Test object as a subject of biometric studies of eye reaction

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Abstract. As you know, a person does not pay attention to any object, but on the basis of the importance of the object or circumstance at the current time. Attention is concentrated on the object the more often, the higher is subjective significance. The significance is due to the motivational force and information saturation of the object. For preventive measures to identify people at risk, you can use test objects that are carriers of well-known information (representing images, audio and video files). Test objects revoke an emotional response from everyone, but the level of emotions experienced will be different. Unambiguous reaction is the presence of emotional components in the waves of attention.

1. Introduction
In the modern world, high technologies are rapidly developing, and this applies to forecasting technologies. Interest in detecting the psychophysical state of a person by various biometric data is becoming more widespread every year. The methods of forecasting include pupillography. Previously it was thought that the appointment of pupil - it is the adjustment of the luminous flux incident on the surface of the eye. Modern studies have shown the complexity of the reactions of the visual nervous system. However, because of the relative ease of implementation and high reliability of the results, the application of pupillography quite common. For example, the pupillograph records changes in pupil size during speech [1]. If a person deceives, he experiences stress, the size of the pupils changes, which registers the pupillograph. With the help of pupillography learned to identify dangerous people who are in a state of drug and alcohol intoxication. Ahmetvaliev A. M., Karasev A. S. introduced the concept of contactless identification of persons in the state of alcoholic and narcotic intoxication presenting a threat to public safety [2]. However, those who are the bearers of evil intentions are in the shadows. The standard method of determining emotions, focused on mimic changes is good, but if a person is good at controlling himself, it is difficult to recognize evil intentions, and sometimes it is too late. Therefore, the purpose of the work is to develop a test object that will allow you to transfer certain emotions to the subject, to register an uncontrolled reaction.

2. Experimental method
We considered the reaction of the pupil to the test objects with a certain thematic focus, which have an emotional impact in proportion to the degree of the individual's internal attitude to the topic. At the first stage of the experiments the images shown on the laptop monitor were used. The subject of information can be determined by the actual problems of society, urgent psychological problems. The average value of the level of intensity of emotions was considered a normal reaction, because the hypothesis was accepted that most people are mentally balanced and tolerant. In General, the intensity of the evoked emotions on a scale from 1 to 10 did not exceed 4, where 10 is the strongest emotion that can be. The following hypothesis is used. For each person there are topics that cause ultra-high
emotional responses. The information that concerns them is significant important for a person, and causes involuntary attention in case of appearance in the field of perception of the individual. If we assume that such information may contain a test object, the reaction of the pupils to such a test object is proportional to the intensity of the emotions experienced at the same time $\Psi$. In the selection of test objects it is necessary to consider the following factors:
- to identify which category of persons the efforts are directed;
- if the illumination of the surface of the eye during the recording of pupillage different, it is necessary to introduce a correction factor;
- the depth of the emotions experienced should not push a person to the beginning of action. As a result, the intensity of the impacting stimulus should belong to the interval $\Psi < \Psi_{activation}$.

For the study, 70 images of various subjects and emotional coloring were selected: education, family values, joy, happiness, cultural traditions of different peoples, belonging to different faiths, loss, violence, etc. the Images were selected so that it was possible to identify existing problems in society. In addition to active test objects, neutral test objects are required. They do not carry any information, or contain insignificant information for people of the target category. Such test objects allow you to "adjust" the system to the selected category of persons, allow you to take into account the spontaneous fluctuations of the pupil and random noise.

The study involved groups of two age groups of 16-25 years and 45-50 years of 10 and 5 people, which were attended by representatives of different sexes. Eye diseases in people were absent, vision was normal or corrected. Entry pupillograph carried out on the installation shown in figure 1. The process of video shooting was carried out while minimizing the effect of illumination from the test object (taking into account its color) on the size of the pupils. Additional control of illumination is carried out by the skin tone of the subject (in the gray scale, normalized by the average value).

![Figure 2(a, b). (a) Experimental setup; (b) Test object and track of the center of mass (focus) of the monitor reflection in the pupil.](image)

For this test, a participant with sensitivity to scandals in the family was selected. The hardware part includes UPS: Galvanic Skin Response Sensor (GSR - Sweating), which measures resistance between two points; Camcorder T7 Camera Astro Astronomical Astronomy Planetary High Speed Electronic Digital Eyepiece Telescope Lens for Guiding Astrophotograp, movie mode 30 fps, lens with optical zoom, 1X-100X; Specially designed helmet, creating a rigid coordinate connection between the camera and the head; Arduino UNO R3; Images were analyzed in the freely distributed program Fiji. It is an improved and expanded distribution ImageJ, combining many plugins that allow you to conduct a complete scientific analysis of the image. Pupillography and oculogram received in the program OriginPro 2019. Figure 2a shows a typical pupillogram. Synchronization of the track of the center of
attention and record pupillography during reaction to a specific test object allows us to specify the element in the test object, which happened emotional reaction.

Figure 2(a, b). (a) Change in pupil size over the entire observation period; (b) Synchronized pupillogram and coordinates of the center of attention in the area with emotion.
For this purpose, the image of the monitor reflected in the pupil was isolated on the obtained video frames. Then the centre of mass of the selection was monitored in each frame and its coordinates were determined. Plots with $S > S_0$ more than 1.2 correspond to the manifestation of emotions or attachments. In our case, as an irritant, stimulating the response of the pupil, complex images were used, the details of which can also be considered under certain conditions as independent stimuli.

3. Results and discussion

In all experiments pupillography participants were allowed to monitor the focusing of the eyes on the desired test object. The structure of the wave of attention in pupillograph includes a saccade when you move the view, micro-saccade focusing on the individual elements of these objects and the emotional component, provided that the test-object is significant for the individual. Evaluation of the level of intensity of emotions caused by information was carried out by statistical method. Participants had to evaluate the emotions that arise when viewing each image on a 10-point scale, in which 1 – the image is very unpleasant, and 10 – the image is very nice. After the survey and data were obtained, the normal distribution was tested using the Kolmogorov-Smirnov test to determine the discriminativeness of the test objects. As a result of the inspection, 26 images were selected that meet the requirements of the law of normal distribution. Then factor analysis was carried out to group the images. As a result of the factorization of the data set by the principal components method, 3 factors were identified, covering 62.58% of the share of the explained variance (table. 1).

| № images | Factors | № images | Factors |
|-----------|---------|-----------|---------|
|           | 1       | 2         | 3       | 1       | 2         | 3       |
| и8        | 0,870   | и34       | 0,864   |         |           |         |
| и10       | 0,809   | и35       | 0,851   |         |           |         |
| и14       | 0,657   | и36       | 0,684   |         |           |         |
| и16       | 0,795   | и38       | 0,757   |         |           |         |
| и21       | 0,668   | и39       | 0,665   |         |           |         |
| и22       | 0,792   | и41       | 0,786   |         |           |         |
| и23       | 0,575   | и43       | 0,630   |         |           |         |
| и25       | 0,589   | и48       | 0,613   |         |           |         |
| и29       | 0,694   | и49       | 0,713   |         |           |         |
| и31       | 0,629   | и56       | 0,592   |         |           |         |
| и34       | 0,864   | и58       | 0,693   |         |           |         |
| и66       | 0,750   | и60       | 0,701   |         |           |         |
The first factor describes 44.25% of the sample. The images of external belonging to the Eastern culture (clothes, rituals) have the greatest load. Taking into account the magnitude of the factor loads, we denote this factor "Belonging to the Muslim culture". The second factor describes 9.65% of the sample. The biggest load is the image of a woman at the head of a team of employees. It also includes images of success and career achievements. Taking into account the values of factor loads, we denote this factor as "career Success". The third factor describes 8.68% of the sample. The greatest burden was a variable with the image of the Christian ritual. Given the values of factor loadings, this factor is denoted "Belonging to the Christian culture". The reliability of the scales was checked by the internal consistency of the items included in them using the Cronbach alpha coefficient: "Belonging to Muslim culture" -0.949; "career Success" -0.877; "Belonging to Christian culture"-0.821. The observed size changes of the pupil resulting from the effect of all the factors (like emotional or any other). All changes are controlled by the potentials of the brain.

The pupillogram in figure 2 belongs to the person whose gaze is directed at the photo of Jim Kirk's face (star Trek movie). From pupillography and oculogram deleted the moment of blinking. In this case, the focus moved vertically from bottom to top (in Fiji, the origin (0;0) is in the upper left corner of the working field). The coordinates had changed little. The amplitude of this pupillogram is weakly dependent on the change in the position of the centre of attention, and consistently exceeds the average value. At the same time, bright emotions are not observed and the wave of attention is steadily positive, without special emotional outbursts. Pupillography well approximated by a Gaussian function having the form:

$$y = y_0 + \frac{A}{w} \sqrt{\frac{4\ln(2)}{\pi}} \exp\left(-\frac{4\ln(2)(x-x_0)^2}{w^2}\right).$$

To find regularities, we found the inter-frame difference between video files containing the pupillary response to the test objects. Then we found the power spectrum (Fig.3, 4). The periodogram allows us to estimate the power from the amplitude of the Fourier transformed data. Blustein's algorithm correctly calculates complex 2D/3D-FFT images of arbitrary size.

**Figure 3.** FFT inter-frame pupil image difference when viewing (from left to right) neutral, emotionally-negative, emotionally-positive test objects.

**Figure 4.** Power spectrum of differential chronogram [3], pupillary response to emotionally negative test objects.
Power spectra indicate a different frequency and amplitude of the pupillary response at different emotional stress test objects. This suggests the possibility of identifying common patterns of pupillary reaction, with the similarity of the polar properties of the emotions experienced.

In the process of development are test objects, which are images, accompanied by short text messages. Text information will more accurately convey the meaning and specify the "pain point". Their purpose is to cause short-term, but bright emotional outbursts. One of the intended applications is to identify people with suicidal intentions. Before the study of the reaction of the pupil to the depressive state of a person, you need to create a room with a home environment, it is desirable that he was in a normal state (not too cheerful, not too sleepy), the subject is desirable to distract from heavy thoughts, should feel comfortable in his clothes, not hungry, as the internal mood affects the passage of the test. To register the reaction of the pupil, it is desirable to use an inconspicuous camera that will not create unnecessary anxiety.

4. Conclusion
Created a set of test objects that cause involuntary human reaction, uniquely interpreted:
- Thematic test objects were developed, the degree of emotional colouring of test objects was estimated by the method of statistical survey. The reliability of the scales was checked by the internal consistency of their items with the application of the Cronbach alpha coefficient. The results suggest a high degree of reliability of each of the scales;
- It was found that the complete replacement of video files with sound test objects is impractical, because in the field it becomes impossible to track the pupillary response and its specification. Therefore, research is aimed at the development of images, video images.
- Developed non-specific test objects that are carriers of well-known information (representing images, sound and video files). Test objects evoke an emotional response in everyone, but the level of emotions experienced depends on the magnitude of the emotion experienced. Unambiguous reaction is the presence of emotional components in the waves of attention. The level of the registered reaction at which it can be considered exceeded the threshold value must be set.

Acknowledgments
The reported research was funded by Russian Foundation for Basic Research and the government of the region of the Russian Federation, grant № 18-47-860018 p_a.

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