Emoticons Convey Emotions without Cognition of Faces: An fMRI Study

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Abstract
In this paper, we describe the brain activities that are associated with emoticons by using functional MRI (fMRI). In communication over a computer network, we use abstract faces such as computer graphics (CG) avatars and emoticons. These faces convey users' emotions and enrich their communications. In particular, when we see some abstract faces, we feel that they are more vivid and lively than photorealistic faces. However, the manner in which these faces influence the mental process is as yet unknown. In this research, we conducted an experiment by using fMRI for the most abstract faces—emoticons. The experimental results show that emoticons convey emotions without the cognition of faces. This result is very important in order to promote an understanding of how abstract faces affect our behaviors.

Keywords
Functional MRI, facial expression, brain activity, emoticon, face mark, nonverbal communication, life-like character, personified agent

ACM Classification Keywords
H.1.2 User/Machine Systems: Human factors.

Introduction
People who exchange messages via e-mail and chat often use symbols for faces, such as the smiley :-). Emoticons

convey users' emotions and have an important role in emphasizing the emotions conveyed in a sentence.

We also use animated agents and avatars in virtual reality; they convey not only verbal messages but also nonverbal information such as facial expressions and body gestures. Animated agents are applied to online sales negotiation via networks [12]. It was found that the use of facial expressions has important effects on the other party's decision-making. For example, in online negotiation, a user tends to agree with a proposal when the opponent's face is happy and discontinues the negotiation when the opponent's face is angry.

We use many types of faces from abstract to photorealistic in computer network applications. Abstract faces include composite sketches, computer graphics (CG) avatars, emoticons, etc. Emoticons, in particular, are highly abstract (Figure 1 [2, 6]).

Many researchers in psychology and neurophysiology investigate the manner in which human faces affect other people. These findings are applicable to contemporary network communication if photorealistic face images are used.

However, photorealistic images cannot be used in e-mails and chats, and more importantly, they convey impressions of the paradoxical "the Uncanny Valley" [7, 10] or look like images of zombies. Fortunately, when we see abstract faces such as in cartoons, our brain fills in the gaps of reality and we see abstract faces that are lively and convincing [5, 6]. The human brain may perceive the abstract face in an entirely different manner, depending on its level of reality. An avatar composed of an abstract face may convey a better impression to the users. However, the mechanism by which the abstract faces are treated in the mental process and how they affect the behaviors and the decision-making in communication over a computer network is unknown.

In this paper, we investigated the brain activities that are associated with emoticons—the most abstract faces— by using functional MRI (fMRI) and described the results of the experiment with appropriate remarks.

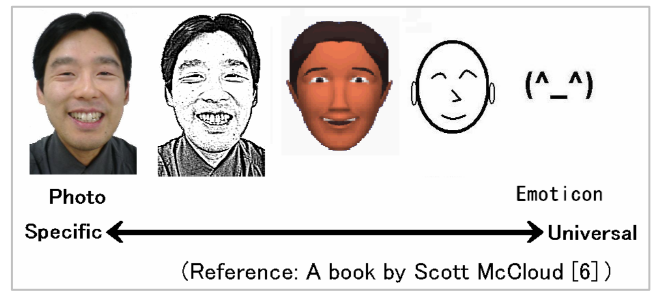

Figure 1. Faces used in communication over computer networks.

Japanese Emoticons

This research uses Japanese emoticons for the following two reasons. First, they represent emotions more expressively than Western emoticons because the former are composed of a double-byte character set. Figure 2 shows the Japanese and Western emoticons.

The second reason is that Japanese emoticons are vertically oriented and are more characteristic of real faces; Western emoticons, on the other hand, are horizontally oriented (Figure 3). The former are therefore more representative of human faces and are somewhat in between characters and real faces. Thus, they are suitable as stimuli for analyzing the responses of the brain.

	Japanese emoticons	Western emoticons
HAPPY	(^◇^) (^_^)	:-D :-)
SAD	(T_T) (;_;)	:-(:'-(
ANGRY	(*`Д´) )`ε´(	:-@ :-||
SURPRISED	w(°o°)w (°O°)	:-O :-|

Figure 2. Japanese and Western emoticons.

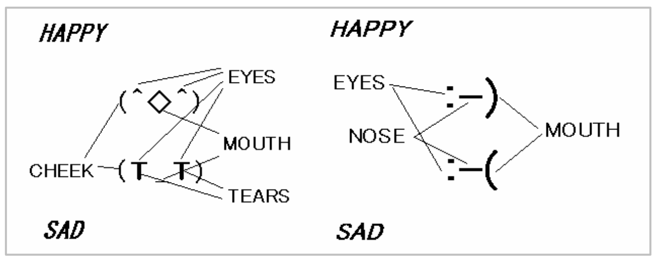

Figure 3. Composition of Japanese (left) and Western emoticons (right).

Previous Studies

According to previous studies, the right fusiform gyrus is strongly associated with the perception of faces [3]. Tong et al. stated that this region was more active during the viewing of photographs of human faces than of schematic faces [11].

Previous studies have reported that the right inferior frontal gyrus processes emotional communicative signals, which could be visual or auditory. Kawashima [4] reported the activation of this region during the discrimination of prosody and the assessment of emotion based on prosodic cues in voices. Additionally, through an emotional valence decision task, Nakamura [8] found that faces in photographs activated most of the fusiform gyrus, the right inferior frontal gyrus, the right inferior parietal lobule, and the right middle frontal gyrus. Therefore, it is said that the right inferior frontal gyrus is related to the processing of emotional communicative signals.

Method

Subjects

Seven Japanese students (age range: 20–22; five males and two females) who frequently used emoticons in their e-mails and chats participated in the experiment.

Functional MRI and Block Design

Data were acquired on a 1.5-T HITACHI STRATIS MRI scanner equipped with a quadrature RF head coil. We conducted three types of experiments (1–3) in this study. The order of the experiments was randomly selected for each subject. Data were collected during three 61-scan (i.e., 305 s) runs. Each run lasted for 5 min and presented 6 alternating epochs of a condition of selecting the target or a baseline condition consisting of viewing visual stimuli. The targets and stimuli were presented using a projector. In Exp.1 and Exp.2, the subjects underwent block-designed scans while evaluating the emotional valence of targets (happy or sad) and responded by pushing a button.

Exp.1 Face Image and Non-Face Image

In this experiment, we used average face images that were prepared in the Harashima Laboratory of Tokyo University [1] (Figure 4). We used two average images: a male image from students in Tokyo University and a female one from researchers. These faces were modified to express happiness and sadness. The reason why we used average faces is that they are less individualistic than the face of a single person. Scrambled images of the average faces were used as control stimuli.

Exp.2 Emoticon and Non-emoticon

This study employed emoticons (adopted from Takehara [9]) and non-emoticons, which consisted of random characters used in emoticons (Figure 5).

Exp.3 Sentences with and without Emoticons

Figure 6 shows examples of sentences with emoticons (T1 and T2) and those without them (R1 and R2). T1 states, "I enjoyed singing the song :-)"; T2 states, "I lost my precious clock :-(." We also prepared sentences that included emoticons expressing emotions contrary to the meaning of the sentence, for example, "I enjoyed singing the song :-(" and "I lost my precious clock :-)." The subjects were required to judge the use of the emoticons in the sentences provided and respond by pushing a button.

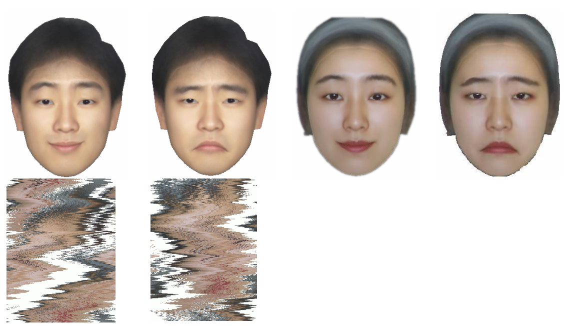

Figure 4. Examples of average faces and scrambled images.

Emoticons

(^o^) (*^_^*) (^u^) (^_^) (^ε^) . . .

(HAPPY)

(T_T) (+o+) (ToT) (;_;) (>_<) . . .

(SAD)

Non-Emoticons

&〇%x ;$& {>●~

}%,≦ ▽&o$ . . .

Figure 5. Examples of Japanese emoticons and non-emoticons.

(T1) 歌を歌って楽しかった(^◇^)

(T2) 大切な時計を失くした(T_T)

. . .

(R1) 歌を歌って楽しかった

(R2) 大切な時計を失くした

. . .

Figure 6. Examples of sentences with emoticons (T1 and T2) and without emoticons (R1 and R2).

Results

For the statistical parametric mapping analysis (SPM), a canonical homodynamic response function within SPM99 was employed as a basis function. The resulting SPM {t} map was transformed to the unit normal distribution SPM {Z} and the threshold at a significance level of $p < 0.05$ corrected for multiple comparisons in SPM. Figure 7 shows a portion of the results obtained during the experiment. The activity areas are colored black. Figure 7 shows the (1) right fusiform gyrus, (2) right inferior frontal gyrus, (3) right middle frontal gyrus, and (4) right inferior parietal lobule. All of these areas were related to the emotional valence decision task in previous studies on faces.

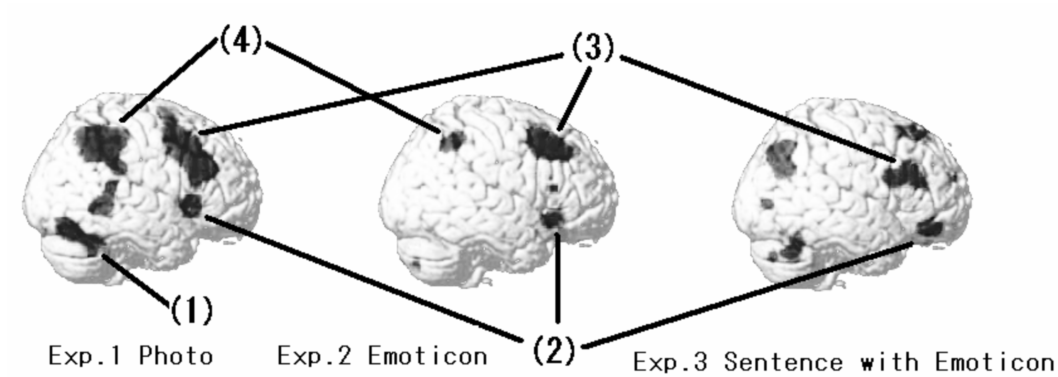

Figure 7. Brain activities in experiments 1–3. The shaded areas indicate the activity areas: (1) right fusiform gyrus (2) right inferior frontal gyrus (3) right middle frontal gyrus, and (4) right inferior parietal lobule.

Discussion

The right fusiform gyrus was activated in response to the photographs presented in Exp.1. However, this region was not activated in response to the emoticons presented in Exp.2. The right fusiform gyrus is known to be associated with the perception of human faces [3, 11]. It is possible that the emoticons were not sufficient to convince the subjects that the target was a face and to affect the right fusiform gyrus. On the other hand, surprisingly, the right inferior frontal gyrus, which is known to be activated by the emotional valence decision task [8], was activated in both Exp.1 and Exp.2.

Based on the results of these two cases, we infer that when humans see the emoticon, they can detect the emotional valence of their opponent even though they do not perceive the emoticons as a face. Since the emoticons were created to reflect the real human facial expressions as accurately as possible and to express many kinds of emotions, we believed that they would activate the fusiform gyrus. However, this region was not found to be activated during the experiment. Meanwhile, the activation of the right inferior frontal gyrus indicates that emoticons certainly play a role in enriching users' emotions, just as prosody enriches vocal expressions. Remarkably, emoticons convey emotions without cognition of faces. This is a very important finding, and it will be useful in understanding how abstract faces affect our behaviors and decision-making in communication over a computer network.

The right middle frontal gyrus and the right inferior parietal lobule were activated in Exp.1 and Exp.2. These areas were activated by the differences in attention given to determine whether or not the target was a face (whether or not it should be discriminated) in the block-design, as seen in Nakamura's study [8].

The right inferior frontal gyrus and the right middle frontal gyrus were activated in response to the sentences with emoticons that were presented in Exp.3. These areas were also activated in response to the photographs and emoticons presented in Exp.1 and Exp.2, respectively. However, there was a subtle difference in the location of the activity in the case of Exp.3. Based on this, we believe that these areas play the role of the working-memory. In our opinion, when a person encounters a sentence with an emoticon, he/she memorizes the content of the sentence and then looks at the emoticon in order to recognize both the sentence and the emoticon. The use of the working-memory in verbal and nonverbal (sentence and emoticon) communication is an invaluable finding. The results will contribute to future studies investigating how abstract faces affect our behaviors.

Conclusion

In this paper, we conducted experiments using fMRI to investigate the brain activities that are associated with emoticons. Based on the experimental results, we believe that emoticons convey emotions without the cognition of faces and that these results are important implications for investigating how abstract faces affect our behaviors. In the future, based on these results, we will attempt to conduct experiments on abstract faces and investigate how such faces are treated in the mental process and how they affect the behaviors in communication over networks.

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