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Research Report

ELECTROCORTICAL DIFFERENTIATION OF EVALUATIVE AND NONEVALUATIVE CATEGORIZATIONS

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Abstract—*The evaluative categorizations that underlie affective and attitudinal judgments have often been equated with nonevaluative categorizations despite the central importance of evaluative processes for survival. In the present experiment, a late positive potential (LPP) of the event-related brain potential elicited when participants evaluatively categorized food items as positive or nonpositive was compared with the LPP elicited when participants semantically (i.e., nonevaluatively) categorized food items as vegetable or nonvegetable. Results revealed that evaluative categorizations evoked an LPP that was relatively larger over the right than the left scalp regions compared with the LPP evoked by nonevaluative categorizations. This finding provides evidence regarding the differences in neural and cognitive processes involved in evaluative and nonevaluative categorizations.*

To survive, organisms must differentiate and respond appropriately to harmful and hospitable stimuli. Evaluative decisions and responses are so critical that organisms have rudimentary evaluative reflexes for categorizing and subsequently approaching or withdrawing from certain classes of stimuli (i.e., beneficial and harmful, respectively), and many organisms have complex and flexible evaluative mechanisms (i.e., affective and attitudinal processes) that can integrate disparate information and elicit diverse efferent responses (Berntson, Boysen, & Cacioppo, 1993; Martin & Levey, 1978). Although the phylogenetically more recent evaluative mechanisms that underlie affective and attitudinal processes share features with, and are therefore frequently equated with, nonevaluative processes that also emerged with increasing encephalization (Fazio, 1990; Ortony, Clore, & Collins, 1988; Tourangeau & Rasinski, 1988), these evaluative mechanisms also display features that are characteristic of rudimentary evaluative reflexes (Berntson et al., 1993). This fact has spurred debate over the differences (and similarities) between nonevaluative processes and evaluative processes underlying affect and attitudes (Lazarus, 1984; Zajonc, 1980, 1984). Empirical evidence addressing this issue, however, is wanting because, in part, research has relied on self-report measures that are likely insensitive to subtle differences between evaluative and nonevaluative judgments.

Recent research demonstrates that late positive potentials (LPPs) of the event-related brain potential (ERP) can be used to investigate evaluative and nonevaluative categorizations relatively independently of subsequent behavioral responses. As people analyze a stimulus, neural units that are associated with the concurrent cognitive processes produce electrical potentials

on the scalp (i.e., ERPs). A large literature demonstrates that one of the LPPs—commonly referred to as a P300—can be used to examine nonevaluative (e.g., physical, semantic) categorization processes. This research has revealed that when individuals categorize stimuli along some nonevaluative dimension, categorically inconsistent (e.g., high tone preceded by a sequence of low tones) stimuli evoke larger LPPs than categorically consistent (e.g., high tone preceded by a sequence of high tones) stimuli (see Coles, Gratton, & Fabiani, 1990; and Donchin, Karis, Bashore, Coles, & Gratton, 1986, for reviews). Furthermore, factors that influence selectively an individual's ability to choose or execute a response to a stimulus (e.g., whether the person is instructed to respond to the word "right" with the right vs. left hand) affect the latency of the behavioral response but do not affect the amplitude or latency of the LPP (McCarthy & Donchin, 1981). Thus, the LPP appears to vary as a function of categorization and not response processes.

Recently, we have extended these findings by demonstrating that the LPP can be used to examine evaluative categorization processes. Our research has revealed that when individuals evaluatively categorize stimuli, evaluatively inconsistent stimuli evoke larger LPPs than evaluatively consistent stimuli (Cacioppo, Crites, Berntson, & Coles, 1993; Cacioppo, Crites, Gardner, & Berntson, 1994). Moreover, the LPP varies as a function of categorization and not response processes (Crites, Cacioppo, Gardner, & Berntson, 1995). Thus, the extant literature illustrates that the LPP can be used to examine evaluative as well as nonevaluative categorizations. Finally, the similarities in the LPPs evoked by nonevaluative and evaluative categorizations suggest that they involve some of the same cognitive and neural processes (Cacioppo, Crites, & Gardner, in press).

Despite the similarities between the LPPs associated with evaluative and nonevaluative judgments, the neural and cognitive processes that underlie evaluative and nonevaluative judgments may not be identical. Consistent with this notion is research suggesting that neural units in the right hemisphere are particularly important for affective or hedonic perception and judgment (see Bryden & Ley, 1983, and Tucker & Frederick, 1989, for reviews). These neural units may be active during evaluative categorizations but inactive during nonevaluative categorizations. Consequently, the LPP associated with evaluative judgments may be asymmetrically distributed relative to the LPP associated with nonevaluative judgments. Research on the LPP, however, has typically focused on the amplitude of the LPP along the midline of the scalp, ignoring potential lateral asymmetries associated with different categorization processes. In the present experiment, we directly compared the lateral distribution of the LPPs evoked during evaluative and nonevaluative judgments to determine whether evaluative and nonevaluative categorizations are differentiated by ERPs. If certain

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neural units in the right hemisphere are active during evaluative, but not nonevaluative, categorizations, the LPP elicited during evaluative, compared with nonevaluative, categorizations should be relatively larger over the right than the left scalp regions.

METHOD

To examine whether the LPP evoked during evaluative categorizations is right lateralized relative to the LPP evoked during nonevaluative categorizations, we instructed participants to either evaluatively or nonevaluatively categorize stimuli that could be categorized along both an evaluative and a nonevaluative dimension. Prior to the experiment, participants completed an attitude survey in which 7-point scales were used to assess their attitudes (i.e., evaluations) toward a number of foods that could be semantically categorized as either "vegetable" or "nonvegetable." Based on this survey, unique sets of liked and disliked vegetables and nonvegetables were selected for each of the 26 participants.

The experimenter then attached the electrodes to each participant, took the participant to an experimental chamber, and explained that stimuli would be presented in sequences of six on a computer monitor. Thirteen participants were asked to evaluatively categorize each food as either positive or nonpositive by pressing one of two keys on a keypad, and 13 participants were asked to semantically (i.e., nonevaluatively) categorize each food as either vegetable or nonvegetable. Half of the participants were told to use their right thumb to indicate positive (vegetable) foods and their left thumb to indicate nonpositive (nonvegetable) foods; the remaining participants were told the converse. Because initial analyses revealed that response hand did not affect the LPP systematically, response hand is not discussed further.

Electroencephalographic and vertical electrooculographic activity were recorded to a single target stimulus within each six-stimulus sequence. The target stimulus within each sequence was either (1) a positive vegetable preceded by positive vegetables, (2) a negative vegetable preceded by positive vegetables, (3) a positive vegetable preceded by positive nonvegetables, (4) a negative vegetable preceded by positive nonvegetables, (5) a positive nonvegetable preceded by positive vegetables, (6) a negative nonvegetable preceded by positive vegetables, (7) a positive nonvegetable preceded by positive nonvegetables, or (8) a negative nonvegetable preceded by positive nonvegetables. Thus, each target stimulus was either evaluatively consistent (types 1, 3, 5, 7) or inconsistent (types 2, 4, 6, 8) with the preceding stimuli and either semantically consistent (types 1, 2, 7, 8) or inconsistent (types 3, 4, 5, 6) with the preceding stimuli. The position of the target stimulus within each sequence was varied to prevent participants from anticipating whether or where an inconsistent stimulus would appear. Each type of target stimulus was presented 30 times during the course of the experiment. ERP waveforms over six lateral (F3, F4, C3, C4, P3, and P4) and three midline (Fz, Cz, and Pz) scalp locations were computed for each of the eight types of target stimuli for each participant. The equipment, data acquisition procedures, and data reduction procedures for computing the ERPs were

similar to those reported in Cacioppo et al. (1994) and Crites et al. (1995).

RESULTS

Before the lateral scalp distribution of the LPP was examined, analyses were performed on data from the midline scalp locations to ensure that participants categorized stimuli along only the task-relevant dimension. As expected, these analyses revealed that when participants evaluatively categorized stimuli, the LPP varied as a function of the evaluative, but not the semantic, consistency of the eliciting stimulus, and when participants semantically categorized stimuli, the LPP varied as a function of the semantic, but not the evaluative, consistency of the eliciting stimulus. Because the midline scalp locations are not relevant to the lateral distribution of the LPP, they were not included in subsequent analyses and are not discussed further.

To examine the scalp distribution of the LPP elicited by evaluative and nonevaluative categorizations, we standardized the amplitudes of the LPP within each experimental factor to eliminate differences in absolute amplitude across experimental factors that can lead to spurious interactions involving the spatial distribution of the LPP (McCarthy & Wood, 1985; see Crites, 1994, for a description of the standardization procedure). The standardized amplitudes were then submitted to a 2 (task: evaluatively categorize vs. semantically categorize) $\times$ 3 (sagittal scalp location: frontal, central, or parietal) $\times$ 2 (lateral scalp location: left vs. right) $\times$ 2 (semantic category of target stimulus: vegetable vs. nonvegetable) $\times$ 2 (valence of target stimulus: positive vs. negative) $\times$ 2 (semantic context of preceding stimuli: vegetable vs. nonvegetable) multivariate analysis of variance with the first factor manipulated between subjects. Results revealed significant main effects for sagittal scalp location, $F(2, 23) = 41.19, p < .01$, and lateral scalp location, $F(1, 24) = 33.66, p < .01$, as well as a significant sagittal-by-lateral interaction, $F(2, 23) = 16.12, p < .01$. These significant effects were qualified by the expected task-by-sagittal-by-lateral interaction, $F(2, 23) = 7.53, p < .01$.

We performed a series of pair-wise comparisons using Tukey's procedure to examine the significant task-by-sagittal-by-lateral interaction. When stimuli were evaluatively categorized, the amplitude of the LPP was larger over the right than the left central scalp region (see Fig. 1), whereas the amplitude of the LPP over the right and left scalp regions did not differ significantly at the parietal or frontal scalp regions. When stimuli were semantically categorized, the amplitude of the LPP over the right and left scalp regions did not differ significantly at the parietal, central, or frontal scalp regions.

The only other significant effects were interactions between task, sagittal location, and stimulus valence, $F(2, 23) = 5.04, p < .05$; task, lateral location, context, and stimulus category, $F(1, 24) = 5.25, p < .05$; and sagittal location, lateral location, context, and stimulus category, $F(2, 23) = 3.63, p < .05$. Because these interactions do not qualify the findings involving the asymmetrical distribution of the LPP, they are not discussed further.

Evaluative Categorizations

Fig. 1. Averaged amplitude of the late positive potential (LPP) as a function of sagittal and lateral scalp location for participants who evaluatively categorized stimuli as either positive or nonpositive (top) and for participants who semantically categorized stimuli as either vegetable or nonvegetable (bottom).

DISCUSSION

Evaluative judgment processes have often been equated with nonevaluative judgment processes because techniques for elucidating the unique aspects of evaluative judgments have not been readily available. In the present experiment, participants either evaluatively categorized or semantically categorized stimuli while the ERPs associated with these judgments were recorded. Results revealed that evaluative categorizations evoked an LPP that was larger over the right than the left central scalp region relative to the LPP evoked by nonevaluative categorizations. These results demonstrate only that the LPP evoked by evaluative categorizations is more asymmetrical than the LPP evoked by nonevaluative categorizations (and not that the LPP evoked by nonevaluative categorizations is symmetrical). Thus, these findings suggest that evaluative and non-

evaluative categorization processes can be differentiated using the LPP.

To examine whether task difficulty might account for the differential lateral asymmetry, we conducted three types of analyses. An analysis on response accuracy revealed no significant difference between the accuracy of participants in the evaluative ($M = 84.6\%$, $SD = 9.6$) and nonevaluative ($M = 77.5\%$, $SD = 11.5$) conditions. An analysis on the latency of the LPP revealed no significant difference between the evaluative ($M = 629$ ms, $SD = 64$) and nonevaluative ($M = 660$ ms, $SD = 88$) categorizations.¹ Finally, we performed a series of multivariate analyses of covariance (MANCOVAs) on the amplitude of the LPP using response accuracy and LPP latency as covariates. Results of each of these MANCOVAs revealed that evaluative, relative to nonevaluative, categorizations evoke an LPP that is larger over the right than the left central scalp regions even when task difficulty, as assessed with LPP latency and response accuracy, is taken into account. Thus, these analyses suggest that the evaluative or nonevaluative nature of the categorization task, and not task difficulty, is responsible for the differential lateral asymmetry.

The scalp topography of the LPP is a function of the electrical activity from all active neural units associated with information processing operations underlying a categorization judgment. Whereas similarities in the scalp distribution of LPPs offer suggestive evidence that many of the same neural units are active during different categorization processes, differences in the scalp distribution provide conclusive evidence that at least some neural units, and the corresponding information processing operations, differ (Johnson, 1993). Thus, the differential lateral asymmetry observed in the present experiment establishes that at least one neural unit is not active during both evaluative and nonevaluative categorizations. The information processing function and the location of the neural unit (or units) responsible for this lateral asymmetry, however, will be identified only through future research.

Nevertheless, the findings of this experiment, as well as previous research, offer suggestive evidence that the neural unit (or units) responsible for the observed lateral asymmetry underlie the right hemisphere and are active during evaluative, but not during nonevaluative, categorizations. In the present experiment, evaluative and nonevaluative categorizations elicited LPPs of comparable amplitudes over the left central ($M_s = 8.63$ and 9.54 μV , respectively), but not over the right central ($M_s = 14.18$ and 11.51 μV , respectively), scalp regions. Furthermore, previous research suggests that neural units in the right hemisphere are particularly important for affective perception (Bryden & Ley, 1983; Tucker & Frederick, 1989) and may be specialized for global integrative tasks (Beeman et al., 1994; Hellige, 1993). The lateral asymmetry observed during evaluative categorizations may, therefore, be due to the activation of neural units in the right hemisphere that assess the hedonic

1. Response latencies are not available for this experiment. LPP latency, however, varies as a function of categorization difficulty and is highly correlated with response latency when response accuracy is emphasized in instructions to participants, as was done in this study (Kutas, McCarthy, & Donchin, 1977).

importance of stimuli or perform global or integrative judgments.

Finally, research suggests that the left and right hemispheres may differ with respect to evaluative efferent responses. Specifically, the left frontal region appears particularly important for positive-approach responses, whereas the right frontal region seems to be important for negative-withdrawal responses (Davidson, 1984, 1992). Because the two hemispheres differ with respect to their relative control over positive and negative efferent responses, it has been difficult to examine selectively the evaluative judgments that underlie affective processes using only behavioral responses. The present findings suggest that the LPP may be able to examine selectively these evaluative judgments.

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