ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2011. No. 10(116)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 120 SYSTEM ENGINEERING, COMPUTER TECHNOLOGY
SISTEMŲ INŽINERIJA, KOMPIUTERINĖS TECHNOLOGIJOS

Investigation of Students' Knowledge and Iris Interrelationship

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crossref http://dx.doi.org/10.5755/j01.eee.116.10.890

Introduction

The interdependence between the psychoemotional state, ideational activity, different emotional stimulus and pupil size variation are known since the ancient times: so, a pupil diameter increase in case of concentration or anxiety is a commonly-known fact.

In latter days investigators have been conducting research using computerized measuring devices to observe and explain the interdependence between the psycho-emotional state and pupil size variation.

Thus [1] have conducted the research on pupil size variation during the mental arithmetic tasks performed by human subjects: We first replicated an experiment performed by [1, 2] for mental arithmetic. In each trial, subjects listened to two spoken numbers between 5 and 19. Five seconds after the second number was spoken, subjects were prompted to type the numbers' product into an on-screen keypad using the mouse. The use of an on-screen keypad kept users' eyes on the screen, in order to maintain pupil visibility and to avoid pupillary light reflexes caused by looking away from the screen. We observed a similarly-shaped pupil response to that reported by [1, 2].

According [3], the results showed that the pupil size was significantly larger during both emotionally negative and positive stimuli than during neutral stimuli. Pupil size variation seems to behave curvilinearly on the valence scale. It is largest at the negative and positive ends of the continuum and smallest at the centre, which represents neutral affect.

Part of the controversial results and theories concerning the relation of affects and pupil size variation may be due to the various stimulus materials used. Mostly, they have been limited sets of pictures varying in content. The materials used have also suffered from methodological problems with color, luminance, and contrast [3, 4]. Clearly, controlled stimulus sets are a necessary precondition for the systematic study of the effects of emotions to pupil size variation.

Recently [3, 5] published a set of systematically studied affective sound stimuli called the International Affective Digitized Sounds.

This stimulus set consists of 117 affective sound stimuli. These stimuli have been extensively studied using the Self-Assessment Manikin, which is a method to study differences in affective experiences using nine-point bipolar rating scales [3, 6]. Their subjects listened to the stimuli and rated them on three bipolar dimensions: emotional valence, arousal, and dominance. However, valence and arousal are the most frequently used dimensions to capture the nature of emotional information. The valence dimension varies from negative to positive emotional experience, and the arousal dimension varies from calm to highly excited. Lang and his co-workers have suggested that the valence dimension reflects the presence of appetitive or aversive motive systems linked to behavioral tendencies of approach and withdrawal, respectively. The arousal dimension reflects the intensity of either appetitive or aversive systems [3, 7–9].

The stimulus set of [3, 5] offers a well-grounded starting point for investigating pupil size responses to emotional stimuli. Because the set consists of auditory stimuli, the problems with visual stimuli can be avoided. The present aim was to investigate pupil size variation in response to auditory stimulation using International Affective Digitized Sounds stimulus materials [3, 5]. We wanted to explore the association of pupil size on three types of emotional sound categories. The categories were negative and positive highly arousing sounds, and emotionally neutral sounds. We also measured subjective experiences to the stimuli. As there is some evidence that males and females may differ in their pupil behaviour, we also explored the possible sex differences in pupil size responses.

According [10], have been conducting researches of interdependence between the pupil diameter and ideational activity. Changes of a pupil diameter have been observed during the following tasks, assigned to students: Students have to carry out five tasks on the main page: read an email in their webmail, add a new module (widget), change the position of another module, access the forum of a subject and access the virtual library. All these tasks can be

done directly from the new main page. More important than the tasks them-selves are the 'key events' that students need to perform in order to accomplish the task. For example, a key event in the task 'add a new module' is to find the right button that allows widgets to be added. Another key event for any of the tasks would be to know how to go back to the main page after the student uses webmail or the forums. The key events are new stimuli within a 'steady/stable interaction', and represent opportunities for increase of arousal, especially when individuals cannot accomplish the event easily. We have identified the following key events: …• To find the key buttons such as: 'add a module', 'personalize your main page', 'virtual library', …'webmail' and 'forums' (a total of 5 events) • To be able to go back to the main page after a task • To understand the concept of module as a box that can be dragged and dropped Apart from key events, we also identified a group of events that require special attention by the user such as typing the password, waiting for the pages to load, reading instructions, accessing wrong pages. We call them 'secondary events'.

One of the most important questions for our proposed methodology [10] is the correlation between positive responses in pupil size and positive responses in heuristics. For most of the students (five) only 40% of the events with increased pupil size also showed any gestural reaction. The two others showed over 80% of correlation. Our conclusion is that pupil size does not seem to be a very good predictor if we only want to use it to infer or to state that the student is 'feeling something'. The size of pupils does not seem to be enough to assess arousal in our particular environment or conditions. Also, almost 40% of the events with increased pupil size did not show any particular facial or body expression.

Besides, additional results have been gained during the investigation:

1. Pupil size tends to be higher during approximately the first minute due to some kind of tension;

2. Sustained concentration makes pupil size increase but is not comparable to pupil size increase in presentation of new interfaces, errors produced or diffi-culties in performance;

3. Concerning patterns of timeline analysis, pupil size is reactive usually 500 ms. before the key event and it keeps increasing depending on how well the user finds a solution but generally maintains the maximum size during 2 sec-onds.

Development of the Pupil Recognition Analysis Subsystem has involved a particular set of experiments on the interdependence between the human psy-choemotional state and changes in a pupil diameter.

Our research includes the investigation of a pupil size variation pupil size variation induced by students' reaction when they know the answer and do not.

Investigation

The following means have been used for the investigation of students' knowledge and iris interrelationship:

-Video processing software. Video processing software includes 10 packages (Fig. 1).

-Image capture device. Image capture device includes helmet with capturing devices, light emitting diodes of the infrared band, video camera and adjusting screws (Fig. 2).

Video processing software and Image capture device have been designed by the article authors and colleagues from Vilnius Gediminas Technical University and Vilnius University.

Further we represent a short description of Video processing software and Image capture device.

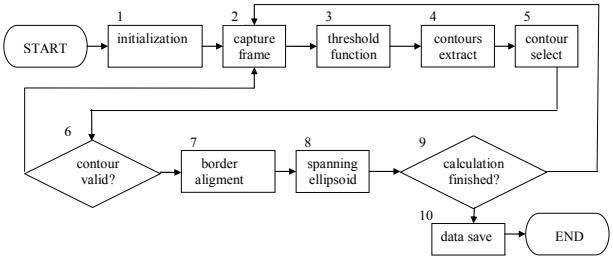

Fig. 1. Video processing software includes 10 packages

The *first* package initiates the pupil recognition – matches the source of the dynamic image (file or video camera).

The *second* package frame capture from video stream.

The *third* package applies the threshold function to the processed image, parameter T of the function is calculated according (1)

$$T = \min(I) + \delta \frac{\max(I) - \min(I)}{100}, \qquad (1)$$

here I – snapshot, δ – threshold factor, *min()* and *max()* – minimum and maximum value of snapshot pixels, correspondingly.

The *fourth* package converts the binary image produced by the application of a threshold function into contours comprising sequences of points.

The *fifth* package performs additional filtration of all contours according to the varying parameters, such as rectangular cover and contoursarea ratio, contours perimeter etc. Thus, the singular contour is extracted.

The *sixth* package is used in order to determine the similarity of the extracted contour and the ellipse.

The *sevenths* package is used to calculate mass centre needed for radial detection of pupil contours according to the initial moments and applying typical functions of OpenCV library.

The *eight* stage foresees the snapping of ellipsoid to the points of the pupil border applying the least square method.

The *ninth* package is used to validate the actuation of Esc button, performed by the user in order to finish the calculation of pupil zone area.

The Image capture device (Fig. 2) is realized as a special helmet (1) equipped with video camera (3), used as the capture device obtaining eye images. The helmet is a rigid type system fixed to the head of the human subject. Essential attention shall be paid to its stability, whereas the system has been used under the real exam conditions, head

movements of the human subjects were unrestricted. The camera shall be correctly positioned, in order to capture the eye image. For the above purpose precise adjusting screws (4) are used, screws enables to position camera correctly. Two light emitting diodes of the infrared band (2) are installed inside the camera and provide infrared brightening of the object.

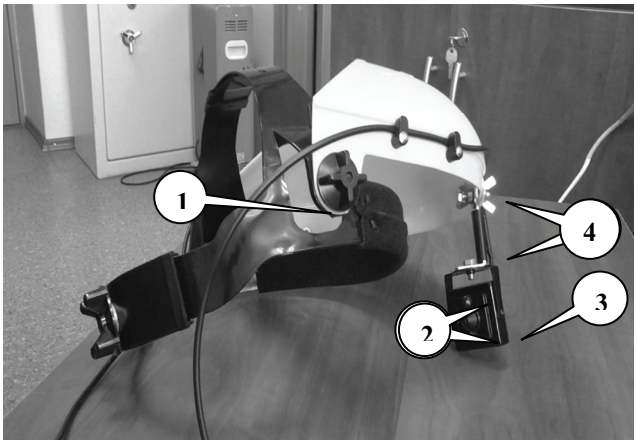

Fig. 2. Image capture device obtaining eye images: 1 – helmet with capturing devices, 2 – light emitting diodes of the infrared band, 3 – video camera, 4 – adjusting screws

Case study

The experiment has been performed as follows: during the research eye images of students-volunteers were recorded under the real exam conditions by a video camera fixed on a special helmet, detailed description of the helmet is provided hereinabove. Captured images were transferred to computer USB input, and then the pupil zone was captured and tracked in order to calculate pupil center coordinates and diameter of pupil ellipsoid at the specified time point.

All the results have been saved in the database. At the same time the database of the electronic exam operating program has been recording the time, when the question appears, and the time when the student marks the answer clicking the mouse button and passes to another question.

Later, the diagrams of interdependence between the pupil diameter variation and the time were plotted. Analysis of the above diagrams has shown common trends of pupil diameter variation within the first minute of question appearance on the screen.

Results of the research are set in a form of diagrams (Fig.3 and Fig. 4).

According to the Fig. 3 and Fig. 4 it appears, that kinetics of pupil diameter change within the first minute upon the question appearance on the screen varies according to the trueness or falseness of answer provided by the student.

14 students (8 females and 6 males) were invited to take part in the real test and answer 20 questions displayed on the screen, the each question was provided with 3-4 answers. The answers were checked applying TRUE/FALSE system. During the exam using the previously described system, the eye images have taken and the time of the question appearance on the screen was recorded. Time of the appearance of the new question on the screen was taken as an initial point. Thus, the each question of the exam was provided with the corresponding diagram of the interdependence between the pupil area and the time period of first 30-50 seconds upon the question appearance on the screen, based on the results obtained. Obtained results coincide with the results described by [1, 3, 10].

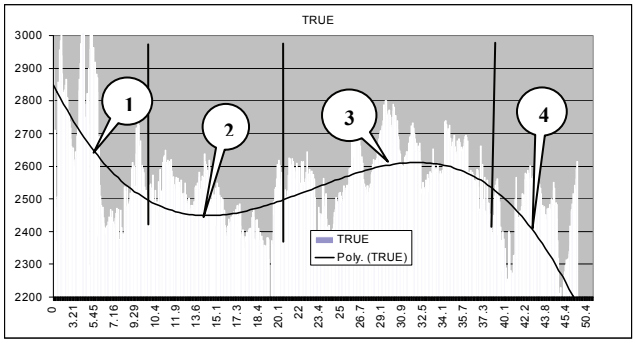

Fig. 3. Diagram of the interdependence between the pupil area and the time, observed within 50 seconds upon the question appearance on the screen, in case of a true answer provided by the student. Area 1- "reading" of the question text, area 2- "acquisition ", area 3- "reflection" of the answer, and area 4- response to the question

Plotted diagrams can be divided into 2 types (specified on Fig. 3 and Fig. 4) according to the curve shapes. First type of diagrams (Fig. 3) is distinctive for the true answer provided by the student (TRUE), these diagrams are applicable for 167 true answers among 246 (68 %).

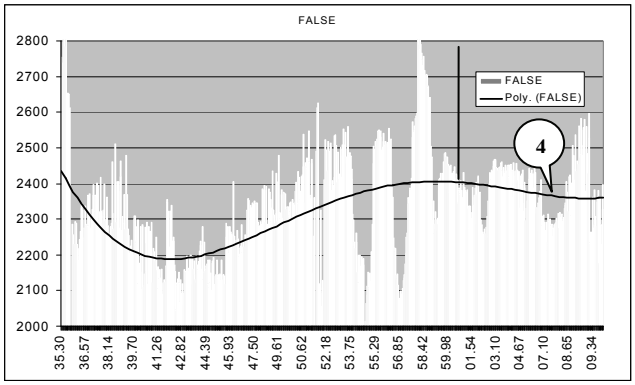

Fig. 4. Diagram of the interdependence between the pupil area and the time, observed within 35 seconds upon the question appearance on the screen, in case of a false answer provided by the student. Area 4- response to the question

The second type (Fig. 4) represents false answers (FALSE), these diagrams are applicable for 86 false answers among 120 (72 %).

Reaction of the student for the time period of the first minute following the appearance of the question on the screen can be contingently divided into areas (Fig. 3): the first area foresees reading of the question 1, area 2 acquisition, area 3 reflection, and area 4 response, if the student have faced the challenge and the question appeared to be complicated the 4 area shows minor changes in pupil

diameter, otherwise, if the student knew the true answer pupil diameter would decrease up to the diameter of 2 phase.

Sometimes correct answers are accompanied by the reaction attributable to false answer it happens due to the fact that further reflection leads to the correct answer or due to the blind guessing one of 3 answers, performed by the student who did not know the correct answer.

In case of wrong answer, when the pupil responds like it was the correct one it can be said that the student made mistake and was confident for the correctness of his answer.

Conclusions

The results of the initial phase of the pupil response for the time period of 30 seconds following the appearance of the question on the screen show, that major part of students demonstrate the general dynamics of pupil deletion which is provided on Fig. 3 and Fig. 4 and coincide with the results described by [1, 3, 10].

Area 4 has shown some disappearances (Fig. 3 and Fig. 4) for the major part of correct and incorrect answers. The above results coincide with the results of the research described by [1], when the pupil's response to the arithmetical problems have been observed: in case of complicated issue the pupil remains widened for some period of time, in our case it was observed when the student could not find the correct answer.

Only pupil's responses to the question, observed within 50 seconds upon the question appearance have been observed, further responses have not shown any particular behavior, thus it can be deemed that pupil deletion could be induced by irrelevant factors.

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Received 2011 05 09
Accepted after revision 2011 09 22

A. Vlasenko, A. Kaklauskas, E. K. Zavadskas. Investigation of Students' Knowledge and Iris Interrelationship // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 10(116). – P. 85–88.

The developers of computer systems intended for detection of pupil size variation in different human states investigates the following two types of the response: response of a pupil to the psychoemotional state; and pupils response in relation with human's intellectual activity performed . During the research we have been analyzing pupil size variation induced by students' reaction when they know the answer and do not. Image capture device with video camera has been designed in order to execute experiments and record eye images. Delivered image has been processed with the help of specially made Video processing software. Gained results are presented in a form of diagrams which shows that response of students' pupil within the first minute upon question reading varies when a student knows the answer and does not. If the answer is unknown – the pupil remains widened after first minute of the response. Ill. 4, bibl. 10 (in English; abstracts in English and Lithuanian).

A. Vlasenko, A. Kaklauskas, E. K. Zavadskas. Vyzdžio skersmens priklausomybės nuo studentų žinių tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 10(116). – P. 85–88.

Specialiųjų biometrinių sistemų kūrėjai skiria du vyzdžio reakcijos tipus pagal skirtingus žmogaus būsenos tyrimus: vyzdžio reakciją į psichoemocinę būseną ir vyzdžio reakciją, susijusią su žmogaus intelektine veikla. Tyrimo metu buvo analizuojami vyzdžio pasikeitimai, atsirandantys dėl studento reakcijos į atitinkamą klausimą (kai jis žino atsakymą arba ne). Buvo sukurtas vaizdo fiksavimo įrenginys (*image capture device*) su videokamera siekiant atlikti eksperimentą ir įrašyti akies vyzdžio pakitimus. Gauti vaizdai buvo apdorojami specialiai sukurta programine įranga (*video processing software*), o rezultatai pateikiami diagramose, kurios parodo studento vyzdžio reakciją į perskaitytą klausimą per pirmąją minutę, kai studentas žino atsakymą arba ne. Jei po pirmos minutes jis atsakymo nežino, vyzdys išlieka išsiplėtęs. Il. 4, bibl. 10 (anglų kalba; santraukos anglų ir lietuvių k.).