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Pupil Size Variation Related to Oral Report of Affective Pictures

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Abstract

The goal of the experiment was to establish pupil size variations while viewing and reporting 48 affective (IAPS) pictures. The experiment consisted of 44 students. Pictures appeared on the screen for 20 secs in random order. After reporting the SAM (Self-Assessment Manikin), the participants orally reported on the pictures. In the phase of picture viewing, the unpleasant pictures revealed larger pupillary responses than neutral and pleasant pictures ($p<.001$). The mean pupil size was at its greatest also during the reporting of unpleasant pictures ($p< .001$). Results indicated that the differences in pupil size variations endure from the viewing phase to the reporting phase of pictures.

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Keywords: emotion; affective picture; pupil size variation; oral reporting

1. Introduction

In general, pupil size variation, as a physiological process has been connected to psychological processes such as behavior and emotions. The connection is not trouble-free and it has generated contradictory results, for instance between the pupillary changes during viewing affective pictures.

It has been reported that unpleasant pictures induce pupil size diminishing when viewing unpleasant pictures and pupillary changes are in general related with hedonic valence (Hess, 1960). On the other hand, it has also emphasized that neutral (non-hedonic) pictures prompt larger pupil dilation than emotional pictures (Libby, et al., 1973). However, it has proposed that there is an explicit connection between emotional arousal and pupillary

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response, manifesting increased pupil size when viewing pleasant and unpleasant pictures (Steinhauer, et al., 1983).

This discrepancy has been studied recently by using affective pictures which allow the control of pleasure and arousal. According to the results, pupils dilated more in pleasant and unpleasant pictures than in neutral pictures during picture viewing. It was concluded that pupil dilation is determined by emotional arousal, despite hedonic valence (Bradley, et al., 2008). This was supported by a study in which the pupil dilation appeared during listening to emotional sounds without any visual context (Partala, et al., 2000).

The first goal of the present study was to examine the changes in pupil dilations during viewing affective pictures, and the relationship between the above-mentioned changes and the changes in pupil dilations during oral reporting of the no longer visible pictures. Secondly, the goal was to verify if the pupil size variations (emotional experiences) are related to the duration of reporting of the affective pictures

2. Methods

2.1. Participants

Forty four right-handed, Finnish speaking (native fluency in Finnish and no reported history of speech disorder), undergraduate students from the University of Oulu participated in the experiment. The students participated voluntarily in the experiment during their psychology studies. Eyesight was tested using the Snellen card, and anxiety was measured using the State Trait Anxiety Inventory (STAI) (Spielberger, et al, 1970). In addition, possible alexithymia was tested with TAS-20 (Bagby, et al., 1994), the validity of which has been tested also in Finland (Joukamaa, et al., 2001). All subjects had normal or corrected eyesight (≥1.0), and no anxiety (STAI score < 35) nor alexithymia (TAS-20 score < 51) was found. After the explanation of the experimental protocol, the subjects gave written consent.

2.2. Apparatus

The IAPS pictures (Lang, et al., 2005) were presented on the screen (17") of a computer with an Intel Pentium 4 processor which was connected to a Tobii 1750 eye tracking system (Tobii Technologies AB, Sweden). The sample rate was 50 Hz, and the spatial resolution was 0.25 degrees. The eye tracking system located every fixation point and measured the duration of fixation, the pupil size variation over time and the distance of the eye from the computer screen. The heart rate variations were measured using beat-to-beat RR-intervals with a Polar S810i heart rate monitoring system (Polar Oy, Finland). The facial expressions were recorded with an IEEE 1394 Firewire camera (Sony DFW-VL500, Japan). In addition, the subject's speech was recorded using a wireless microphone system (Sennheiser HSP2, Denmark).

2.3. Materials

A total number of 48 International Affective Pictures (Lang, et al., 2005) were used in the experiment[1]. The pictures were divided into three different groups; 16 pleasant, 16 neutral and 16 unpleasant pictures (Nummenmaa, et al., 2006). The overall luminance levels of the pictures were adjusted with Adobe Photoshop 6.0 software.

2.4. Procedure

[1] The number of the IAPS pictures used in the experiment were: pleasant (2050, 2057, 2070, 2091, 2165, 2209, 2216, 2340, 2352, 2550, 4608, 4601, 4653, 4700, 8490 and 2040); neutral (2190, 2191, 2215, 2235, 2393, 2487, 2516, 2745, 2840, 2850, 2870, 7493, 7496, 7550, 8311 and 9070); unpleasant (2375, 2750, 2800, 2900, 3015, 3051, 3181, 3301, 3550, 6243, 6570, 6838, 9040, 9421, 9435 and 2095).

The subjects were interviewed and STAI (Form 2) and TAS-20 questionnaires were presented before the experiment. Subsequently, the subject was able to practice the experimental procedure from "the paper version" with the experimenter. Thereafter, the subject practiced the procedure with the computer. Before the actual experiment, the subject rested for 60 secs, while the heart rate monitoring system, audio and camera systems were combined to the eye tracking system. The subject's eye movements were also calibrated into the eye tracking system.

In the experiment, the pictures were presented on the computer screen and the distance of the subject from the screen was 65 cm. At first, the subject had to look at the letter X, which appeared in the middle of the screen, for 30 secs. Sequentially either a pleasant or neutral or unpleasant picture appeared on the screen for 20 secs in random order. Immediately after the 20 secs, the SAM scale appeared. The subject's task was to orally report the valence and arousal of the picture according to the SAM scale (1-9 categories). These categories were grouped according to their valence giving new categories: "pleasant" (1-3), "neutral" (4-6), and "unpleasant" (7-9). This grouping was made to improve comparison with IAPS pictures (pleasant, neutral and, unpleasant pictures).

After the report, the subject had to press the enter button in order to darken the screen. In this phase, the subject's task was to oral report to the experimenter, who was sitting behind the computer screen, on what had been seen, what was happening and what was going to happen in the picture. After the report, the subject had to press the enter button for the next picture to appear. After 48 pictures, the letter X appeared for 30 secs. Finally, the STAI (Form 1) questionnaire was presented. The experimentation was approved by the Ethics Committee of the Faculty of Education, University of Oulu. (see Laukka, et al., 2008, Laukka, et al., 2010, Rantanen, et al., 2010).

2.5. Data analysis

The duration of the phase of picture viewing (20 secs.) was divided into three 5 secs. analyzing periods. The averaged viewing distances of each period were compared as a function of picture content. According to the averaged speech durations (see section 3.3), the phase of oral reporting was analyzed in 40 secs. period, which was divided into seven 5 sec. analyzing periods. Conventional statistical methods were employed, including ANOVA and Paired Sample t-test. Also Fisher's LSD-test and Bonferroni correction method were applied as a Post Hoc test.

3. Results

a. Valence

Valence ratings differed as a function of picture type (pleasant, neutral, and unpleasant), $F(2,45) = 432.85$, $P < 0.001$. The mean valence of pleasant pictures ($M = 1.21$, $SD = 0.097$) differed significantly from the mean valence of neutral pictures ($M = 1.18$, $SD = 0.196$), $P < 0.001$, and the mean valence of unpleasant pictures ($M = 2.77$, $SD = 0.145$), $P < 0.001$. Also the mean valences of neutral pictures differed from the mean valences of pleasant and unpleasant pictures, $P < 0.001$.

b. Pupil size variation during the phase of picture viewing

The mean luminance values of pleasant, neutral, and unpleasant pictures did not differ significantly, $F(2,45) = 0.846$, $P = 0.436$. When the pupil size variation was averaged over time (20 sec.) two seconds after picture onset, the greatest dilation appeared during viewing unpleasant pictures ($M = 4.25$ mm, $SD = 0.092$), then during viewing neutral pictures ($M = 4.22$ mm, $SD = 0.066$), and the smallest dilation during viewing pleasant pictures ($M = 4.15$ mm, $SD = 0.083$), $F(2,54) = 5.84$, $P < 0.01$. Post hoc comparison of pupil sizes revealed significant difference between pleasant and unpleasant pictures, $P < 0.01$.

Fig. 1 illustrates three significant analyzing periods in which the picture content is associated with pupillary responses. In the first analyzing period from 5 to 10 seconds, the mean pupil size was the largest during viewing unpleasant pictures (M = 4.28 mm, SD = 0.030), then during viewing neutral pictures (M = 4.21 mm, SD = 0.039) and the smallest during viewing pleasant pictures (M = 4.17 mm, SD = 0.028), F(2,15) = 17.96, P < 0.001. Post hoc comparison of pupil sizes showed significant differences between unpleasant pictures and pleasant pictures, P < 0.001, and unpleasant pictures and neutral pictures, P < 0.01.

In the second analyzing period, from 10 to 15 seconds, the significant difference between the pupil size variations associated with picture content endured, F(2,15) = 8.89, P < 0.01, as well as in the third analyzing period from 15 to 20 seconds, F(2,15) = 19.14, P < 0.001 (Fig. 1). The post hoc comparison revealed significantly larger pupil size during viewing unpleasant pictures than viewing pleasant pictures in two last periods, (10-15 sec., P < 0.001, and 15-20 sec., P < 0.01), but revealed significant differences between neutral pictures only in the third period (15-20 Sec.), P < 0.01.

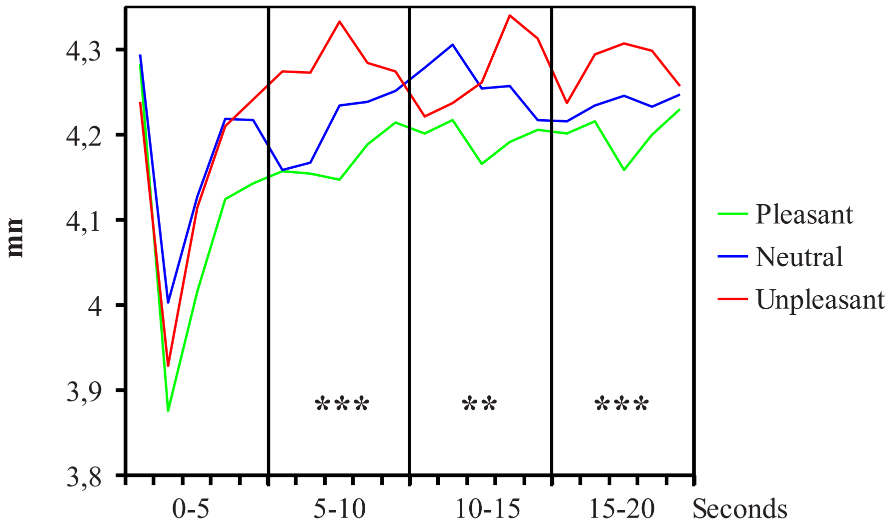

Fig. 1. The pupil size responses analyzed over time in picture viewing of pleasant (green line), neutral (blue line), and unpleasant (red line) pictures. Asterisks indicate the significance of averages pupil size responses in 5 secs. analyzing periods (* p< 0.05, ** p< 0.01, and *** p< 0.001).

c. *Speech duration and pupil size variations in the phase of oral reporting of pictures*

The averaged duration of speech was significantly longer in the reporting on unpleasant pictures (M = 46.7 Sec., SD = 25.6) compared with reporting on pleasant pictures (M = 39.3 sec., SD = 21.1), t = -4.49, df = 43, P<= 0.001. Also the averaged duration of speech in the reporting of neutral pictures (M = 43.1 sec., SD = 23.4) was significantly longer than the duration of speech in the reporting on pleasant pictures, t = -2.99, df = 43, P < 0.01.

When the pupil size variation was averaged over time (40 sec.) two seconds after picture onset, the greatest dilation appeared during reporting unpleasant pictures (M = 5.05 mm, SD = 0.105), then during reporting neutral pictures (M = 4.99 mm, SD = 0.115), and the smallest dilation during reporting pleasant pictures (M = 4.94 mm, SD = 0.118), F(2,114) = 8.45, P < 0.001. Post hoc comparison of pupil sizes revealed a significant difference between unpleasant and pleasant pictures, P < 0.001, and between unpleasant and neutral pictures, P < 0.05.

As shown in Fig. 2, there was also in the phase of oral reporting the same three significant analyzing periods in which the picture content is associated with pupillary responses, 5-10 sec., F(2,15) = 4.76, P < 0.05, 10-15 sec., F(2,15) = 61.50, P < 0.001, and 15-20 sec., F(2,15) = 17.25, P < 0.001. Post hoc comparison showed that the mean pupil size, analyzed from 5 to 10 seconds, was significantly larger during the reporting on unpleasant pictures than reporting on pleasant pictures, P < 0.05. In addition, the mean pupil size was larger during reporting on unpleasant pictures than reporting on pleasant pictures (P < 0.001), and reporting on neutral pictures (P < 0.001) analyzed from 10 to 15 seconds. The same tendency was observable when the mean pupil size was analyzed from 15 to 20 seconds. The pupil size was larger during reporting on unpleasant pictures than reporting on pleasant pictures (P < 0.001), and reporting on neutral pictures (P < 0.01).

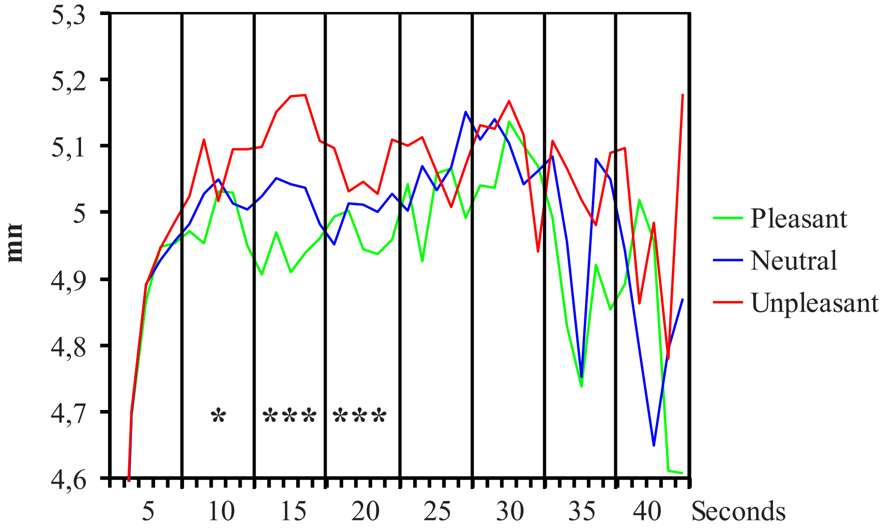

Fig. 2. The pupil size responses analyzed over time in the phase of oral reporting of pleasant (green line), neutral (blue line), and unpleasant (red line) pictures. Asterisks indicate the significance of averaged pupil size responses in 5 secs. analyzing periods (* p< 0.05, ** p< 0.01, and *** p< 0.001).

4. Conclusion

In our previous studies, we measured the changes of viewing distance (Laukka, et al., 2010), heart rate variations (Rantanen, et al., 2010) and facial expressions (Laukka, et al., 2008) with widely used affective pictures (IAPS) where the subject's task was to evaluate the valence and arousal of the affective picture using the SAM (Self-Assessment Manikin) scale. In addition, we attached the third phase to the experimental set-up, in which the subject's task was to oral report to the experimenter, who was sitting behind the computer screen, on what had been seen, what was happening, and what was going to happen in the picture.

We used the same experimental setup for exposing the changes of pupil dilations during viewing of affective pictures, and the relationship between the changes of pupil dilations during picture viewing and the changes of pupil dilations during oral reporting of the invisible pictures. In addition, the goal was to verify if the pupil size variations (emotional experiences) are related to memorizing processes, which could be manifested in the duration of the reporting on the affective pictures. The results of the present study demonstrated that in the phase of picture viewing, the unpleasant pictures revealed larger pupillary responses than neutral and pleasant pictures in last three 5 seconds analyzing periods. The parallel phenomenon was represented during reporting on pictures. The results indicated that the differences in pupil size variations endure from the phase of picture viewing to the phase of picture reporting.

These results confirm the earlier conclusions of our studies that pupil size fluctuates as a function of picture emotionality (Bradley, et al., 2008, Steihauer, et al., 1983). On the other hand, the results are contrary to the studies which have reported pupil constriction during an oral reporting (Hess, et al., 1960, Kahneman, et al., 1966). These studies have examined, for instance, the pupil size variation when the visual target was detected and shortly reported (Privitera, et al., 2010), or an auditory arithmetic problem was given and immediate recall was required

(Hess, et al., 1964, Kahneman, et al., 1966). It has been concluded that the constriction during reporting was due to the changes in accommodative convergence (Hess, et al., 1964), or loading of short term memory (Privitera, et al., 2010, Kahneman, et al., 1966), which were the explaining factors.

The discrepancy could be the consequence of the task we have used in our experiment, which is more demanding than earlier studies have used (Cabestero, et al., 2009). In our experiment, the subject was asked to view the picture, then assess it using the SAM scale, and finally report on it. The duration of the reporting phase ranged from 11 to 138 seconds, and therefore the task could be connected to the processes of long-term memory (Headley, 1981). Secondly, the discrepancy could be explained by the differences of affective pictures used in the experiments. In our experiment, all pictures portrayed one or more people; this was planned to facilitate narration of the pictures. The most confusing discovery of simultaneity of pupillary responses in the phases of picture viewing and picture reporting requires examination the reports using narrative methods.

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