Effects of Attention on Dynamic Emotional Expressions Processing

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Abstract. Attention and emotion both play the crucial roles in human cognitive processing. This study tried to investigate the relationship between attention and emotion, using dynamic facial expressions which are natural and frequently encountered in everyday life. The results showed that the emotional expressions are processed faster than the neutral ones when they are outside the current focus of attention. It indicates that the emotion processing is automatic and not gated by the attention.

1 Introduction

Attention and emotion both play the crucial roles in human cognitive processing. Emotion is one of the basic survival-related factors. It produces specific bodily responses, aimed at preparing the organism for crucial behavior. Specialized neural systems are evolved for the rapid perceptual analysis of emotionally salient events, such as emotional facial expressions. (M. Eimer, A. Holmes, 2003).

Meanwhile, numerous stimuli from the environment confront our limited processing capacity simultaneously. The attention mechanism helps the brain select and process only those stimuli most relevant to the ongoing behavior. But adaptive behavior requires to monitor the environment and detect potential survival-related stimuli (e.g., emotional) even when they are unexpected and not current task relevant or are outside the focus of attention [2].

The notion that attention bias to the emotion was supported by some studies. They provide the evidence that detection of emotional stimuli occurs rapidly and automatically [3]. A controversial issue is whether the encoding and analysis of emotionally salient events can occur independently of attention [4]. Recent studies provided conflicting results. In an fMRI study [5], spatial attention was manipulated by having subjects respond to stimulus arrays containing two faces and two non-face stimuli (houses). Four stimuli were presented with a cross in the center. Faces presented to the left and right of the cross, and houses presented below and above the cross. Or vice versus. In each trial, subjects either compared the two faces or the two houses. Thus, the attention was manipulated on the face pair or on the house pair. And facial

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expression was either fearful or neutral. The results showed that the fMRI response to fearful and neutral faces was not modulated by the focus of attention, consistent with the view that the processing of emotional items does not require attention.

However, the opposite results came up later in another ERP study by Holmes and Vuilleumier [1]. When faces were attended, a greater frontal positivity in response to arrays containing fearful faces than the neutral faces. In contrast, when faces were unattended, this emotional expression effect was completely eliminated. This study demonstrates a strong attentional gating in the emotion processing.

The ERP result was supported by an fMRI research by Pessoa [6]. Participants were instructed to focus on the gender of faces or on the orientation of the bars. A Face in the centre and two bars at peripheral were presented simultaneously. The participants' task was either to judge the gender of the face or to determine whether the two bars had the same orientation. Thus the spatial attention was controlled on or off the face. The bar-orientation task was made very difficult to consume most attentional resources, leaving little resource to process the unattended faces. During the gender task, fearful faces evoked stronger neural activity than neutral faces in a network of brain regions including the fusiform gyrus, superior temporal sulcus, orbitofrontal cortex and amygdala. Note that such different activation was only observed in the gender task but not observed in the bar-orientation task.

Another study by Anderson[7]investigated this question by manipulating object-based attention while keeping spatial attention constant. Double-exposure' images that contained faces and buildings were used. Both of them were semi-transparent, and subjects were instructed to make either a male/female judgment (attend to faces) or an inside/outside judgment (attend to places). No effect of attention was observed for the two expressions. Similar responses were evoked to both attended and unattended fearful or neutral faces in the amygdala. However, an interesting effect was observed with expressions of disgust, which evoked stronger signals in the amygdala during unattended relative to attended conditions [8].

With only a few exceptions [9, 10, 11], studies on perception emotional expressions were conducted using static faces as stimuli. However, neuroimaging studies have revealed that the brain regions known to be implicated in the processing of facial affect, such as the posterior superior temporal sulcus (pSTS), the amygdala and the insula, respond more to dynamic than to static emotional expressions [12]. So it is more appropriate, in research dealing with the recognition of real-life facial expressions, to use dynamic stimuli [11].

The present study thus attempts to investigate the relationship between attention and emotion. To do this we use a standardized set of dynamic facial expressions with angry, happy and neutral emotions, which are presented either attended or unattended as a result of manipulation of spatial attention.

2 Methods

2.1 Participants

Fifteen volunteers participated in the experiment. All the participants had normal or corrected-to-normal vision. The participants received course credits or were paid award for taking part in the study.

2.2 Materials

Videos that consisted of faces of four different individuals (two male, two female) were used. The videos consist of face articulating a nonsense bi-syllable word (without the audio track). Each of the stimuli was expressed by a kind of emotion valence: happy, angry or neutral.

Mean duration of standard (non-target) stimuli is 1170 ms. There is no significant difference among the three different emotional types of stimuli. Deviant stimuli were inserted with a 200 ms interruption on the basic of the standard stimuli. All faces covered a visual angle of about 3.4*4.9 degree.

2.3 Design and Procedure

This is a two-factor within-subject design. The experimental factors are spatial attention (attended/unattended) and emotion valence (angry/happy/ neutral).

Participants were seated in a dimly lit sound-attenuated room, with response buttons under their right hands. All stimuli were presented on a computer screen in front of a black background at a viewing distance of 70cm. A cross maintained at the center of the screen as the fixation. The eccentricity of the faces (measured as the distance between the centre of each face and the central fixation cross) was 4.2 degree.

The experiments consist of six blocks, each containing 48 standard trials and 16 deviant trials. In each block, participants were asked to pay attention to only one side (left or right) and respond to the deviants and standards as soon as possible. Forty-two standards and six deviants were presented at the attended side in every block. In each trial, an expression video was present at only one side of the screen with the central fixation. The ISI varied from 1200ms to 1500ms.

3 Results

One participant's data are excluded due to the low accuracy (below 80%). Fourteen available data were collected and analyzed. Considering the deviants with short interruption were artificially made and can not present the natural expressions, the responds to the deviant stimuli are excluded. Only the data of the standard stimuli are analyzed and compared through different conditions. Repeated Measure ANOVAs with two factors, facial emotion (angry, happy, neutral) and spatial attention were carried out on percentage of accurate responses and reaction time, respectively.

3.1 Reaction Time

The reaction time from the onset of the stimulus to the respond was recorded. The average of RT to all the stimuli is 1214.76ms.

The main effect of spatial attention is significant ($F_{1, 13} = 12.506$, $P<0.01$). The responds to the stimuli in the attended location is much faster than the responds to the unattended stimuli.

RTs of emotional and neutral expressions are different. If we consider all the data regardless the attention factor, the reaction to the emotional stimuli is faster than the neutral stimuli but not significant ($F_{2, 26} = 2.623$, $P=0.092$). But Fig.1 shows the detail

Table 1. RTs of the different expressions under attended/unattended condition (ms)

	Attended	Unattended
Angry	1212.23 ± 59.87	1235.97 ± 55.10
Happy	1212.04 ± 37.95	1223.02 ± 55.62
Neutral	1220.02 ± 65.51	1257.81 ± 60.85
Mean	1214.76 ± 54.45	1238.94 ± 57.19

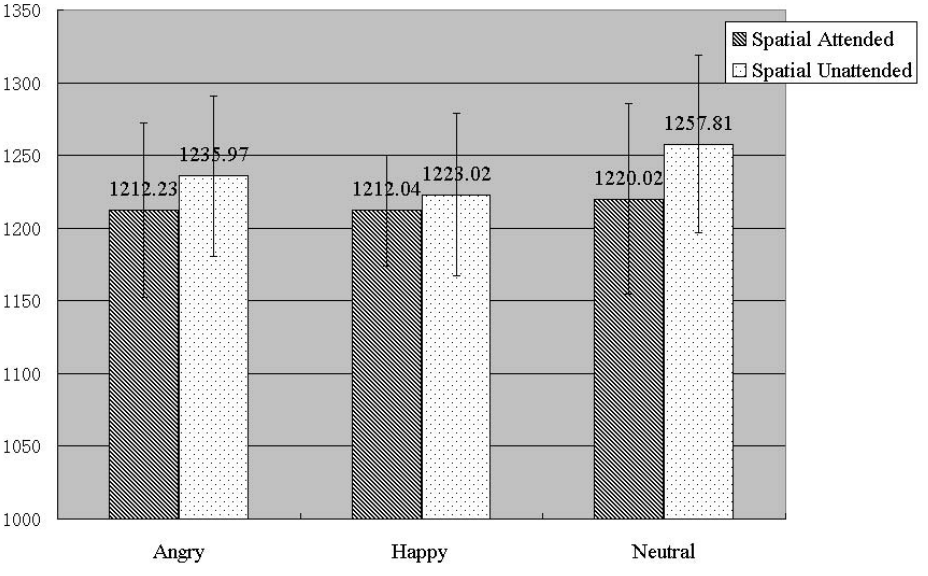

Fig. 1. RTs of the expressions with different emotion valences under attend/unattended condition

Table 2. Paried T-test on RTs of expressions with different emotion valences under attended/unattended condition (ms)

Mean Differences		Spatial Attended			Spatial Unattended		
		Angry	Happy	Neutral	Angry	Happy	Neutral
Spatial Attended	Angry				23.74		
	Happy	0.18				10.98	
	Neutral	-7.79	-7.97				37.80**
Spatial Unattended	Angry						
	Happy				12.95		
	Neutral				-21.84*	-34.79*	

between spatial attention and emotions. There is no difference between emotional and neutral ones when the expressions were presented at the attended location. But there is an obvious difference among emotional and neutral expressions when the stimuli were presented at the unattended location.

Further analysis by Pairwise Comparisons showed that RTs to the unattended angry expression is higher than unattended neutral expression (Diff. = 21.844ms, marginal significant P=0.053). So does RTs of happy expressions (Diff. = 34.792 ms, $P < 0.05$).

Paried T-test was carried out on the RTs of angry, happy, and neutral expressions, respectively. Results showed that the reaction to the emotional expressions varied indistinctively with the attention, but distinctively to the neutral expression ($t_{1, 13}$ = 3.474, P<0.01). RTs of neutral expressions became much slower when the stimuli showed up on the unattended side. But for angry and happy expressions, the reaction changes from attended to unattended location were not significant.

3.2 Accuracy

The overall performance was high. ($Mean_{Accuracy}$ = 82.60%). The accuracy among all the conditions was above 80% except the responds to the unattended neutral expression (79.76%). See Figure 2.

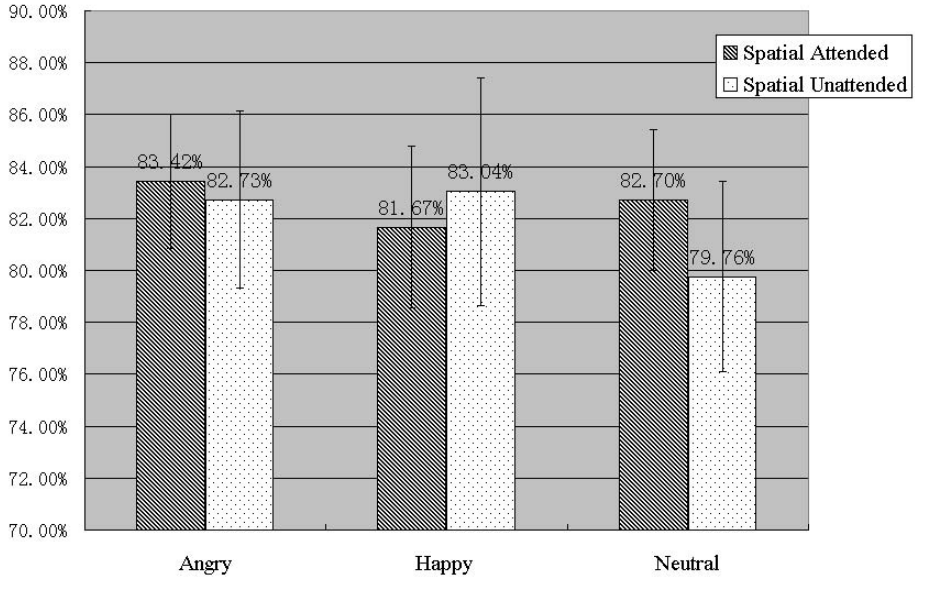

Fig. 2. The accuracies of responds to the expressions with different emotion valences under attend/unattended conditions

Neither the main effect of emotion nor spatial attention is significant at the aspect of accuracy (Emotion $F_{2, 26}$ = .420; Attention $F_{1, 13}$ = .292). Also, there is no interaction between the emotion and attention ($F_{2, 26}$ = .478).

The accuracies of the emotional expressions are the same under the spatial attended condition and the unattended condition. There is a slight difference between the responds to neutral expression under the two attended conditions but didn't reach the significance.

4 Discussion

The primary aim of the present experiment was to investigate the relationship between the attention and emotion. We use dynamic facial expressions as the emotional stimuli, which are natural and frequently encountered in everyday life. The spatial attention was manipulated by instructing the participants to pay attention to one side of the screen thus maintain the attended focus at the certain location. The probability of the stimuli is another complement to control the spatial attention. In each block, 75% stimuli were present at the attended side. A sustained attention paradigm was employed (with left/right side attended tasks delivered in separate experimental blocks).

It is predictable that the process will be slower when the stimuli appear outside the current focus of attention. This is confirmed by the gain of RTs to the stimuli at the attended location comparing with unattended location. The question is whether the emotional expressions are processed pre-attention or automatically.

The emotion is a task-irrelevant factor in this experiment. Participants only have to detect the interruption within the expression, which is a simple physical detection task. If the emotion processing is not automatically, the attention effect will be the same to any type of expressions regardless the emotion valence. That means the decline of the attention absence to the neutral expressions will be the same with the emotional expressions. But the results turned out to be the opposite. It took more time to distinguish the stimuli when the neutral expression appeared outside the focus of attention. But increased cost didn't change significantly when the emotional expressions appeared outside the attention. It implies the emotion information speedup the processing even it is irrelevant to the ongoing task. The result supports the notion that emotion can be processed automatically. The emotion expression drew the attention automatically, which proved the attention bias to emotional objects again.

However, our results are not enough to draw the conclusion that the emotion processing is pre-attention. Comparing with the previous studies, evidence for the processing of emotion stimuli that are outside the focus of attention is mixed. The present result is consistent with some previous study including behavioral experiments, ERPs and fMRI studies. Many fMRI studies pay attention on the respond of amygdala to the fear, and other related area, such as superior temporal sulcus (STS), fusiform cortex [5]. A left amygdala response to fearful compared to neutral faces occurred regardless of whether the faces were at relevant/attended locations or at the irrelevant/ unattended locations, demonstrating that fear processing in the amygdala was obligatory and unaffected by the modulation of spatial attention.

The mixed conclusion can be related to the spare processing capacity that is utilized for the processing of task-irrelevant or unattended items. The studies that revealed that attention modulates the processing of emotional stimuli employed very demanding tasks that might have nearly exhausted the processing capacity. By contrast, the studies that observed little or no effect of attention used less demanding tasks. The task in this experiment is relative simple and with little processing resource involved as our design. It was proved by the high accuracy and the participants'

feedback. Plenty spare processing capacity can be utilized during the task. It is a reason to explain the fast processed to the unattended emotional items.

Besides, the difference only existed between the emotional and neutral expressions, and we didn't find the difference between the positive emotion (happy) and negative emotion (angry). Although there were some studies found the process of positive emotion and negative emotion activated different brain areas and may involve different processing mechanism [13, 6]. Emotional valence should not be neglected when we discuss the attention effect on the emotion processing. In the study by Anderson [7], the amygdala responses to attended and unattended fearful faces were the same, responses to unattended disgusted faces were, paradoxically, increased. Unfortunately, the two negative emotions were not in our experiment. The further research is going to consider more emotion valence.

In summary, the study with dynamic natural expressions found the emotional effect under the unattended condition. It indicates that the expressions with emotional information are processed faster than the ones without emotion (e.g., neutral) when they are outside the current focus of attention. As the salient information for the survival and the keys in human social communication, the emotion requires fast processed. The processing to the emotion is automatic regardless it is inside or outside the attention and regardless it is relevant or irrelevant to the ongoing behavior. Further research should utilize electrophysiology or neuroimaging to test the behavioral results. It will also reveal the details of emotion processing mechanism and the role of attention plays.

References

1. Eimer, M., Holmes, A., McGlone, F.: The role of spatial attention in the processing of facial expression: An ERP study of rapid brain responses to six basic emotions. Cognitive, Affective, and Behavioral Neurosci. 3, 97–110 (2003)
2. Vuilleumier, P., Armony, J.: Reciprocal links between Emotion and Attention Human. In: Brain Function, 2nd edn., pp. 419–444. Academic Press, San Diego (2003)
3. Globisch, J., Hamm, A.O., Esteves, F., Ohman, A.: Fear appears fast: temporal course of startle reflex potentiation in animal fearful subjects. Psychophysiology 36, 66–75 (1999)
4. Holmes, A., Kiss, M., Eimer, M.: Attention modulates the processing of emotional expression triggered by foveal faces. Neurosci. Lett. 394, 48–52 (2006)
5. Vuilleumier, P., Armony, J.L., Driver, J., Dolan, R.J.: Effects of Attention and Emotion on Face Processing in the Human Brain: An Event-Related fMRI Study. Neuron 30, 829–841 (2001)
6. Pessoa, L., McKenna, M., Gutierrz, E., Ungerleider, L.G.: Neural processing of emotional faces requires attention. In: Proc. Natl. Acad. Sci. USA, vol. 99, pp. 11458–11463 (2002)
7. Anderson, A.K., Christoff, K., Panitz, D., De Rosa, E., Gabrieli, J.D.: Neural correlates of the automatic processing of threat facial signals. J. Neurosci. 23, 5627–5633 (2003)
8. Pessoa, L.: To what extent are emotional visual stimuli processed without attention and awareness? Current Opinion in Neurobiology 15, 188–196 (2005)
9. de Gelder, B., Bocker, K.B., Tuomainen, J., Hensen, M., Vroomen, J.: The combined perception of emotion fromvoice and face:early interaction revealed by human electric brain responses. Neurosci. Lett. 260, 133–136 (1999)

10. Kreifelts, B., Ethofer, T., Grodd, W., Erb, M., Wildgruber, D.: Audiovisual integration of emotional signals in voice and face: an event-related fMRI study. Neuroimage 37, 1445–1456 (2007)
11. Collignon, O., Girard, S., Gosselin, F., Roy, S., Saint-Amour, D., Lassonde, M., Lepore, F.: Audio-visual integration of emotion expression. Brain Research 1242, 126–135 (2008)
12. Kilts, C.D., Egan, G., Gideon, D.A., Ely, T.D., Hoffman, J.M.: Dissociable neural pathways are involved in the recognition of emotion in static and dynamic facial expressions. Neuroimage 18, 156–168 (2003)
13. Armony, J.L., Dolan, R.J.: Modulation of spatial attention by fear-conditioned stimuli: an event-related fMRI study. Neuropsychologia 40, 817–826 (2002)