Aging effects on affective responses in pupil dilation and galvanic skin responses

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Abstract. Proper recognition of emotions can be useful in improving friendly user interfaces. As the aging population increasing worldwide, how age effects on emotional decoding have many discussions. Therefore, this study aims to realize the age and emotion differences in pupil dilation and galvanic skin responses under multi-sensory stimuli (film clips). Twenty young and twenty older adults (gender-equaled) were recruited to participate in this study. All procedures approved by the ethics committee of the Institutional Review Board (IRB) at National Tsing Hua University (Taiwan). The participant was asked to seat in an adjustable chair in front of the laptop screen. Six scenarios (film clips) were selected and extracted from the free video channels (YouTube). The measurements include the maximal pupil diameter, the pupil movement velocity, the variances of pupil dilation for both eyes and electrodermal activity. The primary results of this study revealed that different affective stimuli cause varies pupil dilation and galvanic skin responses. For pupil dilation, maximum pupil size and variations of pupil size have significantly different between emotion ($p< 0.05$). Scared feeling causes significant maximum pupil size than other emotions, and sad affection induced more pupil variations than other emotions ($p< 0.05$). In general, the elderly tends with less pupil dilation and pupil variations then young adults ($p< 0.05$). It implies that the elderly has relative lower arousal states to cope with external stimuli. The scared emotion causes manifestly maximal pupil diameter for both ages ($p < 0.05$). In the electrodermal activity, there was significant interaction between age and emotion in galvanic skin responses and variations of GSR during watching films. During watching the sad and scared film, there were greater galvanic skin responses than other emotion, and the variations of GSR was significant less in sad emotion ($p< 0.05$). Further researches were required to precisely modelling the relationship between emotion and physiological features in affective computing applications.

Keywords: aging, emotion, pupil dilation, galvanic skin response

1. Introduction

Emotion recognition becomes a crucial and interest issue in human-computer interaction system. Proper recognition of emotions can be useful in improving man-machine interaction and in designing effective user interfaces. Emotion which is individual's feelings and thoughts comprising with automatic psychological and physiological reactions to the outside situations or their own stimulation (Schacter et al. 2011). Across cultures, people recognize at least six primary expressions of emotion from the face, including joy, sadness, fear, anger, disgust, and surprise (Ekman & Friesen 1986). The autonomic nervous system (ANS) plays an important role in emotional regulations, especially in physiological modulations, e.g., heart rate variability, electrodermal activity, pupil size and eye movement variation, to regulate subject behavior or emotional status (Gilzenrat et al. 2010). Different emotions affect pupil dilation, skin conductance responses, and subjective emotional responses (Kinner et al. 2017). Contrasting cognitive and physical decline; older adults enjoy high levels of affective well-being and emotional stability after 70 years old (Scheibe & Carstensen 2010). Older adults are less able to distinguish different negative emotions via unimodal visual and auditory channels than are younger adults (Ruffman et al. 2008; Fölster et al. 2014). Several studies revealed that elderly show difficulty in identifying anger, sadness, and fear from faces (Ruffman et al. 2008). Age differences in visual scan patterns, older people focus primarily on the lower part of the face and neglect the upper part which is important for expressions of anger, fear and sadness (Calder et al. 2000). The other hands, brain regions are particularly affected by age related changes, sometimes, it could be a kind of protection, for example, the frontal region regulating anger and sadness, amygdala moderating fear and the basal ganglia modifying disgust (Adolphs et al 2005). Moreover, Partala and Surakka (2003) indicated that pupil size was significantly larger during both emotionally negative and positive stimuli than during neutral stimuli. Kinner et al (2017) investigated the effects of different emotion regulation strategies on pupil dilation, skin conductance responses, and subjective emotional responses. It revealed that pupil dilation and skin conductance responses were significantly enhanced when viewing negative relative to neutral pictures. Vasquez-Rosati et al (2017) showed that negative images evoked a greater pupillary contraction, a weaker dilation and a faster physiological recovery to baseline level for practitioners. Previous study suggest that the autonomic nervous system is sensitive to highly arousing emotional stimulation to induce the variations of pupillary constriction. However, how the aging effects on affective responses in pupil dilation and galvanic skin responses were still unclear. This study aims to realize the effects of age and emotion on pupil dilation and galvanic skin responses.

2. Methodology

2.1 Subjects

Twenty young and twenty older adults (gender-equaled) were recruited to participate in this study. Their average age for young group was 21.1 (SD=0.62) and for elderly was 66.2 (SD=3.0), respectively. All of them were self-report with normal hearing and normal corrected vision capacity without physical and mental disorders. The experimental procedure confirmed to the Declaration of Helsinki and was approved by the ethic committee of the Institutional Review Board (IRB) at National Tsing Hua University (Taiwan).

2.2 Measurements

Participants were asked to sit on an adjustable chair in front of the computer screen. Six scenarios (film clips) with dubbing were selected and extracted from the free video channels (YouTube). These films were presented to subjects randomly to induce six various emotion including happy, surprise, disgust, angry sad and scared feelings. Each film lasted for around 4 minutes and before each film clip presentation, there were 3 minutes blank interval to collect the natural (calm) emotion. The Tobii Pro X3-120 eye tracker was used to collect the eye movement with sampling rate of 120Hz. The distance from the participant's eyes to the eye tracker and monitor was approximately 60 centimeters and the gaze angle (α) was around below horizontal plane 35 degree. The dimension of monitor is 1920×1080 mm (width ×height). Moreover, the wearable sensors (Shimmer3 GSR, U.S.A) were wrap on the two fingers to measure the galvanic skin response (GSR) which was active by skin conductivity. The measurements include pupil diameter size(mm), the velocity of pupil movement (mm/s) for both eyes and the galvanic skin response (GSR in μv). All the measurements were normalized with the natural (calm) situation and calculated as the variation of pupil size (Δ pupil size, mm) for both eyes and variation of GSR (Δ GSR, μv).

2.3 Analysis

Two-way ANOVA was performed to evaluate the effect of age and emotion on the pupil dilation and galvanic skin response (GSR). The significant level was set at p-values at 0.05.

3. Results

The results of this study revealed that video could evoke emotion for both age-groups. During emotion adjustment, age and emotion have significant influence on pupil dilation and skin galvanic skin responses ($p < 0.05$). As table 1, there were significant interaction between age and emotion in variations of pupil size, galvanic skin response and variations of galvanic skin response ($p< 0.05$). Age factor has significant influence in pupil dilation and electrodermal activity and emotion has remarkably affect in maximal pupil size, variations of pupil size and electrodermal activity.

Table 1. *The ANOVA results of emotion and age on pupil dilation and electrodermal activity*

Measurements	Factors	Age	Emotion	Age*Emotion
Pupil dilation	Left maximal pupil	0.00*	0.00*	0.62
	Right maximal pupil	0.00*	0.00*	0.80
	Left pupil velocity	0.00*	0.61	0.42
	Right pupil velocity	0.00*	0.35	0.86
	△ Left pupil variation	0.00*	0.00*	0.01*
	△Right pupil variation	0.00*	0.00*	0.02*
Electrodermal Activity	Galvanic skin response	0.00*	0.00*	0.00*
	△ Galvanic skin response	0.00*	0.00*	0.00*

** Significant level was set at p<0.05*

Table 2 displayed the Duncan’s multiple range testing for emotion effect on pupil dilation. The obviously maximal pupil size appeared during scared feelings for both age groups ($p < 0.05$). The significant variation of pupil size (Δ pupil size, mm) was founded in sad emotion. Since emotional arousal is a key element in modulating the pupil response and changes in autonomic function consistent with sympathetic activation (Gilzenrat et al. 2010). This is coherent with previous studies that negative feelings induced a greater pupillary contraction. The same responses were fined in both age-group.

Table 2. *The Duncan’s multiple range testing for emotion effect on pupil dilation*

Measurements	Emotion	p-values
Left pupil maximum	Surprise, Disgust, Happy, Angry, Sad < Scared	0.00*
Right pupil maximum	Surprise, Disgust, Happy, Sad, Angry < Scared	0.00*
Left pupil variation	Angry, Happy, Surprise, Scared, Disgust < Sad	0.00*
Right pupil variation	Angry, Happy, Scared, Disgust, Surprise < Sad	0.00*

** Significant level was set at p<0.05*

Table 3 and table 4 showed the Duncan’s multiple range testing on galvanic skin response (GSR) and variations of GSR between young and old adults. There has a similar tendency that scared feelings has significant greater GSR and sad emotion has less GSR for both age-groups. In the electrodermal activity, there was significant interaction between age and emotion in galvanic skin responses and variations of GSR. For young adults, disgust feelings have less skin conductivity. On the other hands, sad emotion causes elderly have less GSR.

Table 3. *The Duncan's multiple range testing on galvanic skin response between young and old adults*

Groups	Emotion	p-values
Young	Disgust < Sad, Happy, Surprise < Angry < Scared	0.00*
Elderly	Sad < Surprise < Happy, Angry < Disgust, Scared	0.00*
All	Sad < Surprise, Disgust < Happy< Angry < Scared	0.00*

** Significant level was set at p<0.05*

Table 4. *The Duncan's multiple range testing on variations galvanic skin response between young and old adults*

Groups	Emotion	p-values
Young	Disgust < Sad, Happy, Surprise < Angry < Scared	0.00*
Elderly	Sad < Surprise < Happy, Angry < Disgust, Scared	0.00*
All	Sad < Surprise, Disgust < Happy< Angry < Scared	0.00*

** Significant level was set at p<0.05*

4. Conclusions

This is a pilot study to indicated that different affective stimuli cause varies pupil dilation and galvanic skin responses. The young and older adults have the same responses which scared feeling causes significant maximum pupil size than other emotions, and sad affection induced more pupil variations than other emotions. In the electrodermal activity, there was significant interaction between age and emotion in galvanic skin responses and variations of GSR during watching films. During watching the sad film, there were greater galvanic skin responses than other emotion, and the variations of GSR was significant less in sad emotion for elderly. Further researches were required to precisely modelling the relationship between emotion and physiological features in affective computing applications.

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