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Pupil response of Hidden Emotion

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ABSTRACT

This study was to identify a classification between hidden emotion and expressing internal emotion through pupil response analysis to complement limitation of previous studies that classified hidden emotion using facial expression. In order to better understand the underlying physiological mechanism, we measured the pupil responses under different conditions as hidden emotion and expressing internal emotion. During the experiment, Participants imagined and expressed positive or negative emotion in accordance with the instructions of the experimenter. The physiological signals such as pupil size, eye blink were measured and analyzed. There was a significant difference between the two conditions. The results showed that pupil size increased in hidden emotion than expressing internal emotion, whereas eye blink decreased. The results obtained in present study could be used as an important element of hidden emotion classification.

Keywords: Hidden Emotion, Emotion Classification, Pupil Response, Dilation, Blink

1. Introduction

Emotion is an intuitive and instinctive response to external stimulus. Many studies have been shown evidences of emotion recognition using behavior or physical expression (Whang, 2005), especially on facial expression (Paul, E., 1980). Due to the fact that people are efficient at hiding emotion (e.g. Duchenne Smile (Duchenne, B., 1862)), Facial expressions might not reflective of internal emotion (Ekman et al., 1990). Therefore, there is a limitation to social interaction through emotion recognition using facial expression (Côté, 2005).

According as social networking services such as Facebook are popular platforms for self-expression and social connections (Boyd, D., 2011), emotion sharing is more difficult (Kim, C. J., 2012). Thus, it is necessary to present a clear definition on what hidden emotion is and its measurement

We tried to find out whether hidden emotion can be classified using physiological Signal that is hard to hide in comparison with facial expression. Previous studies have shown the potential for hidden emotion recognition using EEG (Electroencephalogram) and responses of the autonomic nervous system (Kim, C. J., 2012; Lee, H. J., 2013). We choose pupillary response which is one of the physiological signals related to emotion.

Previous studies have shown that pupillary responses are an essential element for recognizing emotion and cognition state. Early works by Hess (1965) reported pupil dilations when subjects looked at pictures of positive valence and pupil constrictions when they looked at pictures of negative valence (See also Mudd, S. et al., 1990). Additionally, arousal has influence on pupil dilations. Bradley, M. M. et al., (2008) had investigated whether the pupillary response was an indicator of arousal. They found that pupil size increases as participants are exposed to more arousing images and sounds.

Eye blink information can be used as a useful index of cognitive load (Irwin, D. E., 2010; Kramer, A. F., 1991). Irwin (2010) investigated that eye blink occurrence is reduced with increasing information content and task demands.

Therefore, all things taken together, we assume that the pupils will dilate when participants hide their positive emotion. Also, the eye blinks will reduce in hidden emotion condition which needs to increase cognitive load.

In the present study, our objective was to discriminate intentional expression of hidden emotion

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in the pupillary response and provide people with successful social interaction based on reading emotion correctly.

We aimed to test (a) if the pupils dilate during hidden emotion condition, especially, positive emotion is hidden (b) if eye blink decrease during hidden emotion condition.

Aiming to answer these two questions, we conducted an imagination and expression task in which participants were first asked to imagine own positive or negative experience and then were asked to express their emotion just as it is or contrariwise. We recorded pupillary responses throughout the entire experiment. The physiological signals such as pupil size, eye blink were measured and analyzed.

For the present situation, we had the following predictions for hidden emotion. First of all, if participant hide their positive emotion, also, because of arousal induced by hidden emotion, their pupil sizes would dilate. Further, we expected that eye blinks decrease when they hide their emotion, because the hidden emotion would generate the cognitive loads.

The study reported here went a step further by investigating whether or not the influence of hidden emotion is also mirrored in pupillary responses.

2. Method

2.1 Participants

Ten healthy subjects (6 males and 4 females, average age: 23.8±1.6) participated in this experiment. All reported normal or corrected-to-normal vision, were native Korean speakers, and reported no history of neurologic and affective disorders. Whole subjects signed the agreement that it is explained the experiments. The participants were not told that hidden emotion was the focus of investigation. And they were paid nearly 70$ as part of the remuneration.

2.2 Experimental Setup

We used an eye capturing device (Cho, C. W. et al., 2009) to measure pupil sizes and blinks: It is composed of a universal serial bus (USB) camera (http://www.logitech.com) and a near-infrared light-emitting diode (NIR LED). The captured image from the USB camera has a spatial resolution of 1280×720 pixels and the capturing speed is 15 frames/s. The illumination angle and wavelength of the NIR LED are, respectively, about 23 degrees (horizontally and vertically) and 850 nm. The eye capturing camera was attached to the end of the flexible frame from the head mounting device for to user independently capture NIR light images of the eye

2.3 Experimental Task and Detailed Procedure

As shown in Table 1, the present experiments were consisted four sessions, which were divided for Positive Expression after Positive Imagination (PE-PI), Negative Expression after Negative Imagination (NE-NI), Negative Expression after Positive Imagination (NE-PI) and Positive Expression after Negative Imagination (PE-NI). The first two sessions were for expressing internal emotion just as it and the last two sessions were for hidden emotion. The experimenter and participant were sitting opposite each other and experimenter verbally asked the participant for to perform two tasks in one session. In first experiential imagination task, for induction of emotion, participant was asked to imagine own positive and negative experience. In second verbal expression task, verbal expression of these emotions as possible so experiments can feel the same emotion to the experimenter was instructed to express in detail. We have not put any time limit on expressions and the tasks were finished when the participant wants.

2.4 Analysis Method

Data analysis was performed by Circular Edge Detection (CED) algorithm that refer to previous research (Cho, C. W. et al., 2009; Lee E.C. and Park K. R., 2009; Daugman, J., 2004) and a local thresholding method (Lee, E. C. et al., 2010). Using CED algorithm, first, we detect the initial pupil center and acquired an accurate pupil region. The acquired pupil region gained from the captured image sequences were used to calculate the pupil sizes and blinks of expressing internal emotion condition and hidden emotion condition, respectively.

Pupil data in verbal expression task was calculated the average because participant's emotional expression times were all different.

The averages of the pupil sizes and blinks for the two conditions were compared using Mann-Whitney U Test. As for the statistical test, two groups of data were

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Table 1. Experimental Design

Session	Experiment Condition		Task	Description
1	Expressing internal emotion	PE-PI	Experiential imagination task	Imaging positive emotional experience
			Verbal Expression Task	Expressing internal positive emotion
2		NE-NI	Experiential imagination task	Imaging negative emotional experience
			Verbal Expression Task	Expressing internal negative emotion
3	Hidden emotion	NE-PI	Experiential imagination task	Imaging negative emotional experience
			Verbal Expression Task	Expressing intentional positive emotion of hidden emotion
4		PE-NI	Experiential imagination task	Imaging positive emotional experience
			Verbal Expression Task	Expressing intentional negative emotion of hidden emotion

compared: between the expressing internal emotion condition and the hidden emotion condition (e.g. PE-PI vs. NE-PI and NE-NI vs. PE-NI).

3. Results

In this section, we describe results of the Pupil sizes and eye blinks analysis.

3.1 Pupil size

The pupil size showed statistically significant differences in the positive imagination condition between PE-PI and NE-PI as shown in Figure 1-(a) (Z = -2.646, p < .10). No difference was shown between negative imagination condition (NE-NI and PE-NI) as shown in Figure 1-(b).

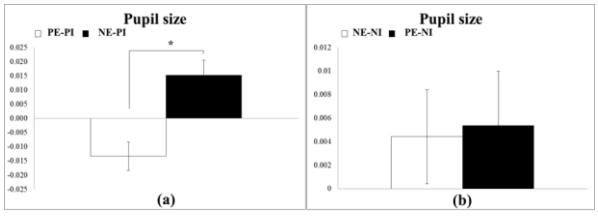

Figure 1. Significant differences shown in the pupil Size (a) positive imagination condition (b) negative imagination condition (*: p < .10)

3.2 Eye blink

The eye blink showed statistically significant differences in the positive imagination condition between PE-PI and NE-PI as shown in Figure 2-(a) (Z = -.907, p < .05) and in the negative imagination condition between NE-NI and PE-NI as shown in Figure 2-(b) (Z = -.529, p < .01).

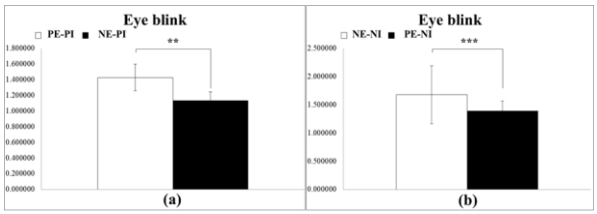

Figure 2. Significant differences shown in the eye blink (a) positive imagination condition (b) negative imagination condition (**: p < .05, ***: p < .01)

4. Discussion and Conclusion

The main purpose of the current study was to discriminate intentional expression of hidden emotion in the pupillary response and furthermore provide people with successful social interaction by reading emotion correctly.

The pupil size showed prominent distinction. For example, when a participant hid their positive emotion and expressed their emotion negatively, their pupil size increased. In line with previous studies from pupillary response to positive valence (Hess, E. H., 1965; Mudd, S. et.al., 1990) and arousal (Bradley, M. M. et al., 2008), we observed a pupil dilation. In the previous study (Lee, H. J. et al., 2013), when a participant hid their emotion, they showed increased GSR (Galvanic Skin Response), indicating arousal. Our results suggest that hidden emotion is associated arousal.

Eye blink also showed significant distinction. For example, when a participant hid their emotion and expressed their emotion contrariwise, their eye blink

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decreased. In light of the previous findings (Irwin, D. E., 2010; Kramer, A. F., 1991), the present result was consistent with those. Our result would be evidence that the hidden emotion increases cognitive load.

Taken together, our findings in the present study indicate that the pupils dilate when positive emotion is hidden and eye blinks decrease when one's emotion is hidden.

The interpretation of these observations is limited by small sample size. Therefore, further work is needed to generalize this finding.

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