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Research article

# Females are sensitive to unpleasant human emotions regardless of the emotional context of photographs

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## HIGHLIGHTS

- Females are sensitive to the depicted person's emotional state.
- We examined the effects of congruency between the valences of face and background.
- The late positive potential (LPP) was estimated as an index of emotional response.
- In females, unpleasant faces elicited larger LPP regardless of background contexts.
- Females are sensitive to human emotions regardless of the emotional contexts.

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ABSTRACT

Previous studies have demonstrated that females exhibit higher sensitivity than males to the emotional state of a person in a photograph. The present study examined whether such females' sensitivity to human emotions could be observed even when the background emotional contexts were incongruent with facial expressions. The late positive potential (LPP) was measured while 19-female and 15-male participants viewed a photograph of a face with varied emotional expressions (pleasant, neutral, or unpleasant) superimposed on a background photograph with varied valences (pleasant, neutral, or unpleasant). The results showed that unpleasant background photographs elicited a larger LPP compared to pleasant and neutral background photographs in both female and male participants. In contrast, a larger LPP for the unpleasant face photographs was observed only in female participants. Furthermore, the effect of face photographs did not interact with the effect of background photographs. These results suggest that females are sensitive to human emotions regardless of the emotional context.



## 1. Introduction

The late positive potential (LPP) of event related potentials (ERPs) has been used as a neurophysiological index of emotional responses [1]. The amplitude of the LPP is larger when viewing emotional photographs (e.g., pleasant or unpleasant photographs) relative to neutral photographs. It is known that not only the emotional valence but also the presence of a person in the stimuli influences LPP amplitudes, particularly for females [2,3]. Previous studies demonstrated that, in female participants, the LPP amplitudes were larger when viewing photographs that included a person (human photographs) than when viewing photographs that did not (non-human photographs) [2]. Furthermore, it was demonstrated that females exhibit larger LPPs when viewing unpleasant human photographs compared to viewing unpleasant non-human photographs, even when the subjective valence scores of the unpleasant human photographs were rated less negatively than those of the unpleasant non-human photographs; this was not the case for males [3]. Such sex-related effects on the LPP elicited by human photographs is considered to result from a higher sensitivity in females to people's emotions.

It has been hypothesized that females have an advantage in unconscious nonverbal perception (e.g., of the facial expression of others) compared to males [4]. In addition, contextual cues have less influence on females than males when the emotional facial expressions of others are perceived [5]. According to these notions, it is plausible that the higher sensitivity to human emotions in females could be induced by the facial expression of others in a photograph regardless of the emotional context. Previous stud-

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ies ([1,3,6]) have demonstrated that viewing emotional human photographs induce larger LPP in females compared to males. However, these studies have used photographic stimuli in which facial expressions of the depicted people and the emotional contexts of the photographs were always congruent (e.g., a happy face in a pleasant background or afraid faces in an unpleasant background). Therefore, the effects of the congruency between the facial expressions and the emotional contexts of photographs on females' sensitivity to human emotions are unclear. If females' sensitivity to human emotions depends only on the facial expressions of others, then greater responses to human emotions should be observed regardless of the congruency between facial expressions and contexts. In contrast to this prediction, it is possible that the congruency influences the sensitivity to human emotions in females. It is known that congruent contexts facilitate the perception of emotional faces compared with incongruent contexts, although whether there is a sex difference for this effect is unclear [7]. In the present study, we examined the sensitivity to emotional facial expressions superimposed on photographs with different emotional backgrounds in females compared to males, by measuring the amplitudes of the LPP as an index of the brain's response to emotions.

We used the International Affective Picture System (IAPS, [8]) and the Karolinska Directed Emotional Faces (KDEF, [9]) for background and face photographs, respectively. The background and face photographs were categorized into three valence levels (pleasant, neutral, or unpleasant) and they were superimposed in nine possible combinations (i.e., three valence levels of background × three valence levels of face) to produce the experimental stimuli. The LPP was measured while the participants viewed these stimuli. If greater sensitivity to human emotions is found in females regardless of the emotional congruency of the background and face, then a larger LPP should be elicited in females viewing emotional faces even when the valence level of the background was incongruent with that of the face.

## 2. Method

### 2.1. Participants

Twenty young-adult females (*Mean* age = 22.1 years, *SD* = .58) and 18 young-adult males (*Mean* age = 23.8 years, *SD* = .72) participated as paid volunteers. All participants had normal or corrected-to-normal vision. The study was approved by the institutional review board of the National Institute of Advanced Industrial Science and Technology. Each of the participants gave written informed consent.

### 2.2. Apparatus and stimuli

The visual stimuli were presented on a 17-in. cathode ray tube display with a resolution of 1280 × 1024 pixels, which was controlled by a computer operating Mac OSX, MATLAB (MathWorks Inc.), and Psychophysics Toolbox [10–12]. The viewing distance was approximately 60 cm.

We used 192 face photographs selected from the KDEF in which facial expressions of 70 people are divided into neutral, happy, angry, afraid, disgusted, sad, and surprised categories. These photographs consisted of 64 happy faces, 64 neutral faces, and 64 afraid faces in pleasant, neutral, and unpleasant categories. Half of these is photographs of males (No. 01-18, 21-25, and 27-35) and the other half is of females (No. 01-10, 12-16, and 19-35). The 192 background photographs (64 photographs for each of the pleasant, neutral, and unpleasant categories based on valence scores [8]), were selected from the IAPS. All background photographs were identical to "non-human pictures" used in previous research [3], which included photographs of animals, food, garbage, insects, landscapes, plants, vehicles, and weapons, among others. These photographs excluded people and highly arousing photographs, such as pictures of mutilations and erotic photographs. All the photographs were in color. Each of the 192 face photographs was superimposed on pleasant, neutral, and unpleasant background photographs to produce the experimental stimuli (total of 576 stimuli). Thus, each face photograph and each background photograph was presented three times in the experiment. In addition to these 576 stimuli, we used 192 target stimuli to which participants were required to respond. All the background photographs used as target stimuli, which were chosen from copyright-free databases, were emotionally neutral and did not include people. All the face photographs used as target stimuli were selected from the KDEF. They were surprised faces whose direction was either right or left, whereas the non-target stimuli were all full-frontal face photographs (see Fig. 1(A)). The width and height of the background photographs were 1024 pixels and 768 pixels, respectively. The width and height of the face photographs were approximately 188 pixels and 254 pixels, respectively.

### 2.3. Procedure

Participants performed two tasks: a go/no-go task and an evaluation task. In the go/no-go task, participants were required to press a button with their right index finger immediately when they viewed a target stimuli (i.e., a photograph of a right or left directed face). Each trial started with the presentation of a black fixation cross (5.0° × 5.0° of visual angle) for 1000 ms at the center of the display on a gray background. Then an experimental stimulus was presented for 2000 ms (i.e., a face photograph superimposed on a background photograph; approximately 24° × 18° of visual angle). The next trial began immediately after the offset of the stimulus. There were 48 trials × 16 blocks (576 of non-target and 192 target stimuli). Participants had a brief rest after each block.

After performing the go/no-go task, participants performed the evaluation task. They evaluated 384 photographs, which consisted of 192 face photographs and 192 background photographs. Target photographs were excluded from the evaluation task. Each photograph was solely presented without superimposition. Participants were required to evaluate the valence and arousal of each of the photographs by using the self-assessment manikin (SAM, [13]): 1 (unpleasant) to 5 (pleasant) for ratings of the valence and 1 (calm) to 5 (excited) for ratings of the arousal. The background or face photograph was presented along with the SAM scale. Participants could choose the valence and arousal values without any time pressure. The presentation order of the photographs was randomized. During the experiment, participants were seated in a reclining chair in a sound-attenuated and electrically shielded room.

### 2.4. EEG recordings

The electroencephalographic (EEG) signals were acquired with a digital amplifier (Nihon-Kohden, Neurofax EEG1100) and silver–silver chloride electrodes which were placed at 27 scalp sites: Fp1, Fp2, F7, F3, Fz, F4, F8, FCz, T3, C3, Cz, C4, T4, CPz, T5, P3, Pz, P4, T6, PO7, PO3, POz, PO4, PO8, O1, Oz, and O2, per the extended international 10–20 system, with AFz as the ground electrode. The EEGs were re-referenced to mathematically averaged earlobes (A1–A2) offline. To monitor eye blinks and eye movements, vertical and horizontal electrooculograms (EOGs) were also acquired using electrodes placed above and below the right eye, and the outer left and right canthi, respectively. The impedance of all electrodes was kept below 10 kΩ. The EEGs and EOGs were digitized at a sampling rate of 1000 Hz and the time constant was set at