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Right hemispheric dominance in processing of unconscious negative emotion

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Abstract

Right hemispheric dominance in unconscious emotional processing has been suggested, but remains controversial. This issue was investigated using the subliminal affective priming paradigm combined with unilateral visual presentation in 40 normal subjects. In either left or right visual fields, angry facial expressions, happy facial expressions, or plain gray images were briefly presented as negative, positive, and control primes, followed by a mosaic mask. Then nonsense target ideographs were presented, and the subjects evaluated their partiality toward the targets. When the stimuli were presented in the left, but not the right, visual fields, the negative primes reduced the subjects' liking for the targets, relative to the case of the positive or control primes. These results provided behavioral evidence supporting the hypothesis that the right hemisphere is dominant for unconscious negative emotional processing.

Keywords: Right hemispheric dominance; Unconscious negative emotion; Subliminal affective priming; Emotional facial expressions

1. Introduction

The neuro-cognitive mechanism of emotion without conscious awareness has long been a subject of great interest (Pribram & Gill, 1976). Neuropsychological studies in split-brain patients suggested that unconscious emotion might be lateralized to the right hemisphere. For example, Gazzaniga and LeDoux (1978) reported that when emotional stimuli were presented to the left visual field (i.e., stimulating the right hemisphere) of a split-brain patient, the patient could not verbally describe the stimuli but showed emotional reactions. As some psychological abilities (e.g., language) are dominantly processed in a single hemisphere, evidence of hemispheric functional asymmetry in unconscious emotion would have intriguing implications regarding its neuro-cognitive mechanism. However, other neuropsychological studies with a split-brain patient (Ladavas, Cimatti, Del Pesce, & Tuozzi, 1993) and unilateral temporal lobectomy patients (Glascher & Adolphs, 2003; Kubota et al., 2000) have not reported such hemispheric asymmetry in unconscious emotion.

Neuroimaging studies in non-brain-damaged subjects have revealed that masked presentations of emotional stimuli, which are not accessible to subjects' conscious awareness, activate the amygdala, particularly when the stimuli are emotionally negative (Killgore & Yurgelun-Todd, 2004; Morris, Ohman, & Dolan, 1998, 1999; Nomura et al., 2004; Rauch et al., 2000; Sheline et al., 2001; Whalen et al., 1998). Some of these studies (Morris et al., 1998, Morris, Ohman, & Dolan, 1999; Nomura et al., 2004) have reported right hemispheric dominance for unconscious negative emotional processing. For example, Morris et al. (1998) reported that when the stimuli were presented subliminally, an angry facial expression conditioned with emotionally negative noise activated the right, but not left, amygdala more than an unconditioned angry facial expression. Other studies (Killgore & Yurgelun-Todd, 2004; Rauch et al., 2000; Sheline et al., 2001; Whalen et al., 1998), however, did

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not report such hemispheric asymmetry in amygdala activity in response to masked emotional stimuli. There have also been a number of neuroimaging studies of brain-damaged patients that have investigated unconscious emotional processing due to cortical lesions (Morris, De Gelder, Weiskrantz, & Dolan, 2001; Pegna, Khateb, Lazeyras, & Seghier, 2004; Vuilleumier et al., 2002). These studies reported inconsistent laterality in amygdala activity in response to unseen emotional stimuli (right in Pegna et al., 2004, left in Vuilleumier et al., 2002, and bilateral in Morris et al., 2001).

Taken together, there is some evidence from neuropsychological and neuroimaging literature for the dominance of the right hemisphere in unconscious emotional processing, particularly for negative emotion, but results thus far have been inconsistent. With regard to this inconsistency, it should be noted that all of these studies tested a relatively small number of subjects (e.g., eight in Whalen et al., 1998). The sample sizes may have been too small to provide statistically reliable data about the existence or otherwise of hemispheric asymmetry in unconscious emotional processing.

Psychophysiological studies in normal subjects using relatively large sample sizes have consistently revealed that subliminal presentations of negative emotional stimuli elicit electrodermal activity (EDA), particularly when the stimuli are presented in the left visual field (Johnsen & Hugdahl, 1991; Kimura, Yoshino, Takahashi, & Nomura, 2004; Peper & Karcher, 2001; Zaidel, Hugdahl, & Johnsen, 1995). For example, Zaidel et al. (1995) tested 33 normal subjects, and revealed that negative emotional scenes elicited more EDA than positive scenes when the stimuli were presented in the left, but not the right, visual field. These data suggest that unconscious negative emotion is processed predominantly by the right hemisphere. However, using EDA as a measure of emotional reactions has a disadvantage in that it could be reflecting various types of psychological processes; even if it does reflect purely emotional responses, it indicates only the arousal level of the emotion without valence information (Bauer, 1998).

To provide behavioral evidence of hemispheric asymmetry in unconscious emotional processing, we tested 40 normal participants using a subliminal affective priming paradigm (Murphy & Zajonc, 1993). In the most typical case in this paradigm, an emotional stimulus with negative (e.g., an angry facial expression) or positive valence (e.g., a happy facial expression), or a control stimulus (e.g., a polygon), is flashed briefly as a prime, and then a nonsense target ideograph is presented. Subjects are asked to judge the target as either preferred or not preferred. Previous studies have reported that subjects' judgment of the target was biased toward having less preference by the unconscious negative primes, but not by the positive or control primes (Murphy, Monahan, & Zajonc, 1995; Murphy & Zajonc, 1993; Winkielman, Zajonc, & Schwarz, 1997). This effect is regarded as evidence that unconscious emotion is elicited and spills over into the judgment of unrelated targets (Murphy & Zajonc, 1993). This subliminal affective priming paradigm could provide information about the valence of unconsciously elicited emotion. Here, we combined the affective priming paradigm with the unilateral visual field presentation. We presented the angry and happy facial expressions as negative and positive primes. Plain gray images were also presented as control primes. Based on the aforementioned evidence indicating right hemispheric dominance in unconscious negative emotion, we predicted that when the stimuli were presented in the left visual field, the negative primes would reduce the subjects' preference for nonsense targets relative to the positive or control prime conditions.

2. Methods

2.1. Subjects

Forty healthy male volunteers (mean $\pm$ *SD* age, 23.9 ± 3.2 years) participated in this experiment. Only male subjects were recruited because there is some evidence that males show clear hemispheric functional asymmetry than do females (Kimura, 1999). All of the subjects were right-handed by self-report. Only right-handed subjects were tested, because left-handed individuals have been reported to have different patterns of hemispheric functional asymmetry (e.g., Heller & Levy, 1981). All of the subjects had normal or corrected-to-normal visual acuity. All of them were Japanese, and none of them knew Korean characters (the target ideographs in this experiment). All were ignorant of the purpose of the experiment.

2.2. Experimental design

The experiment was constructed as a within-subjects two-factorial design, with prime (negative/positive/control) and visual field (left/right) as the factors.

2.3. Stimuli

Grayscale photographs were chosen from the Ekman and Friesen's (1976) standardized facial expression set to serve as emotional primes. These stimuli were the faces of 12 models (six females and six males) expressing the emotions of anger and happiness. The 24 faces were oval-shaped for the purpose of minimizing extraneous clues (e.g., hair). As a mask stimulus, a mosaic pattern made up of fragments of these faces was prepared. As a number of previous studies utilized no prime presentations as a control condition (Murphy & Zajonc, 1993), a no prime control condition was prepared; an oval-shaped plain gray image, the same size as the emotional primes, was created.

Korean characters were used as the target nonsense ideographic stimuli. To ensure that the target stimuli were emotionally neutral, we initially showed 96 Korean characters to 32 subjects (none of whom took part in the experiment itself). These subjects evaluated each stimulus for

preference using a 5-point scale from 1 (not liked at all) to 5 (liked very much). Seventy-two characters that had been thus rated as relatively neutral (mean $\pm$ $SD = 2.9 \pm 0.2$) were then chosen as the target stimuli. The target stimuli were randomly assigned to the prime and visual field conditions.

2.4. Apparatus

Events were controlled by SuperLab Pro 2.0 software (Cedrus), implemented on a Windows computer (MA55J, NEC). The stimuli were presented on a 17-in. CRT monitor (T550, Flex Scan). The refresh rate of the monitor was set to 80 Hz and the resolution was 800×600 pixels. The subjects' responses were recorded using a response box (RB-400, Cedrus).

2.5. Procedure

The experiments were conducted individually in a chamber room. Subjects were comfortably seated with their head supported by a chin-and-forehead rest, 0.57 m from the monitor. The resulting visual angle of the stimuli was 7.0° vertical $\times$ 5.0° horizontal.

A preference judgment session was conducted, followed by a forced choice recognition session. After the forced choice recognition session, debriefing was conducted and the subjects were asked whether they had consciously perceived the primes in the preference judgment session.

2.5.1. Preference judgment

A total of 72 trials (12 negative, 12 positive, and 12 control primes for both left and right visual fields) of preference judgments were performed. All trials were conducted in a randomized order. Subjects were first given a block of ten practice trials to familiarize them with the procedure.

Fig. 1 illustrates the sequence of events in each trial. For each trial, a cross was initially presented as a fixation point at the center of the visual field for 500 ms. Then a prime stimulus flashed for 25 ms in either the left or right visual field (the inside edge was 9.5° peripheral from the center), followed by presentation of a mask stimulus for 200 ms in the same place, with no delay. The exposure duration of prime and mask stimuli, and the stimulus onset asynchrony (SOA) between them, were determined based on the data of previous subliminal studies (e.g., Esteves & Oehman, 1993) and the results of our preliminary studies. Finally, the target ideograph was presented in the same place, again with no delay, until the subject had finished making response.

The subject was asked to maintain fixation throughout on the point where the fixation point had been presented. The subjects' task was simply to judge their preference for the target ideographs using two alternatives: either they liked or disliked it. Subjects were asked to indicate their response by pressing a key with their index or middle fingers. The hands used to make the responses were counterbalanced across subjects. As the cover story, subjects were told that this experiment dealt with preferences for the nonsense ideographs.

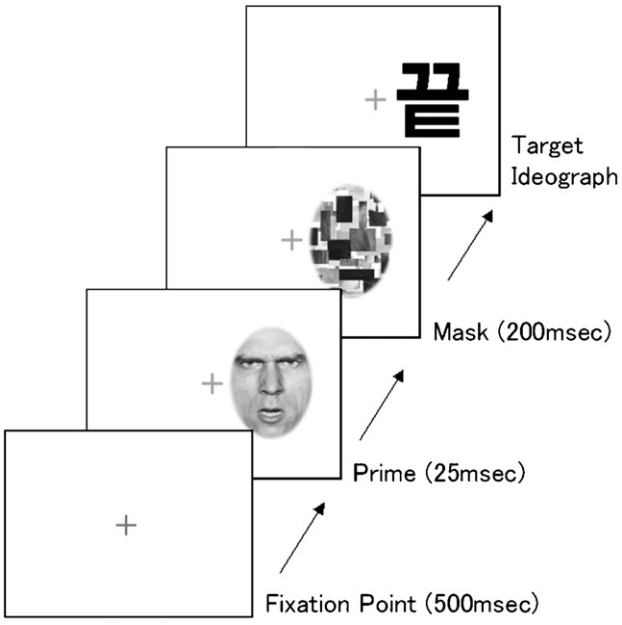

Fig. 1. The sequence of a trial.

2.5.2. Forced choice recognition

To provide the objective criterion of prime stimuli that could be presented without entering into subjects' conscious awareness, we prepared the forced choice recognition session after the preference judgment sessions, as in previous studies (e.g., Murphy & Zajonc, 1993).

In total, 32 trials (with eight negative and eight positive primes for left and right visual fields) were conducted. In each trial, the sequence of events was presented in the same manner as in the preference judgment session. Then, the two facial stimuli, one of which had been the prime in the trial, were presented in the upper and lower visual fields. The emotion of the two facial stimuli was identical (i.e., both anger or both happiness). The subjects' task was to make perceptual matching judgment as to which face had been presented before the target.

2.6. Data analysis

Data were analyzed with SPSS 10.0J software (SPSS Japan). For the preference data, the percentage of preference was analyzed with a 3(prime) $\times$ 2(visual field) repeated measures ANOVA. As follow-up analyses, simple effect analyses and multiple comparisons with Tukey's HSD methods were performed.

For the forced choice recognition data, we conducted a one-sample t test (two-tailed) on the percentage of correct recognition.

Values were considered significant at $p < .05$. In cases when the assumption of sphericity was not met ($p < .1$, Mauchley's sphericity test), the Huynh-Feldt adjusted degree of freedom was used.

3. Results

3.1. Preference judgment

The mean percentage of preference is shown in Fig. 2. The ANOVA revealed a significant interaction of prime × visual field ($F(2,78) = 4.00$, $p < .05$), indicating that either the effect of prime differed across visual fields, or the effect of visual field differed across primes. The main effect of prime was also significant ($F(2,78) = 3.13$, $p < .05$) and the main effect of visual field was not significant ($p > .1$).

As follow-up analyses of the interaction, the simple main effects of prime were analyzed for each visual field. The results revealed a significant effect of the prime for the left visual field ($F(2,78) = 7.58$, $p < .001$), but not for the right visual field ($p > .1$). Multiple comparisons for the simple main effect of the prime for the left visual field showed that the preference responses for the negative prime were less frequent than those for the positive and control primes ($p < .05$). There was no significant difference between the positive and control primes ($p > .1$).

For the interaction, the simple main effects of visual field were also analyzed for each prime. The results revealed the significant effect of visual field for negative prime ($F(1,39) = 6.33$, $p < .05$), indicating that the preference responses were less frequent in the left visual fields than in the right visual fields. The simple main effects of visual field for positive and control primes were not significant ($p > .1$).

3.2. Forced choice recognition

The mean ($\pm SD$) percentage of correct recognition was 50.1% (±8.7). A one-sample t test showed that the percentage of correct recognition did not differ from chance ($p > .1$). This result provided the objective criterion that the primes had been presented subliminally under the present experimental condition (Eriksen, 1960). The debriefing interview also confirmed that none of the subjects had subjectively perceived the primes.

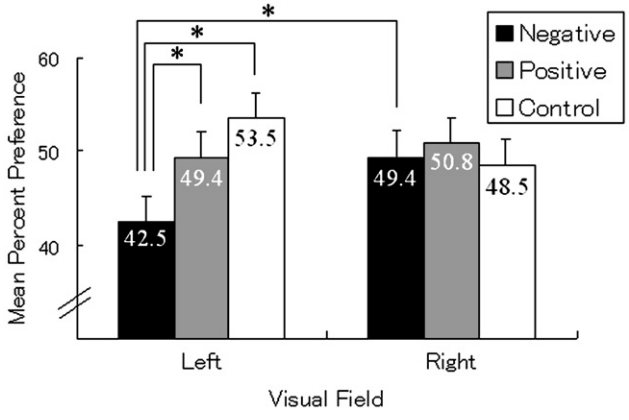

Fig. 2. Mean (with SE) percentage of preference for targets preceded by each prime (negative, positive, and control) in each visual field (left and right). Data labels indicate mean values. Asterisks indicate the significant differences in follow-up analyses of ANOVA ($p < .05$).

4. Discussion

The results revealed that the unseen negative primes reduced the subjects' preference for the targets relative to the positive or control primes when the primes were presented in the left, but not the right, visual fields. The preference responses for the targets preceded by negative primes were less frequent in the left visual fields than in the right visual fields. These results corroborate previous neuropsychological, neuroimaging, and psychophysiological studies reporting right hemispheric dominance in unconscious processing of emotionally negative stimuli. However, previous neuropsychological and neuroimaging studies reported inconsistent results, and hence it was unknown whether there was robust hemispheric asymmetry in unconscious emotion. This may have been because of the relatively small number of subjects in these studies. Here we tested 40 subjects, which was a relatively large sample size. Previous psychophysiological studies in normal subjects (e.g., Zaidel et al., 1995) consistently reported right hemispheric dominance in unconscious negative emotion by recording the EDA. However, there is no clear evidence that EDA actually reflects emotional responses, and if it does, which valence of emotion it reflects (Bauer, 1998). The present study applied subliminal affective priming, which could provide the evidence of emotional processing with valence information. With this improvement in procedure, the present study provided clear behavioral evidence supporting the hypothesis that unconscious negative emotion is processed predominantly by the right hemisphere.

The present results did not show a significant difference between the positive and control primes. The same null result has also been reported in a previous study using subliminal affective priming (Murphy et al., 1995; Experiment 2). One interpretation may be that the unconscious processing of positive emotion is not strong or robust enough to detect. Previous neuroimaging studies reported higher activation of the right amygdala in response to unconscious negative versus positive emotional stimuli (e.g., Whalen et al., 1998). On the basis of our own experiment, taken together with the above mentioned data, we postulate that the neural and behavioral evidence for unconscious positive emotional processing may simply be less apparent than in the case of the negative emotional processing.

We speculate that the most plausible neural substrate of the present unconscious priming effect may be the amygdala. As mentioned above, previous neuroimaging studies (e.g., Morris et al., 1998) indicated that the amygdala was active in response to unseen emotional stimuli. A recent neuroimaging study (Sato, Yoshikawa, Kochiyama, & Matsumura, 2004) revealed that the amygdala activity in response to emotional stimuli corresponded to the intensity of experienced negative emotion. It may be possible that the right amygdala rapidly produces emotional reactions even when the stimuli are not consciously perceived, and in such a case, as Murphy and Zajonc (1993) have proposed, emotion without awareness could spill over to affect unrelated

emotional judgments. However, it must be noted that the present behavioral data do not provide direct evidence on the involvement of the amygdala. Additionally, as some neuroimaging studies have not found the amygdala activity in response to unconscious negative emotional stimuli (e.g., Phillips et al., 2004), the involvement of the amygdala in unconscious emotion may be inconclusive. Future neuroimaging and behavioral studies are necessary to investigate this issue.

Some limitations to this study should be acknowledged. First, since we tested only male subjects, generalization to female subjects is unproven. We expected that male subjects would show clearer hemispheric asymmetry in unconscious emotional processing than do females because the size of corpus callosum relative to the rest of the brain is smaller in males than in females (Driesen & Raz, 1995; however, see Bishop & Wahlsten, 1997), and there are more fibers in the anterior commissure of females than of males (Highley et al., 1999). The investigation of females using the present paradigm is an important matter for future research.

Second, as we only tested facial stimuli, it is unknown whether the present right hemispheric dominance could be generalized to the processing of non-facial emotional stimuli, such as emotional scenes. However, as previous psychophysiological studies have reported right hemispheric superiority in physiological arousal to unseen negative emotional scenes (e.g., Zaidel et al., 1995), as well as negative emotional faces (e.g., Johnsen & Hugdahl, 1991), we speculate that the present behavioral evidence of right hemispheric dominance in unconscious negative emotional processing would not be specific to facial stimuli. Future behavioral studies utilizing the subliminal presentations of emotional scenes could verify this idea.

Finally, it is possible that the right hemispheric dominance in negative emotional processing that we found is not specific to unconscious processing but also occurs in conscious processing. Some previous neuropsychological studies have reported right hemispheric dominance for the processing of consciously perceived emotional stimuli (e.g., Adolphs, Tranel, & Damasio, 2001). At the same time, some neuroimaging studies have reported left hemispheric dominance of amygdala activity in response to consciously perceived emotional stimuli (e.g., Morris et al., 1998). In the present study, we tested only unconscious emotional processing using the affective priming paradigm because it has been shown that subjects intentionally dilute the emotional influence of emotional primes when they consciously perceive them (Murphy & Zajonc, 1993). It may prove to be valuable to investigate hemispheric asymmetry in conscious and unconscious emotional processing by adopting other paradigms.

In summary, we investigated hemispheric asymmetry in unconscious emotional processing. We used the affective priming paradigm in combination with unilateral visual presentation. The results revealed that negative primes reduced the subjects' preference for the targets relative to positive or control primes when the stimuli were presented in the left, but not the right, visual fields. These results indicate right hemispheric dominance for unconscious negative emotional processing.

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References

Adolphs, R., Tranel, D., & Damasio, H. (2001). Emotion recognition from faces and prosody following temporal lobectomy. *Neuropsychology, 15*, 396–404.

Bauer, R. M. (1998). Physiologic measures of emotion. *Journal of Clinical Neurophysiology, 15*, 388–396.

Bishop, K. M., & Wahlsten, D. (1997). Sex differences in the human corpus callosum: Myth or reality? *Neuroscience and Biobehavioral Reviews, 21*, 581–601.

Driesen, N. R., & Raz, N. (1995). The influence of sex, age, and handedness on corpus callosum morphology: A meta-analysis. *Psychobiology, 23*, 240–247.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect.* Palo Alto, CA: Consulting Psychologist.

Eriksen, C. W. (1960). Discrimination and learning withtout awareness: A methodological survey and evaluation. *Psychological Review, 67*, 279–300.

Esteves, F., & Oehman, A. (1993). Masking the face: Recognition of emotional facial expressions as a function of the parameters of backward masking. *Scandinavian Journal of Psychology, 34*, 1–18.

Gazzaniga, M. S., & LeDoux, J. E. (1978). *The integrated mind.* New York, NY: Plenum Press.

Glascher, J., & Adolphs, R. (2003). Processing of the arousal of subliminal and supraliminal emotional stimuli by the human amygdala. *Journal of Neuroscience, 23*, 10274–10282.

Heller, W., & Levy, J. (1981). Perception and expression of emotion in right-handers and left-handers. *Neuropsychologia, 19*, 263–272.

Highley, R. J., Esiri, M. M., McDonald, B., Roberts, H. C., Walker, M. A., & Crow, T. J. (1999). The size and fiber composition of the anterior commissure with respect to gender and schizophrenia. *Biological Psychiatry, 45*, 1120–1127.

Johnsen, B. H., & Hugdahl, K. (1991). Hemispheric asymmetry in conditioning to facial emotional expressions. *Psychophysiology, 28*, 154–162.

Killgore, W. D., & Yurgelun-Todd, D. A. (2004). Activation of the amygdala and anterior cingulate during nonconscious processing of sad versus happy faces. *Neuroimage, 21*, 1215–1223.

Kimura, D. (1999). *Sex and cognition*. Cambridge: MIT Press.

Kimura, Y., Yoshino, A., Takahashi, Y., & Nomura, S. (2004). Interhemispheric difference in emotional response without awareness. *Physiology and Behavior, 82*, 727–731.

Kubota, Y., Sato, W., Murai, T., Toichi, M., Ikeda, A., & Sengoku, A. (2000). Emotional cognition without awareness after unilateral temporal lobectomy in humans. *Journal of Neuroscience, 20*(RC97), 1–5.

Ladavas, E., Cimatti, D., Del Pesce, M., & Tuozzi, G. (1993). Emotional evaluation with and without conscious stimulus identification: Evidence from a split-brain patient. *Cognition and Emotion, 7*, 95–114.

Morris, J. S., De Gelder, B., Weiskrantz, L., & Dolan, R. J. (2001). Differential extrageniculostriate and amygdala responses to presentation of emotional faces in a cortically blind field. *Brain, 124*, 1241–1252.

Morris, J. S., Ohman, A., & Dolan, R. J. (1998). Conscious and unconscious emotional learning in the human amygdala. *Nature, 393*, 467–470.

Morris, J. S., Ohman, A., & Dolan, R. J. (1999). A subcortical pathway to the right amygdala mediating "unseen" fear. *Proceedings of the National Academy of Sciences USA, 96*, 1680–1685.

Murphy, S. T., Monahan, J. L., & Zajonc, R. B. (1995). Additivity of nonconscious affect: Combined effects of priming and exposure. *Journal of Personality and Social Psychology, 69*, 589–602.

Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology, 64*, 723–739.

Nomura, M., Ohira, H., Haneda, K., Iidaka, T., Sadato, N., Okada, T., et al. (2004). Functional association of the amygdala and ventral prefrontal cortex during cognitive evaluation of facial expressions primed by masked angry faces: An event-related fMRI study. *Neuroimage, 21*, 352–363.

Pegna, A. J., Khateb, A., Lazeyras, F., & Seghier, M. L. (2004). Discriminating emotional faces without primary visual cortices involves the right amygdala. *Nature Neuroscience, 8*, 24–25.

Peper, M., & Karcher, S. (2001). Differential conditioning to facial emotional expressions: Effects of hemispheric asymmetries and CS identification. *Psychophysiology, 38*, 936–950.

Phillips, M. L., Williams, L. M., Heining, M., Herba, C. M., Russell, T., Andrew, C., et al. (2004). Differential neural responses to overt and covert presentations of facial expressions of fear and disgust. *Neuroimage, 21*, 1484–1496.

Pribram, K. H., & Gill, M. M. (1976). *Freud's "Project" re-assessed: Preface to contemporary cognitive theory and neuropsychology*. New York, NY: Basic Books.

Rauch, S. L., Whalen, P. J., Shin, L. M., McInerney, S. C., Macklin, M. L., Lasko, N. B., et al. (2000). Exaggerated amygdala response to masked facial stimuli in posttraumatic stress disorder: A functional MRI study. *Biological Psychiatry, 47*, 769–776.

Sato, W., Yoshikawa, S., Kochiyama, T., & Matsumura, M. (2004). The amygdala processes the emotional significance of facial expressions: An fMRI investigation using the interaction between expression and face direction. *Neuroimage, 22*, 1006–1013.

Sheline, Y. I., Barch, D. M., Donnelly, J. M., Ollinger, J. M., Snyder, A. Z., & Mintun, M. A. (2001). Increased amygdala response to masked emotional faces in depressed subjects resolves with antidepressant treatment: An fMRI study. *Biological Psychiatry, 50*, 651–658.

Vuilleumier, P., Armony, J. L., Clarke, K., Husain, M., Driver, J., & Dolan, R. J. (2002). Neural response to emotional faces with and without awareness: Event-related fMRI in a parietal patient with visual extinction and spatial neglect. *Neuropsychologia, 40*, 2156–2166.

Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *Journal of Neuroscience, 18*, 411–418.

Winkielman, P., Zajonc, R. B., & Schwarz, N. (1997). Subliminal affective priming resists attributional interventions. *Cognition and Emotion, 11*, 433–465.

Zaidel, D. W., Hugdahl, K., & Johnsen, B. H. (1995). Physiological responses to verbally inaccessible pictorical information in the left and right hemispheres. *Neuropsychology, 9*, 52–57.