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ISSN 0543-5846
METABK 53(1) 85-88 (2014)
UDC – UDK 617.72.771.3:339.4:338.7=111

POSSIBILITIES AND PROBLEMS OF USING PUPILLARY REFLEX FOR SUBCONSCIOUS DETECTION OF CONSUMER PREFERENCES

Received – Prispjelo: 2013-02-12
Accepted – Prihvaćeno: 2013-05-15
Preliminary Note – Prethodno priopćenje

The article describes the possibilities of using the pupillary light reflex for subconscious ascertainment of consumer preferences also in technical, industrial sectors. It describes the essence and use of pupillometry in marketing, types of pupillometry, practical suggestions as well as the prerequisites for future use in marketing. It suggests the procedures of an experiment with the use of an eye camera with an integrated pupillometer, and it points out to selected practical problems which must be eliminated during the experiments. If we wish to achieve growth of the industry the first necessary step is clear focus on the customer and on a user-friendly program of communication with customers and potential customers.

Key words: eye camera, pupillary light reflex, consumption, industrial sector, marketing

INTRODUCTION

Pupillometry is a method for measuring the change of the size of the pupil in response to a stimulus of the so-called pupillary light reflex. When light is directed into the eye the ciliary muscles contract and therefore reduce the size diameter of the pupil [1].

Pupils, however, do not only respond to light; they also respond to convergence and accommodation in connection with focusing, to painful stimuli on the skin, to emotions etc. At a close look, the pupil constricts in dependence on the accommodation of the eye. Emotions such as joy, fright, stress, pain, orgasm, or touch on the skin stimulate the sympathetic trunk, which results in dilation of the pupil [2].

Specific responses of the pupil also invoke constriction of the eye lids, mechanical contact with the eye and a look to the side, stimulation of vestibular and acoustic centers.

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DESCRIPTION OF PROCESS OF THE EXPERIMENT

Pupillometry can be considered a research method which tries to discover how a stimulus will be perceived by the respondent. Monitoring of pupils is used in cognitive psychology – in the research of perception and reading, in ergonomics and, as the case may be, in marketing [4]. If we need to communicate a message /marketing communication/ about industrial products or the metallurgical industry itself the specific manner of expression must conform to the local cultural, economic and industrial requirements in every region of the world [5]. Integrated steel companies use within their communication mix in the process of customer acquisition also sales to pre-determined interested parties [6]. Acquisition of a customer requires an expert approach to the selection of the right presentation (manner) of the industrial products offered [7, 8]. This process requires application of various psychological-physiological procedures to achieve a positive marketing response. The selection of the process of presentation largely affects the decision of the potential customer. This is also true in the metallurgical industry [9]. The solution, also in the other industrial sectors, is implementation of pupillometry in marketing. Next possible solution is implementation of GIS (Geographical information system) in process of pupillometry. GIS is universal tool for management of information in space [10].

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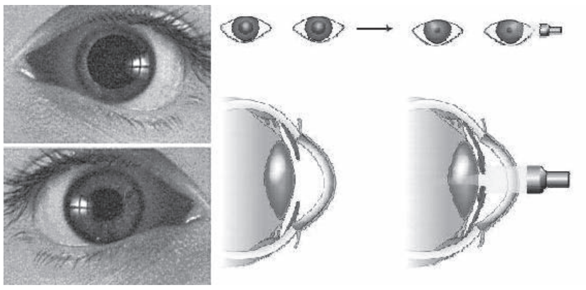

Figure 1 Pupillary reflex [12]

PROBLEMS ASSOCIATED WITH THE USE OF PUPILLOMETRY

Pupillometry in practice faces problems which prevent its simple utilization. The tests are performed using the so-called eye camera. The eye camera with the pupillometer and detection of the center of the pupil [11] records the size of the pupil in time of the respondent during the experiment. The recorded data includes diameter of the pupil on axis x and y. The values are used to calculate, using the formula for the area of an ellipse, the total area of the pupil in pixels. For every person tested, the same visual stimuli are projected. The size of the pupil changes based on the above-mentioned pupillary reflex (Figure 1).

If we perform a simple experiment with the so-called "wheel of emotions" according to Robert Plutchik [13] and show the respondent a projected red, blue, green and yellow color we assume that, according to Plutchik's theory, it will trigger similar emotion in every respondent.

For similar emotions we assume similar changes to the pupil. At the beginning of the experiment we display the black color in the duration of 10 seconds in order to calibrate the size of the eye.

After the execution of the experiment, however, we discovered that the data measured does not show dependence on colors and the time changes of the size of the pupil are different for different individuals tested. It is therefore obvious that the measurement is subject to a system error, and it means that some of the above-mentioned assumptions related to the projected results of the experiment are not relevant.

Problems occur during the measurement due to the sensitivity of the human eye [12]. The sensitivity of the eye is different for different stimuli. One of the majority stimuli affecting the size of the human eye is change of the light flux arriving in the eye. We discovered that the system error of the measurement is caused by the different flux of light which is radiated by the monitor area for the different colors. The curves measured are therefore rather time changes of the pupil size depending on changes of light fluxes corresponding to the individual colors. If we want to eliminate this system error we must eliminate or compensate the effect of the light flux of the monitor.

RESULTS - PROPOSED SOLUTIONS TO THE PROBLEMS DISCOVERED

Theoretically, light can be eliminated by the use of pictures – visual stimuli which have the same light flux. If we therefore use the original stimulus in question and make a mosaic out of it we presume an emission of approximately the same light flux (Figure 2). In such case, however, the relevant factor is the size of the grain and approximation of the grain to the corresponding color share. The greater the grain the greater the deviation of brightness relative to the original pattern in question. In the case of a smaller grain the respondent starts apprehending the original pattern. Then, when displaying the original pattern, we measure the actual response to the stimulus.

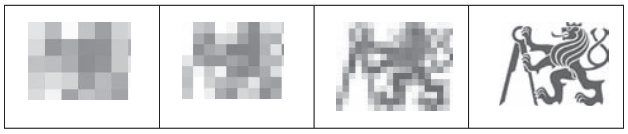

Figure 2 Mosaics [authors; the logo of Czech Technical University in Prague]

Another technical option to eliminate the lighting (*E / lx)* of the pupil is to measure the dependence of the dilation of the pupil on the change of brightness. For a neutral color – grey – we measure for different shares the changes of the monitor's light flux and thus also the dependence of the pupil dilation on that change. The values measured with a luxmeter at a distance of 60 cm from the computer with the sensor of the luxmeter being set in a perpendicular position are shown on the following chart on Figure 3.

Axis X shows the continuous change of grey color from white (far left) to black (far right); in RGB system from 255,255,255 to 0,0,0. If we displayed from black to white the lighting curve would be rotated along the vertical axis. The dependence is nonlinear, and we assume also nonlinear dependence of the pupil dilation. With white color (the highest light flux emitted by the monitor) the pupils will be the smallest; with black they will be the largest.

With the change of brightness for the different levels of grey and also the average size of the pupil we obtain the curve of dependence of the pupil size on lighting change (Figure 4). Axis Y of the chart shows the size of the pupil; from physiological point of view, however, units are intentionally not provided. With respect to the difference of the size of the pupil in the persons tested, what is important is not quantification of the curve but rather the basic knowledge of its form. Axis X shows the size of lighting in luxes caused by the emission of light flux of the monitor.

When comparing the two charts above we can see some similarity but the curve is not the same for all individuals tested. The curves show different deviations, nevertheless the tendency of the curves is as expected.

Therefore it seems that the change of the pupil is not proportional to the change of lighting. According to the

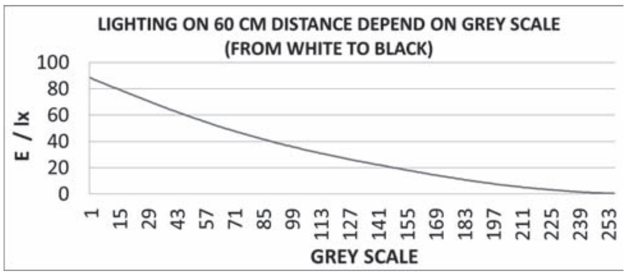

Figure 3 Results of the measurement with a luxmeter [authors]

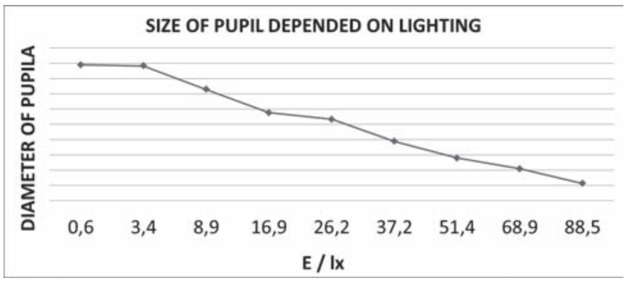

Figure 4 Dependence of pupil diameter on lighting [authors]

assumption, the pupil size can only be changed by one or several of the factors mentioned in the introductory part of the article, or all disruptive effects during the experiment described in the introductory part of the article could not be eliminated.

Another significant discovery is the size of the pupil of the tested person measured with the same stimuli during one measurement cycle. The respondent is exposed to the same stimuli twice in a row (Table 1).

Table 1 **Overview of the stimuli – different level of grey (RGB) and times of duration of the stimulus**

0, 0, 0,	32, 32, 32,	64, 64, 64,	96, 96, 96,	128, 128, 128,	160, 160, 160,	192, 192, 192,	224, 224, 224,
10 sec	3 sec	3 sec	3 sec	3 sec	3 sec	3 sec	3 sec
0, 0, 0,		64, 64, 64,		128, 128, 128,		192, 192, 192,	224, 224, 224,
3 sec		3 sec		3 sec		3 sec	3 sec

Source: authors

Although most of the parameters do not change during this measurement the size of the pupil dilates differently. Chart on Figure 5 shows the apparent differences. These differences do not show any regularity or predictable component affecting the pupil size. Upon the second measurement the values measured are different from those of the first measurement although the stimulus was identical. The diameter of the pupil in the second measurement is sometimes greater and sometimes smaller than the diameter of the pupil with the same stimulus during the first measurement. Of course, the differences can be caused by the calculation of the arithmetic mean (strong dependence on one dominant value)

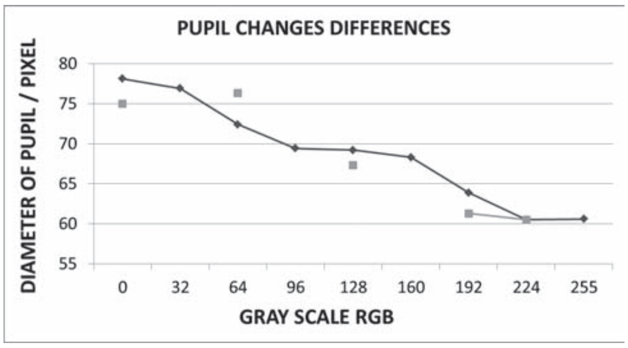

Figure 5 Differences in pupil dilation [authors]

of the pupil over the time of display of the grey stimulus. We assume, however, that for one participant in the experiment this deviation is minimal.

If we use a correlation coefficient for comparison of such curves the values of the coefficient will not be stabilized on the same or slightly deviating level. The correlation coefficient for the selected examples fluctuates from the maximum 0,923 up to the minimum 0,706.

RESULTS – PUPIL CHANGES

By comparing the curves of the values measures (not the average values) for a specific grey scale color (e.g., RGB 64,64,64) we can evaluate – using the correlation coefficient – the similarity of one respondent's response to the same stimulus. The scanning frequency of the eye camera is 25 Hz. In 3 seconds of the display of the stimulus we can compare approximately 75 values. The lighting value is stabilized in this case and the chart will only show the response to a change of lighting.

Figure 6 shows the similarity of both curves; the correlation coefficient in this case is 0,9. At the beginning of the curve the initial values differ significantly.

This is probably due to the delayed response of the pupil to the previous stimulus. In the case of the blue curve the previous stimulus was (RGB 32,32,32; 3.4 lux); for the red curve the previous stimulus was (RGB 0,0,0; 0,6 lux). The difference in lighting in luxes is 2,8 and 8,3.

The pupil was more dilated for the black color stimulus in RGB 0,0,0. The difference in the starting conditions and the minima and maxima shows that the size of

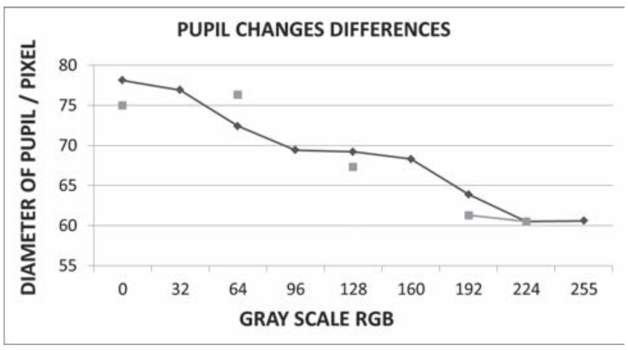

Figure 6 Respondent's response to the same stimulus [authors]

the pupil does not depend only on the current stimulus and the light flux emitted by it but also on the preceding conditions. Achievement of the minimum for both curves is approximately the same in the 17th and 19th frame, the sampling frequency being 25 Hz in 0,68 second and in 0,76 second. The two minima differ from each other. The minimum for the red curve is 4 278,8 and for the blue curve 4 056,2. The maxima also differ. For the red curve it is the 7th sample and value 5 614,8, and for the blue curve also in the seventh sample with the value 5 184,7. The angular coefficient k = dy/dx between the maximum and the minimum is 133,6 for the red curve, and 94,04 for the blue curve. The red curve therefore shows a steeper slope.

CONCLUSION

The executed experiments show that dilation and contraction of the pupil in dependence on lighting is not only proportional to the change of the emitted light flux. Its size depends on the previous condition. Therefore the respondent shows different responses to the same stimulus. For future analysis it will be advisable to eliminate the time of delay of the pupil, i.e., the beginning of the curve.

The question of further research is definition of the stabilized value upon changes of visual stimuli. The curve of the change of pupil size after elimination of the effect of the light flux (illumination of the eyes) will probably show influence by other factors in addition to emotions.

Elimination of these influences will be subject to further research.

Acknowledgement

The paper was written within the framework of the implementation of a grant project called "New Technologies in a Marketing Studies" SGS10/270/OHK5/3T/13 at the Department of Economics, Management and Humanities, Faculty of Electrical Engineering, Czech Technical University.

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Note: The responsible translator for English language is PaedDr Viera Nemčoková CSc., from TU Košice, Slovakia