emotions, the deficit-laden stimuli have reflected some separated emotions. The list of the selected emotions has included surprise, fear, anger, disgust, rage and enjoyment. Moreover, the surrounding of the center-placed deficit-burden stimulus has incorporated not only the photos, but also the respective emoji, which have expressed different variants of emotional responses by a human. To achieve the required simulation effect, the number of such images has been gradually increased from 8 to 24.

From the beginning till the end of the presentation of each stimulus, we have employed our PC-assisted hemodynamic analyzer Cardiocode to record an ECG and a Rheo of every examinee. Upon completion of the recordings, based thereon, the corresponding values of the Baevsky stress index (SI) have been calculated with the use of the proprietary software of the Cardiocode device.

A total of 147 tested subjects, aged from 18 to 46, have been enrolled in our experimental studies. All measured cardiometric parameters have been obtained with the above hemodynamic analyzer Cardiocode, and all oculometric measurements and the demonstration of visual stimuli have been performed with portable monitoring-type eyetracker GP-3. The delivered parameters and the obtained data have been processed with statistics software package STADIA 8.0.

## Results and discussion

The main data, obtained in the course of determining criteria validity of cardiometric assessments of results upon psychosomatic self-regulation training, conducted in accordance with the above described procedures, are given in Table 1 herein.

Table 1 offers tabulated statistics parameters upon processing the values of the Baevsky stress index (SI) in individuals, measured under the pre- and post-test conditions utilizing PC-assisted device Cardiocode, in the course of the psychosomatic self-regulation training, when performing the same test tasks. The test tasks in Table 1 are numbered as given below: 1 – imagination by the examined subjects of a calming video clip; 2 – imagination by examinees of TV news reporting dramatic incidents, emergencies and calamities; 3 – self-relaxation, the task to get relaxed and initiated an emotional balance.

The statistical significance of the differences shown in Table 1 has been estimated with the chi-squared criterion, considering the obtained empirical distributions. Since it has been found that all values of the chi-squared criterion, computed by applying statistics software STADIA 8.0, reach at least 1000, all differences and deviations computed and indicated in Table 1 can be treated to be statistically significant at a level of no less than 0,01. Besides, as indicated by

Table 1 herein, upon the completion of the training, the SI parameters are characterized by a narrower dispersion of the observed values. This sort of more compact distributions of the SI data can be explained by an adjustment of the level of preparedness of the examinees to solve the test task targeted at formation of calm, well-balanced emotional state by them. All this can be considered as a clear demonstration of the criterion validity of the cardiometric assessments of the effectiveness results of the completed training.

During the evaluation of the construct validity of the measured cardiometric values, we have detected that for the well-trained operators, who have a large experience in the proper operation of complex machinery, typical is a gradual decrease in the Baevsky stress index values as they complete the different tasks of the above described visual test simulation & training session. As to those, who have been found to be less skilled and experienced, we can observe a diameterally opposite tendency: their stimulation advance has been accompanied by an increase in the SI values. It should be noted that in this case, according to the indicators of the eyetracker equipment, in general, both tested groups have selected the proper sequence of the procedural actions.

All this bears witness to the fact that the Baevsky stress index can be successfully used to judge the degree of effectiveness in mastering a skill. As to group one, the skill has been acquired to such a degree that it has become automated, when the experienced operators have perceived the simulation tasks to be performed as their routine job. Therefore, when going from one task to another, they have demonstrated their capability performance of keeping customary pace with their usual work that has been well represented by the decrease in the Baevsky index level. The tested subjects in group two have viewed the test tasks as serios examinations, which have induced stress in them, even though these less experienced operators have properly decided on how to act. So, following this way, we can say that these results lend credence to our idea that the cardiometric parameters enable us to assess the degree of effectiveness in mastering a skill formed upon the respective training sessions.

As a result of our investigations, addressed assessing of the content validity of cardiometric measurements as fingerprints of the availability of the desired training effect, it has been detected that as the number of photos surrounding a deficit-laden stimulus increases, the Baevsky index values show their statistically significant growth rates. Typically, such growth for most tested subjects reaches a two- or three-fold increase as compared with the data recorded upon presentation of the first stimulus. Later we observe a considerable decrease in this parameter: it averages between 30 and 40% of the achieved maximum value. As a rule, this effect has been identified after the photos appearing around the deficit-laden stimulus are over 14-16 in number. Since in this case, according to the eyetracking data, the accuracy in correspondence between the deficit-laden stimulus and the respective photos remains at the same level, we can state with assurance that the tested individuals have reached their qualitatively higher level of mastering the skill to identify facial expressions of emotions.

In our post-test communication, the majority of the tested persons have noticed that at the instant their Baevsky stress index value substantially drops, they "suddenly" experience "ease" of finding the required images. This has also supported the fact that the cardiometric parameters are capable of properly indicating the key points of qualitative transformations associated with the level of mastering of the desired skill immediately at the training-in-progress stage.

## Conclusions

Upon completion of our scientific investigations we have obtained the experimental confirmation of the validity of the applicability of a complex cardiometric fingerprint, like the Baevsky stress index, in order to assess the applicability and effectiveness of the training courses. Thus we have shown by the example of the psychosomatic self-regulation that it is just the Baevsky stress index that may be properly exploited in assessing the fact that the desired skills to control its own emotional state by a trainee have been effectively formed as the designed outcome of this training type. Discussing an example illustrating the execution by the complex machinery operators of the specific training test tasks, we have pioneered in demonstrating that the Baevsky stress index can be best applied in estimating the degree of interiorization of the formed skill and the robustness of the integration of the latter into the human individual life experience. Upon treating one more exemplary case of the visual-verbal practical testing, focused on the development of emotional intelligence, we have shown that there is a possibility to identify and trace the availability of

the training effect according to the variations in the Baevsky stress index values, when performing the test tasks in the training as described above.

## Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.

## Conflict of interest

None declared.

## Author contributions

V.A.Z., E.V.L., L.P.N. and M.Y.R. conceived and planned the experiments, interpreted the results. R.S.K., P.A.K., P.A.M. and N.V.M. carried out the experiments and prepared the manuscript. A.S.O. took the lead in writing the manuscript and supervised the findings of this work. All the authors read the ICMJE criteria for authorship and approved the final manuscript.

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