Cognitive Processing in Attractiveness Judgment: An Electrophysiological Study

Sayaka Sugimoto and Hiroshi Nittono

Graduate School of Integrated Arts and Sciences, Hiroshima University, Higashi-Hiroshima 739-8521, Japan

E-mail: nittono@hiroshima-u.ac.jp

Abstract

The present study examined how the initial brain response to the visual appearance of an object is related to the subjective feeling of attractiveness. Twelve student volunteers viewed 240 pictures of everyday objects. They made a forced-choice attractiveness judgment (attractive or unattractive) on half of the pictures and a forced-choice complexity judgment (complex or simple) on the other half of the pictures. Event-related potentials (ERPs) time-locked to the picture onset were averaged separately according to each viewer's judgments. The objects judged as attractive elicited a smaller early negative potential (N2, peaking around 220 ms after stimulus onset) and a larger late positive potential (LPP, occurring after 400 ms) compared with the objects judged as unattractive. In the complexity judgment, the N2 was larger for the objects judged as complex than for the objects judged as simple, but the LPP did not differ between the categories. These findings suggest that visual information processing of attractive objects differs from that of unattractive objects at an early stage and that attractive objects enhance the cortical process reflected in the LPP, which has been previously reported to be associated with emotional valence.

Key words: *Attractiveness, Complexity, N2, Late positive potential*

Introduction

Our daily lives are filled by various artifacts with different designs. Some of them are attractive, others are not. In the present study, we examined how the initial brain response to the visual appearance of an object is related to the subjective feeling of attractiveness. As a brain activity measure with a good temporal resolution, we recorded event-related potentials (ERPs) to reveal the time course of attractiveness judgment.

In a study about interest, drawings rated as more interesting elicited a larger early negative potential (N2, peaking at 245 ms after the stimulus onset) than did drawings rated as less interesting (Nittono, Shibuya, & Hori, 2007). Because novel stimuli generally attract more interest than familiar stimuli, the N2 is considered to be sensitive to the novelty of visual stimuli. In this connection, Zajonc (2001) has proposed the mere exposure hypothesis about preference formation, which argues that people come to like a particular object when they are exposed repeatedly to that object. According to this hypothesis, it is predicted that an individual would find familiar objects more attractive as compared to novel objects and that a smaller N2 should be elicited by attractive objects than by unattractive objects.

In studies about facial attractiveness, a late positive potential (LPP, occurring after 400 ms after stimulus onset) has been found to be larger for attractive faces than for unattractive faces (Johnston & Oliver-Rodriguez, 1997; Werheid, Schacht, & Sommer, 2007). The LPP also increases for pictures with positive and negative emotional valence (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Sabatinelli, Lang, Keil, & Bradley, 2007; Schupp, Cuthbert, Bradley, Cacioppo, Ito, & Lang, 2000) and is assumed to reflect attentional resources allocated to arousing stimuli. Although there are few ERP studies about the attractiveness judgment of non-facial, common objects, a larger LPP would be expected for attractive objects than for unattractive ones.

In the present study, we examined the time course of attractiveness judgment by recording ERPs with particular interest in the N2 and LPP components. Participants were asked to judge whether the object was attractive or unattractive in a forced two-choice task. In addition, the participants performed a forced-choice complexity judgment task. It has been reported that visually complex pictures elicit a larger frontal negativity, similar to the N2, than do simple pictures (Bradley, Hamby, Löw, & Lang, 2006). Comparing ERPs obtained in the two conditions with different judgment criteria will reveal the processes specific to attractiveness judgment.

Methods

Participants

Twelve student volunteers at Hiroshima University participated in the study (five men and seven women, *M* = 22.7 years old). All participants were right-handed and had normal or corrected-to-normal sight, according to the self-reports. They gave written informed consent.

Stimuli

A total of 240 pictures of everyday objects were selected from copyright-free photo collections (Master Clip 303,000 V3, H2 soft, Tokyo, Japan). Figure 1 shows examples of the pictures. Each picture was presented on a 21-inch cathode ray tube display. The size of the picture was 10 × 10 cm and the visual angle was about 3.8°. The viewing distance was 150 cm. The pictures were divided into two sets of 120 pictures each and used for the attractiveness or complexity judgment tasks, respectively.

Procedure

The experiment was performed in a dimly lit, sound-attenuated room, where participants sat on a comfortable chair. Two experimental sessions were conducted in a counterbalanced order. Participants pressed one of two keys to make an attractiveness judgment at one session and a complexity judgment at the other session. Each session consisted of 120 trials with 120 different pictures. In each trial, a picture was presented for 1,500 ms, followed by a blank screen for 500 ms. Then a question mark was presented to prompt the participant's response. The question mark disappeared immediately after the key press, and the next picture was presented after 1.8–2.2 s (*M* = 2.0 s). The participants were instructed not to bias their responses toward one category.

Figure 1. Examples of the pictures used in the study.

Electrophysiological Recording

An electroencephalogram (EEG) was recorded from 38 scalp sites according to the extended 10−20 system using an elastic cap (EASYCAP, Munich, Germany) with Ag/AgCl electrodes. The ground electrode was fixed on the forehead. A high-pass filter of 0.016 Hz (a time constant of 10 s) and a low-pass filter of 60 Hz were used at recording. Horizontal and vertical electrooculograms (EOGs) were recorded bipolarly from the electrodes placed at the outer canthi and from the electrodes placed above and below the left eye, respectively. The sampling rate was 500 Hz. Electrode impedances were kept below 10 kΩ.

Data Reduction

For each session, the 120 pictures were sorted by each viewer's judgments. The EEG data were re-referenced to the linked earlobes (A1–A2) offline. A digital bandpass filter of 0.05–30 Hz was applied and ocular artifacts were corrected. ERP waveforms were calculated separately for the pictures that were judged as attractive and unattractive and the pictures that were judged as complex and simple. The period between 200 ms before and 1000 ms after the onset of pictures was averaged. The mean amplitudes of 150–248 ms and 400–998 ms were measured for the N2 and LPP, respectively.

Statistical Analysis

Repeated measures analyses of variance (ANOVAs) were performed on the data. Whenever appropriate, degrees of freedom were corrected using the Huynh–Feldt epsilon (ε). A Judgment (attractive vs. unattractive, or complex vs. simple) × Site (8 electrodes on the midline: AFz, Fz, FCz, Cz, CPz, Pz, POz, and Iz) ANOVA was performed for each amplitude measure. The significance level was set at .05 for all analyses.

Results

Subjective judgments

Table 1 shows the mean percentages of selected categories in the attractiveness and complexity tasks. Participants responded almost evenly to the two options.

Table 1. The mean percentage (standard deviation) of selecting each response category in the two tasks

	Attractive	Unattractive
Attractiveness	45.1 (9.8)	54.9 (9.8)
	Complex	Simple
Complexity	45.2 (6.2)	54.8 (6.2)

ERPs

Figure 2 shows the grand mean ERP waveforms for the pictures that were judged as attractive or unattractive and that were judged as complex or simple. All types of picture categories elicited an N2 (peaking around 220 ms after stimulus onset) and LPP (occurring after 400 ms).

In the attractiveness judgment task, a Judgment × Site ANOVA on the N2 amplitude showed significant main effects of judgment and site, $F(1, 11) = 5.80$, $p < .05$; $F(7, 77) = 6.52$, $p < .05$, $\varepsilon = .23$, respectively. The interaction was also significant, $F(7, 77) = 4.17$, $p < .05$, $\varepsilon = .35$. Tests of simple main effects showed that the objects judged as attractive elicited a smaller N2 than the objects judged as unattractive at AFz, Fz, FCz, Cz, and CPz; *ps* < .05. Figure 3 shows the scalp topographic map of the N2 difference (unattractive minus attractive). The difference is prominent at the frontal sites. For the LPP amplitude, the main effects of judgment and site were significant, $F(1, 11) = 9.89$, $p < .01$; $F(7, 77) = 6.86$, $p < .01$ $\varepsilon = .29$, respectively. The interaction was also significant, $F(7, 77) = 4.44$, $p < .05$, $\varepsilon = .38$. Tests of simple main effects showed that the LPP was larger for attractive objects than for unattractive ones at FCz and Cz; *ps* < .05. As shown in Figure 3, this enhancement is prominent at the frontocentral sites.

In the complexity judgment task, a Judgment × Site ANOVA on the N2 amplitude showed a significant main effect of site and a significant interaction, $F(7, 77) = 10.12$, $p < .01$, $\varepsilon = .23$; $F(7, 77) = 4.66$, $p < .01$, $\varepsilon = .50$, respectively. Tests of simple main effects showed that the N2 was larger for the objects judged as complex than for the objects judged as simple at AFz and Fz; *ps* < .05. As shown in Figure 3, the N2 difference (complex minus simple) is prominent at the central sites, which is different from the frontal-dominant N2 difference in the attractiveness judgment. For the LPP amplitude, the main effect of site and the interaction were significant, $F(7, 77) = 4.98$, $p < .05$, $\varepsilon = .30$; $F(7, 77) = 2.49$, $p < .05$, $\varepsilon = .74$, respectively. However, tests of simple main effect showed no significant effect of judged complexity on the LPP amplitude.

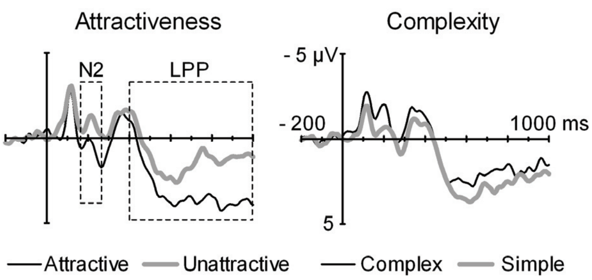

Figure 2. Grand mean ERP waveforms at Cz ($N = 12$).

Discussion

Given that the frontal N2 is related to the appraisal of the novelty of the eliciting event (Nittono et al., 2007), the decreased N2 for the objects judged as attractive may suggest that attractive objects are less novel than unattractive objects. This idea is consistent with the mere exposure hypothesis, which argues that viewers prefer familiar objects than novel objects (Zajonc, 2001). The enhancement of N2 elicited by the objects judged as complex is consistent with the finding of Bradley et al. (2007). Different scalp topographies suggest that these N2s may reflect different cortical processing.

The LPP increased for the objects that were judged as attractive. This result is consistent with the previous finding of the ERPs for facial attractiveness (Johnston &

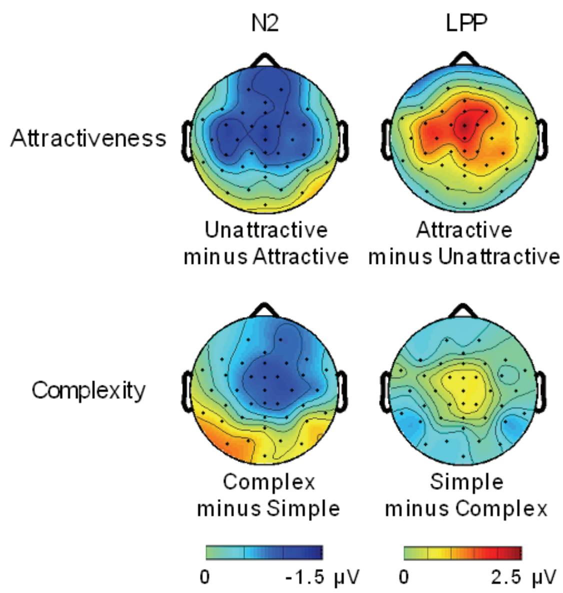

Figure 3. Scalp topographic maps of the judgment-related differences in the N2 and LPP.

Oliver-Rodriguez, 1997; Werheid et al., 2007) and suggests that more attentional resources were allocated to attractive objects than to unattractive ones. In contrast, the LPP did not differ between simple and complex pictures.

In conclusion, the present study suggests that visual information processing of attractive objects differs from that of unattractive objects at an early stage, which is reflected in the N2 difference that is possibly related to novelty checking. It also suggests that attractive objects enhance the cortical process reflected in the LPP, which has been previously reported to be associated with emotional valence (Cuthbert et al., 2000; Sabatinelli et al., 2007; Schupp et al., 2000). Further research is required to elucidate the temporal order of the subjective feeling of attractiveness and the LPP elicitation.

References

Bradley, M. M., Hamby, S., Löw, A., & Lang, P. J. (2006). Brain potentials in perception: Picture complexity and emotional arousal. *Psychophysiology*, **44**, 364–373.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*, **52**, 95–111.

Johnston, V. S., Oliver-Rodriguez, J. C. (1997). Facial Beauty and the late positive component of event-related potentials. *Journal of Sex Research*, **34**, 188–198.

Nittono, H., Shibuya, Y., & Hori, T. (2007). Anterior N2 predicts subsequent viewing time and interesting rating for novel drawings. *Psychophysiology*, **44**, 687–696.

Sabatinelli, D., Lang, P. J., Keil, A., & Bradley, M. M. (2007). Emotional perception: Correlation of functional MRI and event-related potentials. *Cerebral Cortex*, **17**, 1085–1091.

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Cacioppo, J. T., Ito, T., & Lang, P. J. (2000). Affective picture processing: The late positive potential is modulated by motivational relevance. *Psychophysiology*, **37**, 257–267.

Werheid, K., Schacht, A., & Sommer, W. (2007). Facial attractiveness modulates early and late event-related brain potentials. *Biological Psychology*, **76**, 100–108.

Zajonc, R. B. (2001). Mere exposure: A gateway to the subliminal. *Psychological Science*, **10**, 224–228.