Study of the Possibility of Using Pupillography for Personnel Selection at Hiring

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Abstract. Detection of the psychophysical state of a person and identification of a person by various biometric data is becoming an increasingly popular and widespread every year. The systems also detect the state of alcohol or drug intoxication. Managers need an employee who has certain qualities: paying attention to small details, honest and stress-resistant. At the same time, employers are faced with the task of choosing one of several job applicants. Video analytical tracking systems, supplemented by Eye tracking system and special test objects register parameters by which you can judge the characteristics inherent in the applicants. Such systems will make it easier to find people who have the competencies expected by the employer. The article presents the first results of the research on the reaction of the human pupil in response to an irritant compared with a stressful situation.

1. Introduction

In recent years, due to the increased number of various kinds of emergency situations, researchers are showing increasing interest in maladjustment conditions that are detected in workers in unfavorable working conditions [1-5]. The most common type of employee selection is based on an analysis: a questionnaire completed by the candidate, a conversation held between the candidate and the manager, and training [6]. However, these methods of selection cannot fully describe and predict how a person will behave when performing the work he faces threats to his life. Byalt V. S. describes the selection of employees in the US police. The only difference from the most common selection is the psychological analysis of the candidate and the use of a polygraph. He says that the level of error in the analysis of employee tests is 19%, and that these tests often provide an opportunity to "guess" the correct answers [7]. The problem with training can be solved by increasing the period of training and vetting of candidates, as it is used in the police of the Kingdom of Belgium [8]. Although there is a drawback – a large amount of time is spent on training one employee. The lack of analysis of employee abilities to respond adequately to an emergency situation increases the risk of errors in performing the work duties. [9]. Due to the use of biometric systems it becomes possible to ensure an optimal level of assessment of the personal and professional capabilities of future workers who are subjected to special responsibility and have to follow the safety and health measures. This technology is an innovative tool in this area and allows us to solve the tasks most effectively [9-10].
When passing the written test, the risk of cheating is high and a person can learn how to present himself correctly to the employer during the interview. To reduce the level of subjectivity of the selection, it is necessary to use such methods so that the person cannot influence on them. One of such

methods is pupillography. A number of its features include non-invasive research and the use of pupillary reactions in identifying the psychophysical state of a person, in which there is no possibility to hide the personal reaction or affect the result of the examination [11]. The use of pupillography, as a method of studying the human response to an emotional stimulus, may contribute to the professional selection of specialists in future. Employees will be examined and selected for their working duties depending on their ability to respond adequately in an extreme situation.

It is known, that there is a unique biochemical relationship between the size of the pupils and the experienced emotion [12]. If the external stimulus for a person is not indifferent, it will cause a physical and chemical reaction of the body, which will justify the reaction of the pupil. However, the existing systems of passive recognition of the psychophysical state of a person are not based on the analysis of pupil size of the eye. This is due to the existing strong dependence of pupil size on illumination, selective color sensitivity and uncertainty of the initial state of the pupil [13]. On the basis of which the goal of this research work was to explore the possibility of using pupillography for the selection of personnel for employment. The main task is to compare changes in the size of pupils of different people and to determine the nature of the reaction in response to the presented stimulus.

2. Overview

Existing methods of testing for employment should be improved. Shevchenko T. V. in his book describes the pros and cons of various methods of selection: resumes, interviews, medical examinations, psychological tests to the most exotic-graphology and so on. Using various methods it is possible fully and efficiently evaluate candidates who are able to achieve the expected result of the organization and only benefit from their work [14]. The different selection criteria are used in different countries. A sample of hiring managers in a large labor market determined that the main advantage of informal recruitment is the quality of candidates, and formal recruitment is the number of candidates [15]. The modern world has become tolerant, and many foreign works describe, for the most part, not to select an employee based on his record. Every person is different, selecting employee according the gender, race, and so on is the wrong concept [16-19]. For this purpose, it is necessary to conduct a thorough selection and analysis of the employee's behavior in the working environment, so that no prejudices can affect the quality of the selected staff. Gurevich K. M. in his book confirms the importance of professional selection, because every person is able to master the profession to some extent, but it can take a lot of effort and resources, such as time [20]. One of the methods of analysis of the psychophysical state of a person is pupillography. Interest in the possibilities of pupillographic research as a possible method of diagnosing personal characteristics is justified by 50 years of experience in psychology and psychophysiology. Scientists are looking for relationships between the structure and functioning of the human eye and the psychological characteristics of a person [21]. A few years ago, the Swedish scientist Mats Larsson in a study of 428 volunteers revealed the connection of clear lines on the iris with impulsivity and neuroticism, which allowed him to assume a genetic condition of the eye pattern and some personal qualities [21]. Also pupillography is used to detect such physical condition as an intoxication [11,22]. Pupillography demonstrates a wide possibility of obtaining informative signs of conditions of the central and autonomic nervous system in the form of its temporal and amplitude characteristics [23]. Also, this method helps to identify the state of mental satiety, "emotional burnout", mental stress and emotional stress [24]. With the help of pupillography, athletes are examined for their physical and mental health (study of endurance, exhaustion of the central and autonomous nervous system, adjustment disorder) [25]. This contributes to a more accurate development of therapeutic recovery measures. Pupillography is also used to establish the fact of damage by toxic chemicals [26-27]. It is actively used in medicine for carrying out the analysis of diabetic patients [28]. The method of dynamic pupillography is used to assess the vegetative tone and reactivity in response to a provocative test for cold [29]. This allows us to learn speed of reaction of human to exposure factors which can lead to function of unconscious reactions. As a non-invasive method, autonomous infrared pupillography is used as a measure of predicting the functional neurological outcome in patients during the critical condition, because it has higher

reliability of the data compared to the use of flashlight pens [30]. Pupillography is used to study the influence of an external stimulus on psychophysiological indicators of mental effort and motivational mood, when the demand for tasks varies [31-33]. This study describes the physical indicators of the body when we take series of mental tests to determine the level of motivation to perform the specific tasks. A wide range of applications of pupillography confirms the objectivity of the data obtained by scientists. Using this method, it is possible to analyze how the pupil of the eye responses to an emotional stimulus.

Scientists are working on the study of the dependence of bioparameters to stressful situations, but existing methods do not always give a full amount of information about the psycho-emotional state of a person. Anyushin M. V. describes clearly advantages and disadvantages of using bioparameters in his publications. So the use of microwave and terahertz technology is limited by the safe exposure time to human. The scientist also says that the use of passive technologies is more preferable, since they do not have any impact on the personnel working with dangerous objects, and do not create unwanted interference to the working equipment. These technologies register only natural radiation of the human body. As an example of such technologies, Anishkin M. V. cites the use of acoustic, optical (including pupillography), gas analysis and high-quality technologies. However, the scientist does not cite pupillography specifically as a method for studying the reaction in response to stimuli [34]. There are some research works which are aimed at studying the condition of a person experiencing a phobia. The works contain materials of studying clinical cases in medical institutions [35]. The examined patients have narcolepsy [36], sleep disorder [36-35], are subject to anxiety attacks [39-40, 43], phobias [37-38, 40]. There are also a number of works describing the study of the so-called school phobia-fear of students before society, through the study of pupillograms [41]. Pupillography is also used to study anxiety states [42]. However, there is actually no work specifically aimed at studying the dynamics and behavior of the pupil of people who are subject to anxiety states or phobias. Scientists describe only the available information about the change of such a vegetative feature as pupil dilation. But there is very little information. This gives the right to judge this topic in an up-to-date way. Based on this, we can say that this topic and this method of using pupillography are new and relevant.

A hypothesis has been put forward, that if a person has some phobias or experiences stress under the influence of fear, then he will respond to test objects which has the image of the object that causes stress or fear, more clearly than one who does not have a phobia or stress reaction. The confirmation of this hypothesis will be analyzed in this work with the help of pupillography. This can be tracked by the dynamics of the pupil movement, so if you make an average pupillogram, the pupillogram having a deviation from the average values will mean the presence of a stressful reaction of a person in response to an emotional stimulus. The article presents the first results of experiments in this direction.

3. Methodology

To analyze the psychophysical state of a person, an optoelectronic experimental setup was developed (Fig.1). A more detailed description of the installation is described in the work "Using active testing objects in security systems" [44]. 21 students have taken part in the experiment. Their age category is from 18 to 22 years, there are 14 male students and 7 female students. The respondents don't have any eye diseases. All participants have been informed about the experiment in advance and only voluntarily students participated in the experiment. Pictures with emotional coloring «fear» were used as the test objects. The total time of the entire study procedure for one person takes no more than 5 minutes, which does not affect the fatigue of the respondents, but it is enough to follow the track of the eye. As a result, 8 best video files were selected. For the next test, there were selected about 70 images on various themes and emotional coloring: education, family values, joy, happiness, loss, violence, cultural traditions of different peoples who belong to different faiths and etc. The images were selected so that it was possible to identify existing problems in society. The test participants were asked to rate the emotions that arise when viewing each image on a 10-point scale (from 1 to 10), in which number 1 means that the image is very unpleasant, and number 10 represents that the image is very pleasant. The images in this tests were rated by 62 people, the University staff and students (n=62). According

to the results of the test, there were selected 26 images that meet the requirements of the law of normal distribution.

Figure 1. The experimental setup.

Processing and analysis of the results was carried out in two stages. First, image preparation, processing, and pupil contouring were performed in FiJi. Then for the statistical analysis, we used the StatPlus program to visualize the OriginLab2020 data.

4. The discussion of the results

The method of processing in semi-automatic mode is used at this stage of the research. There was an attempt to establish the functional dependence between parameters of eye pupil (S/Sm, where S is the area of the pupil, and Sm is the most common pupil size in the data array during the time of stimulus exposure).

We assume that by setting a standard for the average human response to a visual stimulus from a test object, it will be possible to identify various deviations from the average response. These deviations will indicate a reaction caused by a critical change in the emotional response that is compatible with a particular emotion. To do this, it is necessary to analyze for the presence of matching peaks on the charts. If the peaks from the X, Y coordinate graphs coincide with the peak on the graph of the pupil area change, then this change is caused by blinking of the eye or the eye makes movements (saccades and microsaccades), leading to a change in the size of the pupil. This takes into account the change in the center of attention, which does not carry an emotional load. Figure 2 shows an example of a graph when we used test objects with emotional coloring-fear. It shows a pupillogram of a young, 20 years old girl, who is afraid of spiders pathologically. The stimulus material included images of insects, including spiders. In this experiment, the girl was shown the stimulus material slide and then the monochromatic gray slides. This was necessary to simplify the allocation of the emotional component. Scientific works describe the change of such a vegetative feature as an increase in the pupil size in anxiety states and phobias. Although there was no noticeable increase in the amplitude, the standard deviation was 0.15 for the average relative pupil size of 0.98. The difference was the presence of a series of blinks (see graphs X, Y) on the section of the pupillogram (time interval from 27.6 to 31.2 seconds), corresponding to the response to the slide with the spider image. It is known that for people with phobia, when faced with a source of fear, the change in the size of the pupils should be significant. When viewing these images, a similar reaction was also expected. However, the observed changes in the pupils are not as strong as expected. To answer this question, it is necessary to study the issue further with the involvement of physicians.

At the end of each test procedure, the tested person gives feedback, because at this stage of the research work we have to establish the relationship between the induced emotion and the reaction of

the eye pupil. The survey allows us to compare the obtained data with the real feelings of a person. The test objects were randomly selected. The survey confirmed that the test subject was uncomfortable and did not want to look at the screen when the spiders was demonstrated as the test objects , which caused an active eye movement during the time of the demonstration of spiders.

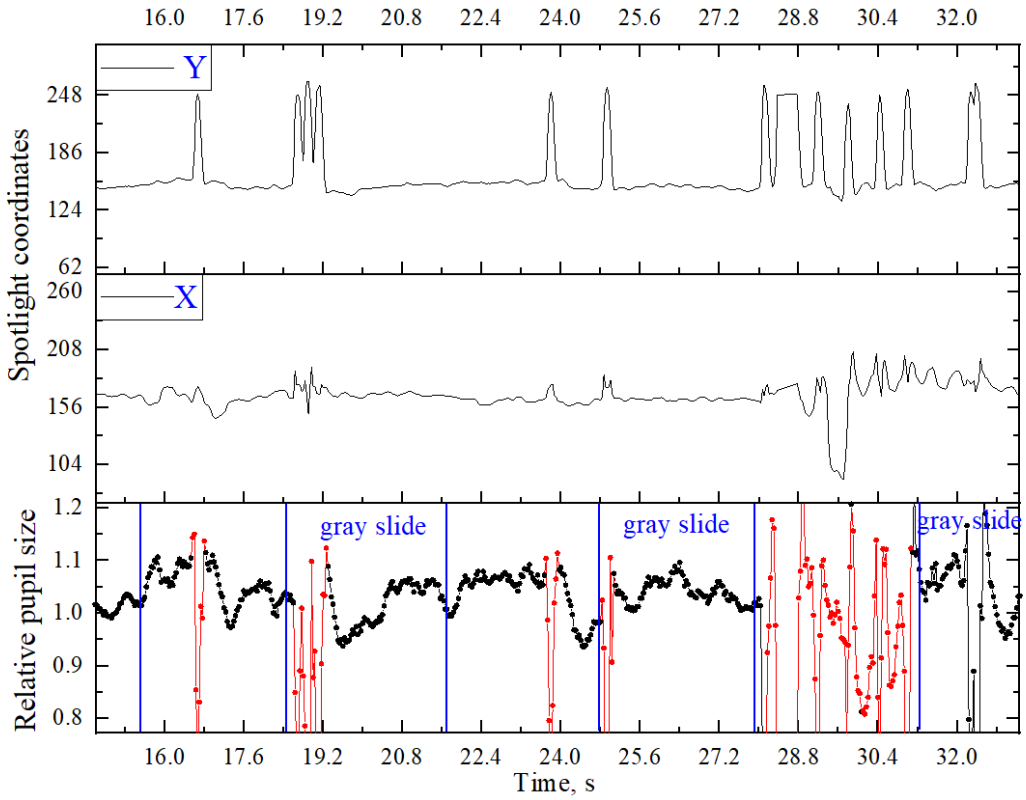

Figure 2. a) a change in relative changes in the size of the pupils in response to the presented stimuli; b) conform the oculograms.

At this stage, we identify specific deviations. We establish unnatural eye movements - a sharp increase/contraction of the pupil and compare these deviations with the coordinate graphs. This allows us to determine their nature - caused by the deviation of the natural need to blink/change position or caused by the physical and chemical reaction which leads to the emotional response. Therefore, graphs that do not have strong changes, justified by the emotion, at this stage can be characterized as the average human reaction when viewing this set of test objects. At this stage, the situation is complicated by the fact that when viewing the same test object, different people may experience different emotions, as well as one person may experience more than one emotion, so the selection of the emotional component becomes difficult. That is why we conduct a survey at the end of the experiment procedure. With the increase in the statistics of the analyzed graphs, it is planned to create a certain evaluation scale that allows you to uniquely judge the presence of a specific emotion in a person by deviations in the graph. In the meantime, we present the most purely selected sections of the charts, where the changes are justified by the arisen emotional response.

Figure 3 shows the pupillogram of the pupil's response to the emotional stimulus "fear". Car accident records were used as test objects here. The graph shows that the pupil area is rapidly growing in the interval from 0.3 to 2.4 seconds. The amplitude of the change in the relative size of the pupils S/Sm=1,4. Based on the graph, there is a rising peak in the size of the pupil at the time of the accident itself. In this case, the change in the coordinates of the center of attention is insignificant, which

indicates that the change in the size of the pupils is caused by emotion. As we can see, in this case, the change in the size of the pupils was even greater than that of the previous girl. Therefore, there is a doubt whether the girl really has a phobia.

Thus, having accumulated a sufficient amount of statistics, you can classify the results by levels of stress resistance. Conducting a professional examination based on the identification of pathological fears and even phobias, is able to inform the employer at the initial level that an emergency situation may occur in the workplace due to the influence of an external factors, which the employee may not cope with.

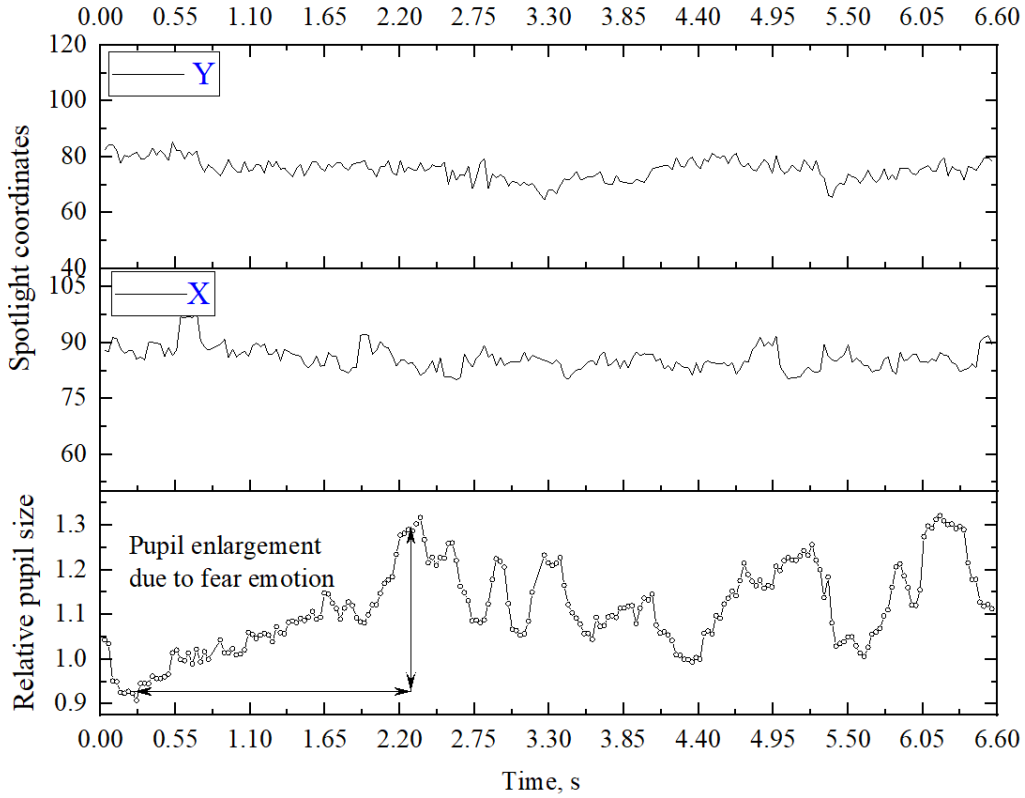

Figure3. Change of pupils' size caused by the "fear" emotion.

5. Main conclusions

The article presents the first results of the research work of the reaction of the human pupil in response to an irritant compared with the reaction of pupil to stressful situation. It was found that the stimulus material, which can cause an emotional response, can characterize the difference between the emotions "fear" and the existing phobia. A description of changes in the dynamics of the pupil of different subjects was carried out to determine the nature of the reaction in response to the presented stimulus. In the future, to establish the relationship between the reactions of people in response to the provided emotional stimulus, you can use the results of pupillograms to compare the difference between the amplitudes of changes in the area of the pupil. This research work may be used for development of the program for professional selection of employees based on the criteria of having fear or phobias in the working environment, which is based on the application of pupillography.

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