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Semantic, Evaluative, and Self-Referent Processing: Memory, Cognitive Effort, and Somatovisceral Activity

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ABSTRACT

Twenty-six subjects performed orthographic, grammatical, evaluative, and self-referent orienting tasks. During each trial, integrated facial and forearm EMG activity, HR, and T-wave amplitude were monitored; following each trial, response latency and either reported task difficulty (Replication 1) or cognitive effort (Replication 2) were assessed; and recall was assessed at the conclusion of the session. Recall was poorest when words were judged in terms of their orthographic appearance, moderate when words were judged in terms of their grammatical or evaluative features, and best when words were judged for their self-descriptiveness, even though response latency was longest and reported effort was greatest for the grammatical task. Results also revealed that somatovisceral responses varied across tasks, with clear differences emerging between semantic and nonsemantic processing and between evaluative and self-referent processing. Results suggest that cognitive effort, rather than encoding efficacy, influences task-evoked somatic responses.

DESCRIPTORS: Electromyographic activity, IEMG topography, Perioral EMG, Heart rate, T-wave amplitude, Social cognition.

The purpose of this study was to examine the somatovisceral effects of people relating incoming social information to specific knowledge domains. To examine this issue, orienting tasks were employed in which subjects were instructed by cue-questions to focus on a particular feature of positive or negative trait words.

The orienting task was first employed in cognitive psychology to study encoding operations (Craik & Tulving, 1975). Although various features of a stimulus are analyzed, sometimes automatically or simultaneously, predictable encoding operations are invoked by orienting tasks as long as subjects do not have extended periods to think about and scrutinize the stimulus once they have responded to the cue-question. Results of these studies have generally shown that the more semantic (i.e., meaningful) the cued analysis, the more likely subjects are to remember the stimulus word, and these effects are especially evident when semantic processes are cued both at the time of encoding and at the time of retrieval. These data have been interpreted as indicating the existence of qualitatively different processes by which incoming information is related to one or more existing domains of knowledge (see Cermak & Craik, 1979; Craik, 1979).

The orienting task has been employed in social psychology to investigate possible differences in the organization of domains of social knowledge. For instance, Cacioppo and Petty (1981b) exposed subjects to trait adjectives, with each preceded by a cue-question which defined the processing task. Results revealed that mean recognition confidence ratings were ordered as follows: self-reference, evaluation, association, rhyme, and volume discrimination, with all but the last two differing significantly from one another. Similar results have been

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found using recall rather than recognition confidence (e.g., Cacioppo & Petty, 1979b; Rogers, Kuiper, & Kirker, 1977). Social psychological research has also shown that trait adjectives are better recalled when rated for their descriptiveness of oneself or one's best friend than of people about whom one has little or no direct knowledge (e.g., Keenan & Baillet, 1980). As Ferguson, Rule, and Carlson (1983) note, the domains of knowledge (e.g., one's self) accessed by tasks (e.g., self-referent task) that produce relatively better recall of the incoming stimuli are thought to be characterized by greater elaboration (i.e., more associates), integration (i.e., stronger interassociative bonding), and/or differentiation (i.e., more chunking of associates into distinct but related subsets).

Somatovisceral activity was also recorded in the Cacioppo and Petty (1981b) experiment and analyses revealed that: a) the mean amplitude of IEMG activity over the perioral region was lowest for the nonsemantic tasks of rhyme and volume discrimination, intermediate for the task of association, and equally high for the tasks of evaluation and self-reference; b) cardiac activity and the mean amplitude of IEMG activity over a nonoral muscle region did not vary as a function of the type of task performed; and c) the association between task and perioral IEMG activity was temporally specific, with task-differentiating IEMG activity observed only while subjects analyzed the aurally presented trait adjective and formulated their response. Hence, the ratings of recognition confidence suggested that the evaluative and self-referent processing of social information proceeded differently, whereas analyses of somatovisceral activity failed to differentiate these tasks. One interpretation of these data is that evaluation is a central dimension along which incoming information such as trait words is categorized and stored (Osgood, Suci, & Tannenbaum, 1957; Zajonc, 1980), as indicated by the high level of recognition confidence achieved by the evaluative relative to the associative and nonsemantic tasks. The significant difference in recognition confidence between tasks (e.g., self-reference, evaluation) nevertheless suggests that incoming stimuli are related differently to memory, with self-referencing serving as the best mnemonic of the set. In this view, the mean amplitude of perioral IEMG activity varies only with fairly gross changes in linguistic processing or cognitive effort.

The major purpose of the present research was to examine the possibility that a more comprehensive analysis of the somatovisceral effects of these orienting tasks would differentiate not only semantic and nonsemantic tasks, but also evaluative and self-referent tasks. To circumvent some of the limitations inherent in the use of mean amplitude to quantify IEMG activity, a procedure developed by Cacioppo, Marshall-Goodell, and Dorfman (1983) to quantify the form and topographical features of an IEMG response over a given muscle region was employed in the present research.

In addition, IEMG activity was recorded over four separate task-relevant muscle regions. IEMG activity over the *orbicularis oris (OOR)* muscle region was monitored because past research has shown IEMG activity over this region to increase during silent language processing and suggests that perioral IEMG activity varies as a function of short-term language processing (see reviews by Cacioppo & Petty, 1981a; McGuigan, 1978). Hence, we hypothesized that perioral IEMG activity would be higher during the semantic than during the nonsemantic tasks. In addition, regression analyses were planned to determine whether IEMG activity over this region was related more closely to the cognitive effort expended when relating the incoming information to existing domains of knowledge (as indexed by self-reports regarding task difficulty or cognitive effort) or to the efficacy of encoding (as indexed by recall).

Previous research has found that analysis of the mean amplitude of IEMG activity over the *superficial forearm flexors (SFF)* region during problem solving and silent language processing yields weak or null effects (see review by McGuigan, 1978). In most previous research, however, IEMG activity was recorded from the nonpreferred forearm, and subjects were not allowed to use this arm when responding to the task. In the present experiment, IEMG activity was monitored over the *SFF* region of the preferred rather than nonpreferred arm, and subjects responded "yes" or "no" using their preferred hand once they had formulated their decision. The form of the underlying somatic response, therefore, was expected to be at least as informative as response latency. Specifically, we hypothesized that the simple orthographic task would lead to a relatively sharp and well-defined increase in somatic activity over the forearm at the end of the processing epoch, indicating less equivocation in responding.

Two additional sites, the *corrugator supercilii (CS)* and the *zygomatic major (ZM)* muscle regions, were selected for study because of past facial EMG research showing that activity over these regions varies as a function of positive and negative affective processes in studies ranging in focus from emotional imagery (Schwartz, Fair, Salt, Mandel, & Klerman, 1976a, 1976b), to moods (Sirota & Schwartz, 1982), to depression (Schwartz et al., 1976b), to attitudes and persuasion (Cacioppo &

Petty, 1979a; Cacioppo, Petty, & Marshall-Goodell, 1984; McHugo, 1983), to empathy and counter-empathy (Englis, Vaughan, & Lanzetta, 1982). It is not clear from prior research, however, whether simply *thinking* about a stimulus with positive or negative connotations is sufficient to evoke changes in IEMG activity over these muscle regions. In recent models of semantic memory and emotion, affect has been viewed as one of several attributes linked to a memory representation (Bower, 1981; Fiske, 1982). Activation of the representation, therefore, may be sufficient to evoke subtle displays signifying affective features (Schwartz et al., 1976a). We hypothesized that IEMG activity would be greater over the *CS* and less over the *ZM* region in response to negative than positive trait words.

Finally, heart rate (HR) and T-wave amplitude (TWA) were monitored. The Laceys (e.g., Lacey, Kagan, Lacey, & Moss, 1963; Lacey & Lacey, 1970) have observed phasic decelerations of HR when individuals awaited or attended closely to a simple sensory stimulus (e.g., flashing lights) and phasic accelerations of HR when individuals were engaged in "mental concentration" (e.g., mental arithmetic). Obrist and his colleagues have observed similar effects (e.g., Obrist, 1963) but have viewed the phasic changes in HR as reflecting metabolic rather than attentional demands (e.g., Obrist, Webb, Sutterer, & Howard, 1970). The inclusion of multiple measures of somatic activity allows us to examine the phasic effects of these tasks on HR while also determining whether these changes covary with similar low-level changes in somatic activity.

In addition, Heslegrave and Furedy (1979, 1980) summarized evidence suggesting that the PNS influences on the ventricular myocardium are relatively sparse and that sympathetic influences predominate (cf. Matyas & King, 1976). Although the use of the TWA to index sympathetic activity has not gone unchallenged (e.g., Newlin & Levenson, 1979; Schwartz & Weiss, 1983; Weiss, Del Bo, Reichek, & Engelman, 1980; cf. Furedy & Heslegrave, 1983; Heslegrave & Furedy, 1983), TWA has been found to be sensitive to variations in cognitive processing (Heslegrave & Furedy, 1979; Ginsberg, Heslegrave, Scher, Wong, & Furedy, 1980; Scher, Furedy, & Heslegrave, 1984). For instance, Scher et al. (1984) had subjects perform a series of backward digit span tasks; some of these tasks were simple and others were difficult. In addition, subjects were forewarned that their performance would be evaluated on some trials and not be evaluated on others. Results revealed that believing their performance would be evaluated was associated with attenuated TWAs prior to and during the digit span task; and that TWAs were smaller during the difficult than simple digit span tasks. We assessed TWA during the processing epochs in the present study to examine its empirical utility in discriminating among simple cognitive tasks which required no overt vocalizations and minimal if any covert vocalizations to perform.

Method

Subjects and Design

Twenty-six right-handed healthy undergraduate women participated in the experiment. The within-subjects factors included Task (orthography, grammar, evaluation, and self-reference), Word Valence (positive and negative), and Trials (1–8). Examples of the cue-questions used to define Tasks are: a) Is the word printed in upper case? (orthography), b) Is the word a noun? (grammar), c) Is the word good? (evaluation), and d) Is the word self-descriptive? (self-reference). Subjects were randomly assigned to one of two replications, which represented two concurrently conducted versions of the experiment. The two replications were identical except for: a) the use of different random orderings of trait words and tasks, b) the counterbalancing of the keys on the response-panel used to indicate a response of "yes" versus "no," and c) the questioning of subjects following each trial about the difficulty of the preceding task (Replication 1) or the amount of cognitive effort they felt they expended (Replication 2). Multiple operationalizations were employed to assess reported cognitive effort because we were not entirely satisfied *a priori* with the validity of either alone.

Apparatus

Electromyographic (EMG) recordings were bipolar from pairs of 5 mm diameter Ag/AgCl surface electrodes with inter-electrode distances of 12.5 mm. Electrode pairs were placed on the right arm over the *SFF* region; and on the left side of the face over the *OOR*, *CS*, and *ZM* muscle regions. An electrocardiogram (EKG) was obtained using gold-cup electrodes placed on the left arm and left leg. A single ground electrode was placed on the left ear lobe. Additional electrodes were placed on the face, palm, right ear-lobe, and over the upper-left and upper-right portion of the trapezius muscle to lend credance to the cover story that the study concerned "involuntary neural responses during problem solving."

Each electrode for EMG and EKG recording was filled with a high conductivity commercial gel and attached using adhesive collars after the site on the skin had been abraded and cleansed with acetone. All inter-electrode resistances on the face were reduced to less than 5 Kohms and on the arm to less than 15 Kohms. The EMG signals were relayed through six Grass high impedance probes to six Grass 7P3 wide-band AC preamplifiers, which were calibrated to yield a full-scale deflection to an 80 μV signal. Outputs from the amplifiers were individually rectified and summed using six Grass integrators with time constants of 0.02

s and thresholds were adjusted to place the "zero signal" of each at 2% of full-scale deflection. IEMG activity for each channel was monitored continuously on a Grass Model 7C and transmitted simultaneously to a laboratory computer, where each input stream was sampled at a rate of 100 Hz and recorded on disk for subsequent data reduction and analysis. A Grass 7P4 preamplifier and tachograph was modified to relay to the laboratory computer the moment in time each heartbeat occurred. The time at which each heartbeat occurred was then stored on disk for subsequent analysis.

Experimental instructions and stimuli were presented on a 48.24 cm (19″) videomonitor, and subjects were monitored unobtrusively and videotaped using a hidden videocamera, recorder, and monitor. The videotapes were used subsequently to identify and delete trials during which time the subject moved or displayed overt facial actions. Although some movement and facial action occurred during the intertrial interval, the number of edits due to overt muscle actions during the brief processing epoch was small and did not differ across conditions.

Procedure

During a preliminary session, potential participants completed surveys about their handedness, health history, use of medication, and need for cognition. Subjects also completed forms indicating whether or not each of 225 positive or negative trait words (e.g., athlete, intelligent) was "good" or "bad," an adjective or noun, and self-descriptive or not. The "accuracy" with which subjects responded during the encoding tasks, therefore, could be determined. A unique set of trait words was prepared for each subject such that (a) the various combinations of stimuli appeared equally often within each task (e.g., one of the eight words about which subjects were asked orthographic questions was a positive, self-descriptive adjective, one was a positive self-descriptive noun, etc.), and (b) the correct response to half the questions within each task was "yes" and the correct response to half the questions was "no." A random procedure was used to determine for which four of the eight questions within each task the correct answer was "yes." Thus, although subjects were unaware of the purpose of the rating task, each subject developed her own scoring key for assessing her performance on the various orienting tasks. Finally, subjects were informed of the nature of the experimental tasks and measurement procedures, and volunteers who met the selection criteria were scheduled to participate in the experiment from one to six weeks later. Subjects were scheduled to appear individually for several hours to allow sufficient time for them to relax and become well-practiced at the task prior to the onset of the experimental trials.

When subjects arrived at the laboratory, the experimental tasks were reviewed and electrodes were attached. Subjects next were seated in a comfortable chair approximately one meter from the videoscreen in a sound attenuated, temperature-controlled testing room adjacent to the control room housing the oscillograph and laboratory computers. The subject was informed that the study concerned the involuntary bodily responses that accompanied problem solving. Subjects were instructed to respond quickly, but accuracy was stressed. A 12-key response-panel was positioned such that 1 cm × 1 cm keys labeled "yes" and "no" rested comfortably under the index and middle fingers of the subject's preferred hand. Response latency was recorded to the nearest hundredths of a second using a laboratory computer.

The remaining instructions and all experimental tasks and stimuli were programmed to appear on the videoscreen in the testing room. First, each subject went through 10 min of progressive relaxation and was instructed to remain as relaxed as possible throughout the session. The rationale given to subjects for this task was that overt movements and muscle tension could obviate the small involuntary neural responses we were investigating.

Baseline recordings were obtained after subjects completed tensing and relaxing muscles and were used to establish the maximum level of somatic activity that could be exhibited prior to the onset of an experimental trial (see McHugo & Lanzetta, 1983, for a discussion of the "closed-loop" baseline procedure). Subsequently, the subject was reminded that a cue-question would be presented and would be followed at variable intervals by four separate presentations of English words. The subject was instructed to answer the question posed for each word by pressing the appropriate button on the response-panel.

A trial was defined as: a) a 5-s closed-loop baseline; b) a variable-length processing epoch, which began with the presentation of a trait word in the center of the videoscreen and terminated when the subject responded by pressing a button or until 5 s elapsed (in the latter case, the data from the trial were disregarded); c) presentation of a brief message indicating what response had been made (i.e., yes, no, or no-response); d) presentation of a 9-point graphic asking for a rating of the difficulty of the decision just made (Replication 1: 1 = "very easy," 9 = "very difficult") or the cognitive effort expended (Replication 2: 1 = "very little effort," 9 = "considerable effort"), to which subjects responded by pressing the appropriate button on their response-panel, e) presentation of a brief message indicating what response was entered by the subject; and f) a 5-s interval preceding the search for an appropriate baseline for the onset of the next trial. Only physiological activity exhibited during the processing epoch was stored on the laboratory computer.

A cue-question was presented after every 4 trials, with any given cue-question never appearing consecutively. Before proceeding, the subject was required to press a button indicating that she had read and understood the orienting task instruction to be used. To assure that the instructions were understood and task performances were maximal at the time recordings were obtained, subjects performed 32 practice trials prior to the onset of 64 experimental trials. (Subjects were unaware of the transition from practice to experimental trials, and data from the practice trials were not recorded.) Finally, the use of the closed-loop baseline procedure enabled subjects to move somewhat between experimental trials if they felt uncomfortable or tense.

At the completion of the study, subjects spent 60 s counting backwards by threes from 100 to prevent rehearsal of the trait words. Subjects were then given 5 min to list all of the words they could remember from the study. The proportion recalled correctly within each condition served as the dependent variable. Finally, subjects were interviewed and debriefed, thanked, given laboratory credit, asked not to disclose any aspect of the experiment to others in their class until the end of the semester, and dismissed. Our postexperimental interviews of subjects indicated that none realized that voluntary somatic activity was being monitored.

Data Reduction

Four cognitive measures were obtained in each replication: proportion of words recalled correctly, mean response latency, proportion of correct responses, and mean rating of task difficulty (Replication 1) or the cognitive effort expended (Replication 2). (Since ratings of either task difficulty *or* cognitive effort were obtained, a variable labeled "task demand" was employed to represent these measures across Replications.) In addition, IEMG activity was monitored over four separate muscle regions, and eight distinct topographical features were extracted from the IEMG activity observed over each site to quantify the overall form of IEMG activity during each trial. To accomplish this, the array of A/D observations from a subject that represented IEMG activity at a given recording site and trial was converted to an array of amplitudes expressed in microvolts. Next, these amplitudes were denoised in quadrature using the zero signal for each particular channel and subject as the minimum (Fridlund, Cottam, & Fowler, 1982), and topographical parameters were extracted (Cacioppo et al., 1983). The expected main effect for Task on response latency required a slight modification in the topographical analysis, however. As noted above, the recording interval was delimited by the presentation of the trait word and the subject's response. Since two of the topographical parameters (i.e., mean time, variance time) are sensitive to differences in the length of the recording interval (Cacioppo et al., 1983), the measures of mean time and variance time were converted prior to analysis from temporal units (e.g., seconds) to percentages of the recording interval. For example, the mean time of an IEMG response whose center of mass occurred midway through a task taking 2.0 s to perform would be expressed as a percentage (i.e., 50%) rather than in terms of seconds (i.e., 1.0 s). Cardiac activity was also recorded throughout the processing epoch, and mean HR and the mean amplitude of the T-wave of the heartbeats observed during the processing epoch were calculated. Mean HR was calculated by averaging the second-by-second HRs exhibited during the processing epoch, and TWA was calculated by measuring the height of the T-wave using the midpoint of the isoelectric Q–P interval as the baseline.

Finally, to obtain more reliable measures in the present study, each measure was averaged across the Trials factor prior to analyses.

Results and Discussion

Performance and Ratings

Overview. The dependent measures were analyzed using three planned contrasts. The first represented the full factorial model and weighted the four tasks equally. The remaining contrasts were designed to isolate the effects across the four tasks. To review, one contrasted the effects of the semantic (i.e., grammatical, evaluative, and self-referent) tasks with the effects of the nonsemantic (i.e., orthographic) task; the second contrasted the effects of the evaluative task with those of the self-referent task. To protect against Type-I errors, a multivariate version of each contrast (MANOVA) was conducted using the four cognitive measures as the criterion variables. Wilks' criterion and *F*-approximations were used in evaluating the statistical significance of the tests in the MANOVAs. Significant effects in the multivariate contrasts were followed by univariate versions of the contrasts ($ps<.05$).

Results of the MANOVA using the full model revealed the expected main effect for Task, $F(12/166) = 27.80$, and a main effect for Word Valence, $F(4/19) = 4.09$. Importantly, results of the MANOVA contrasting the semantic and nonsemantic tasks produced a significant main effect for Task, $F(4/19) = 87.76$, indicating as expected that the set of grammatical, evaluative, and self-referent tasks had different overall cognitive effects than did the nonsemantic task. The main effect for Word Valence was, of course, again significant since these particular contrasts involve the same data as do the analyses of the full model.

Results of the MANOVA contrasting the evaluative and self-referent tasks yielded a highly significant main effect for Task, $F(4/19) = 40.36$, confirming that these tasks resulted in discriminable cognitive effects even when subjects and experimental stimuli were held constant across tasks. This MANOVA also yielded a significant effect for Word Valence, $F(4/19) = 4.22$.

Recall. It was reasoned that the organization of the schema invoked by the orthographic task was the simplest, followed by the tasks of grammar, evaluation, and self-reference. Accordingly, it was hypothesized that recall would be poorest for the orthographic task and best for the self-referent task. Analysis of the proportion of words recalled correctly revealed a main effect for Task, $F(3/66) =$

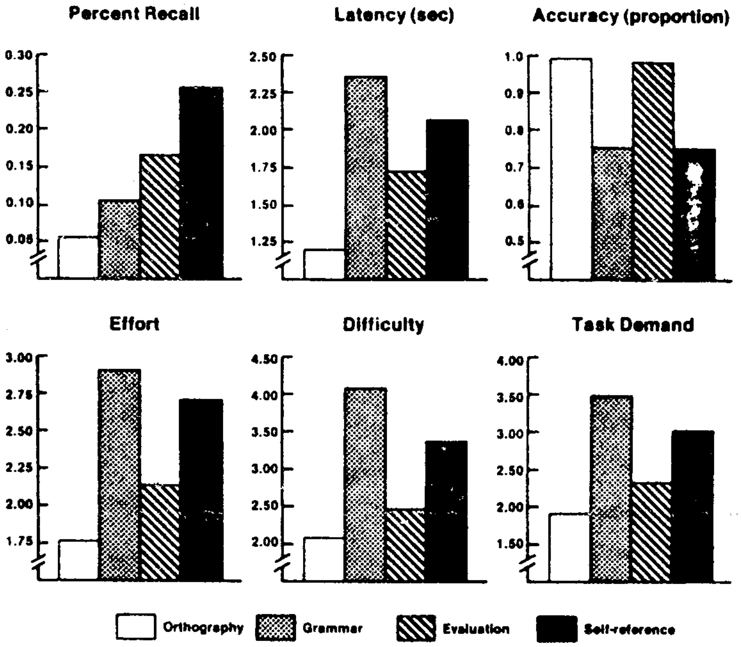

Figure 1. Mean scores on cognitive measures as a function of Task. Reported task difficulty was measured in Replication 1, and reported cognitive effort was measured in Replication 2. "Task demand" represents the results of these data averaged across replications.

20.21. Cell means, which are summarized in Figure 1, supported expectations. The planned contrasts identified more specifically wherein lay the differences across tasks. Recall was poorer for the nonsemantic ($\overline{X} = .06$) than semantic tasks ($\overline{X} = .17$), $F(1/22) = 51.74$. In addition, the planned contrast comparing the tasks of evaluation and self-reference confirmed that the latter produced superior recall, $F(1/22) = 11.28$.

Analyses using the full model also revealed a tendency for positive words ($\overline{X} = 0.16$) to be recalled better than negative words ($\overline{X} = 0.13$), $F(3/66) = 4.23$, $p = .052$. An identical result was, of course, obtained in the contrast comparing semantic vs. nonsemantic tasks. The final contrast, which involved only the evaluative and self-referent tasks, produced a significant main effect for Word Valence ($\overline{X}$ positive = 0.24, $\overline{X}$ negative = 0.18), $F(1/22) = 5.47$. No other effect was significant.

Response Latency. The overall ANOVA showed that response latency varied as a function of Task, $F(3/66) = 78.18$. As expected, the contrast comparing the nonsemantic and semantic tasks produced a significant main effect for Task, $F(1/22) = 253.78$, indicating that the semantic tasks took longer to perform ($\overline{X} = 2.05$) than the nonsemantic task ($\overline{X} = 1.22$). Finally, the contrast comparing the evaluative and self-referent tasks revealed that evaluative judgments were formed more quickly than were self-referent judgments, $F(1/22) = 28.92$ (see Figure 1).

The only other significant effect observed was a main effect for Word Valence. Replicating the observations of Ferguson et al. (1983), the overall ANOVA indicated that latency was longer for negative ($\overline{X} = 1.90$) than for positive words ($\overline{X} = 1.78$), $F(1/22) = 7.72$. This main effect was also significant in the contrast comparing the tasks of evaluation and self-reference ($\overline{X}$ positive = 1.82, $\overline{X}$ negative = 2.00), $F(1/22) = 6.32$.

Accuracy. Response latencies have been used previously to index the ease with which incoming trait information was related to existing domains of knowledge in this paradigm, and analyses of the accuracy and self-report data support this interpretation. Recall that the ratings of the trait words obtained from each subject prior to the experiment were used to select the particular set of trait words used during her testing (e.g., only adjectives that the subject rated as adjectives were used in the grammatical task if the correct response was to be "yes," etc.). Nevertheless, the overall ANOVA revealed a significant main effect for Task on the measure of accuracy, $F(3/66) = 55.69$ (see Figure 1). Contrasts revealed that accuracy was better on the nonsemantic ($\overline{X} = 0.99$) than semantic tasks ($\overline{X} = 0.83$), $F(1/22) = 160.96$, and, interestingly, that more "errors" were made in the self-referent than evaluative task, $F(1/22) = 100.47$. Consistent with previous research, most of the "errors" in the self-referent task were attributable to people rating positive trait words as self-descriptive and negative trait words as undescriptive even though they had rated the self-descriptiveness of these adjectives differently during preliminary testing. The tendency for individuals to view themselves in a positive light is apparently quite strong, particularly when (unlike in the pretest) there is not a clear majority of positive words which subjects normally might rate as highly self-descriptive.

Self-Report Data. The main effect for Task was significant in the overall ANOVA of the self-report data, $F(3/66) = 27.83$, with the pattern of cell means mirroring that observed for response latency (see Figure 1). Contrasts confirmed that the semantic tasks were perceptibly more demanding ($\overline{X} = 2.96$) than the nonsemantic task ($\overline{X} = 1.93$), $F(1/22) = 66.61$, and that forming judgments about the self-descriptiveness of trait words was more demanding than forming evaluative judgments about the trait words, $F(1/22) = 14.90$.

Integrated Electromyographic Activity

To determine whether the experimental factors had a significant effect on the form of the IEMG activity exhibited during the task, we planned to submit the set of eight parameters extracted from the IEMG activity observed over each site to a MANOVA. As in the analyses of the cognitive measures, each set of eight somatic measures was also analyzed using the two planned multivariate contrasts described above in an effort to isolate the effects across the four tasks.

Orbicularis Oris Region. The overall MANOVA of IEMG activity over the *OOR* muscle region produced a main effect for Task, $F(24/171) = 2.86$. ANOVAs of the eight topographical parameters were performed next and revealed a main effect for Task on the measures of skew amplitude, $F(3/66) = 3.39$, and kurtosis time, $F(3/66) = 4.77$ (see Table 1). Previous research using less emotional trait words than employed here has found higher mean amplitude IEMG activity over the *OOR* region during self-referent than orthographic tasks; this effect, however, was only partially replicated in the present study. The main effect for Task on the measure of mean amplitude was not significant, but rather a Task × Word Valence interaction was obtained, $F(3/66) = 3.74$, indicating that the previously observed relationship between mean amplitude and semantic processing was evident in the case of positive trait words ($\overline{X}$ orthography = 30.01, $\overline{X}$ grammar = 32.04, $\overline{X}$ evaluation = 31.91, $\overline{X}$ self-reference = 31.42), but not in the case of negative trait words ($\overline{X}$ orthography = 32.45, $\overline{X}$ grammar = 30.74, $\overline{X}$ evaluation = 31.83, $\overline{X}$ self-reference = 31.49). The cause of the atypical results for the negative trait words is unclear, although it may be noteworthy that analyses of the cognitive data indicated that subjects encountered more difficulty in processing negative than positive trait words regardless of the task.

The MANOVA contrasting the semantic and nonsemantic tasks revealed the expected main effect for Task, $F(8/15) = 37.05$, with subsequent univariate contrasts indicating that the semantic tasks led to higher variance amplitude, $F(1/22) = 6.46$, nonsignificantly higher skew amplitude, $F(1/22) = 4.01$, $p < .07$, and higher kurtosis time, $F(1/22) = 5.46$. The Task × Word Valence interaction was again significant in the analysis of mean amplitude: the semantic processing of positive words was associated with greater perioral IEMG activity ($\overline{X} = 31.79$) than was the orthographic processing of positive words ($\overline{X} = 30.01$), whereas the orthographic processing of negative words ($\overline{X} = 32.45$) was associated with slightly higher mean amplitude than the semantic processing of negative words ($\overline{X} = 31.35$), $F(1/22) = 6.99$.

Importantly, the MANOVA contrasting the effects of the evaluative and self-referent tasks on IEMG activity over the *OOR* region yielded a significant effect for Task, $F(8/15) = 7.92$, suggesting that the previous inability of perioral IEMG activity to differentiate these particular orienting tasks was attributable at least in part to the insensitivity of mean amplitude to subtle differences in social cognition. The planned univariate contrasts indicated that these tasks were distinguished by skew amplitude, $F(1/22) = 5.32$, and kurtosis time, $F(1/$

Table 1

Integrated EMG response parameters over the Orbicularis Oris *muscle region* (OOR) *as a function of task*

	Mean EMG Responses							
Tasks	**Mean Amplitude**	**Variance Amplitude**	**Skew Amplitude**	**Kurtosis Amplitude**	**Mean Time**	**Variance Time**	**Skew Time**	**Kurtosis Time**
Orthography	31.23	15.70	0.08	0.15	52.12	902.97	0.00	−1.20
Grammar	31.39	17.65	0.15	0.24	50.64	843.55	−0.01	−1.19
Evaluation	31.87	17.78	0.09	0.17	51.05	859.51	0.00	−1.19
Self-Reference	31.46	20.20	0.17	0.25	50.63	840.50	−0.01	−1.18

22) = 4.31. These findings suggest that self-referent, relative to evaluative, processing was characterized by relatively high-amplitude bursts of perioral IEMG activity set against a background of predominantly low-level activity, and that there was a tendency for dispersion in the IEMG activity to be high early and/or late during the processing epoch.

The overall MANOVA also yielded a main effect for Word Valence, *F*(8/15) = 4.79, and the ANOVAs revealed a main effect for Word Valence on the measure of kurtosis amplitude, *F*(1/22) = 4.39. Briefly, this result is due to greater dispersion among the amplitudes distant from the mean amplitude when processing negative ($\overline{X}$ = 0.29) than positive trait words ($\overline{X}$ = 0.12), suggesting that the occasional spiking of IEMG activity over the *OOR* region was more frequent and/or longer in duration when processing negative than positive trait words. Given the relative difficulty subjects encountered in processing negative, in contrast to positive, trait words, this effect may not be a consequence of stimulus affectivity per se. No other tests were significant.

Finally, two sets of regression analyses were performed. In the first, the percent of words recalled served as the criterion measure, whereas in the second the reported task difficulty or cognitive effort served as the criterion; the predictors in each were the eight topographical parameters extracted from the IEMG activity over the perioral region. Results revealed that all but variance amplitude predicted ratings of cognitive effort, with mean amplitude serving as the best single predictor. Furthermore, none of the measures predicted recall performance, suggesting that IEMG activity is affected by short-term rather than long-term memory processes in this paradigm.[1]

Superficial Forearm Flexors Region. The overall MANOVA of IEMG activity over the *SFF* muscle region yielded a significant main effect for Task, *F*(24/171) = 3.05. In accord with previous research, the mean amplitude of IEMG activity did not vary across tasks ($p > .10$); however, the *form* of this activity was found to change as a function of task. The overall ANOVAs revealed main effects for Task on the measures of variance amplitude, *F*(3/66) = 4.74; skew amplitude, *F*(3/66) = 3.98; kurtosis amplitude, *F*(3/66) = 9.29; mean time, *F*(3/66) = 6.77; skew time, *F*(3/66) = 22.49; and kurtosis time, *F*(3/66) = 3.65 (see Table 2).

The MANOVA contrasting the effects of the semantic and nonsemantic tasks on IEMG activity over the *SFF* region also revealed a significant effect for Task, *F*(10/13) = 10.43. Univariate contrasts revealed that semantic tasks were associated with lower variance amplitude, *F*(1/22) = 7.57; higher kurtosis amplitude, *F*(1/22) = 9.54; and a larger skew time, *F*(1/22) = 18.14. This profile suggests that the orthographic (i.e., nonsemantic) task was associated with a sharper rise in IEMG activity over the preferred forearm near the completion of the task than were the semantic tasks, again as would be expected if responses to the relatively simple orthographic task involved less response equivocation.

The MANOVA contrasting the effects of evaluative versus self-referent tasks on IEMG activity over the *SFF* region did not yield a significant effect for Task, *F*(8/15) = 2.41.

Corrugator Supercilii Region. We observed subjects to maintain a relatively high level of somatic tension over the *CS* region and that EMG activity increased markedly whenever a visual stimulus was presented. The overall MANOVA of the IEMG activity recorded over the *CS* region during the tasks indicated main effects for Task, *F*(24/171) = 2.51, and Word Valence, *F*(8/15) = 3.39. The overall ANOVAs of the topographical parameters revealed main effects for Task on the measures of variance amplitude, *F*(3/66) = 10.36; kurtosis amplitude, *F*(3/66) = 5.50; and kurtosis time, *F*(3/66) = 2.95.

Table 2

Integrated EMG response parameters over the Superficial Forearm Flexors *muscle region* (SFF) *as a function of task*

Tasks	Mean EMG Responses							
	Mean Amplitude	**Variance Amplitude**	**Skew Amplitude**	**Kurtosis Amplitude**	**Mean Time**	**Variance Time**	**Skew Time**	**Kurtosis Time**
Orthography	35.19	156.18	1.01	0.52	62.45	887.08	−0.46	−0.89
Grammar	34.85	140.03	1.08	1.22	58.50	834.09	−0.32	−0.99
Evaluation	34.12	140.69	1.22	1.39	60.10	854.34	−0.38	−0.98
Self-Reference	34.31	135.43	1.13	1.23	59.10	837.11	−0.36	−0.98

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[1] Comparable regression analyses were conducted for the IEMG recordings obtained over each site. Results of these analyses corresponded closely to those described in the text for IEMG activity over the *OOR* region. Thus, IEMG activity generally appeared to be related to reported cognitive effort rather than to encoding efficacy.

Table 3

Integrated EMG response parameters over the Corrugator Supercilii *muscle region* (CS) *as a function of task*

	Mean EMG Responses							
Tasks	**Mean Amplitude**	**Variance Amplitude**	**Skew Amplitude**	**Kurtosis Amplitude**	**Mean Time**	**Variance Time**	**Skew Time**	**Kurtosis Time**
Orthography	44.46	23.65	0.00	0.04	52.02	900.27	0.00	−1.19
Grammar	45.63	29.93	0.07	0.34	50.54	844.13	0.00	−1.18
Evaluation	45.06	28.77	0.04	0.23	50.95	856.73	0.00	−1.19
Self-Reference	44.71	33.86	0.06	0.41	50.20	839.45	0.01	−1.18

The planned contrasts helped to isolate the specific locus of these effects. Recall that analyses of the cognitive data revealed that the orthographic task was simpler than the semantic tasks, and that the self-referent task was more demanding than the evaluative task. The multivariate contrast comparing the effects of semantic and nonsemantic tasks on IEMG activity over the *CS* region yielded a significant main effect for Task, $F(8/15) = 6.77$. Univariate contrasts indicated that semantic tasks led to higher variance amplitude, $F(1/22) = 16.88$, and higher kurtosis amplitude, $F(1/22) = 7.33$, than the nonsemantic task (see Table 3).

In addition, the MANOVA contrasting the effects of the self-referent and evaluative tasks on the form of IEMG over the *CS* region yielded a significant effect for Task, $F(8/15) = 9.70$. Univariate contrasts revealed that the more cognitively demanding self-referent task led to higher variance amplitude, $F(1/22) = 9.38$; kurtosis amplitude, $F(1/22) = 4.45$; and kurtosis time, $F(1/22) = 6.13$, than did the evaluative task.

As noted above, the overall MANOVA also uncovered a main effect for Word Valence. The ANOVAs of the topographical parameters across the four tasks revealed that the processing of negative words was associated with higher mean amplitude IEMG activity over the *CS* region ($\overline{X} = 45.29$) than was the processing of positive words ($\overline{X} = 44.64$), $F(1/22) = 6.78$. The association of higher mean amplitude IEMG activity with negative, in contrast to positive, information processing is consistent with past research (cf. Fridlund & Izard, 1983), but it is somewhat surprising that the mean level of IEMG activity over the *CS* region was higher for negative than positive words even when subjects were judging the orthographic features of the stimuli ($\overline{X}$ negative $= 45.01$, $\overline{X}$ positive $= 43.90$). Recall, however, that the analysis of the cognitive data revealed that the processing of negative words was more cognitively demanding across tasks than was the processing of positive words. Therefore, it is possible that the elevation in IEMG activity over the *CS* region may be attributable to a cognitive disturbance (i.e., the more difficult time subjects apparently had when processing negative trait words) rather than to the unpleasant affect associated with processing the negative trait words and/or performing a difficult task. Still, one might view these data as evidence that IEMG activity over the *CS* region reflected the consequence of rudimentary emotional processing (such as might accompany automatic attentional processing), with words with unpleasant in contrast to pleasant connotations provoking greater IEMG activity over the *CS* region. Analyses of IEMG activity over the *ZM* region are pertinent here, and we turn to these next.

Zygomatic Major Region. Variations in the level of activity over the *ZM* as well as the *CS* region have been linked to emotional states (e.g., Ekman, Friesen, & Ancoli, 1980; Schwartz et al., 1976a), although activity over the *CS* region may be a more sensitive measure (cf. Fridlund & Izard, 1983). Nevertheless, if negative trait words are found to be associated with lower levels of IEMG activity over the *ZM* than positive trait words, then converging evidence is obtained for the notion that the effect of Word Valence on IEMG activity over the *CS* region reflects affective processes. A failure to find an effect for Word Valence on IEMG activity over the *ZM* region, in conjunction with the absence of a Word Valence effect on IEMG activity over the *OOC* and *MF* regions (see above), would leave both interpretations equally plausible. The overall MANOVA produced a significant main effect for Task, $F(24/171) = 4.82$, but the main effect for Word Valence did not approach significance, $F(8/15) = 1.42$, $p < .25$. The variations in IEMG activity observed over the *CS* region, therefore, may well have reflected people's level of concentration while performing the cognitive tasks (e.g., lowering the inner brow during concentration) rather than affective processes per se.

The overall univariate analyses of IEMG activity over the *ZM* region also revealed that the type of cognitive task performed affected variance amplitude, $F(3/66) = 3.47$; skew amplitude, $F(3/66) = 3.28$; kurtosis amplitude, $F(3/66) = 5.43$; and

Table 4

Integrated EMG response parameters over the Zygomatic Major *muscle region* (ZM) *as a function of task*

Tasks	Mean EMG Responses							
	Mean Amplitude	Variance Amplitude	Skew Amplitude	Kurtosis Amplitude	Mean Time	Variance Time	Skew Time	Kurtosis Time
Orthography	14.85	9.75	0.24	0.79	51.58	903.16	0.02	−1.19
Grammar	15.16	13.21	0.34	1.25	50.53	852.01	0.00	−1.19
Evaluation	15.56	12.62	0.34	1.12	50.67	868.18	0.01	−1.20
Self-Reference	15.38	15.83	0.42	1.10	50.73	847.61	−0.01	−1.18

skew time, $F(3/66) = 5.57$ (see Table 4). Little overall tension was observed in this region. Nevertheless, as was the case for IEMG activity over the *MF* and *OOC* regions, the orthographic task appeared to be characterized by less variability in the set of amplitudes observed during the task than the remaining tasks (e.g., see the measures of variance and kurtosis amplitude).

The multivariate contrast comparing the semantic and nonsemantic tasks supported this observation, yielding a significant main effect for Task, $F(8/15) = 13.71$. Corresponding univariate contrasts revealed that the semantic tasks led to significantly higher variance amplitude, $F(1/22) = 5.32$; a more positive skew amplitude, $F(1/22) = 5.20$; larger kurtosis amplitude, $F(1/22) = 18.16$; and a smaller skew time, $F(1/22) = 9.00$. This profile suggests that orthographic, in contrast to semantic, processing was characterized by shorter and/or fewer bursts of IEMG activity and by a relative decline in IEMG activity over the *ZM* region during the task.

Finally, the MANOVA contrasting the effects of the tasks of self-reference and evaluation failed to yield any significant effects.[2]

Cardiac Activity

Two dependent measures of cardiac activity were subjected to analyses: heart rate and T-wave amplitude.[3] The effects of the experimental variables on the overall level of cardiac activity were assessed using the same multivariate and univariate contrasts as employed above.

The overall MANOVA of cardiac activity yielded a main effect for Task, $F(6/100) = 9.76$, with univariate analyses revealing that HR, $F(3/51) = 16.15$, and TWA, $F(3/51) = 5.32$, each varied as a function of Task. Cell means are summarized in Figure 2. Analyses also revealed a main effect for Word Valence on the measure of TWA, $F(1/17) = 4.54$, showing that TWA was smaller while processing the negative ($\bar{X} = 0.49$) than positive trait words ($\bar{X} = 0.55$). Although this result is consistent with the view that processing the negative words was more demanding (cf. Scher et al., 1984), the absence of a significant multivariate F-test for Word Valence renders this finding tentative.

The MANOVA contrasting the effects of the semantic and nonsemantic tasks on cardiac activity revealed a significant effect for Task, $F(2/16) = 22.16$, and a Task × Word Valence interaction, $F(2/16) = 6.69$. Univariate contrasts revealed that semantic tasks were associated with lower HR, $F(1/17) = 25.23$ ($\bar{X}$ semantic $= 69.88$, $\bar{X}$ nonsemantic $= 73.23$), and smaller TWAs, $F(1/17) = 13.77$ ($\bar{X}$ semantic $= .48$, $\bar{X}$ nonsemantic $= .65$). A significant Task × Word Valence interaction was also obtained on the measure of HR, $F(1/17) = 6.01$, showing that the lowered HR during semantic processing was slightly more evident during the processing of negative ($\bar{X}$ semantic $= 69.77$, $\bar{X}$ nonsemantic $= 73.62$) than positive trait words ($\bar{X}$ semantic $= 70.30$, $\bar{X}$ nonsemantic $= 73.05$).

The MANOVA contrasting the effects of evaluative and self-referent tasks revealed only a main effect for Task, $F(2/16) = 3.67$. ANOVAs revealed that TWA was smaller during self-referent process-

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[2] A Replication × Task × Word Valence × Recording Site ANOVA was conducted on the measure of mean time, the purpose of which was to examine temporal differences across muscle regions in the midpoints of the task-evoked somatic responses. The analysis revealed a main effect for Recording Site, indicating that the point in the processing epoch at which the total amount of MAP activity preceding and following it were equal varied as a function of location. Inspection of Figure 2 indicates that this effect is due primarily to the center of gravity of the IEMG response occurring later than over facial muscle regions. A Task × Recording Site interaction was also obtained, which was primarily attributable to variations across tasks in mean time over the *SFF* region. Specifically, the mean time of responses recorded over facial muscle regions all equalled approximately 0.51, whereas mean time over the *SFF* region occurred later during the simple orthographic than remaining tasks. These results are consistent with the view that IEMG activity over the *SFF* region uniquely indexed response execution, with the least equivocation in executing the response occurring in the case of the simple orthographic task.

[3] Due to hardware modifications made during the semester in which the experiment was conducted, data from only 18 subjects were available for analyses.

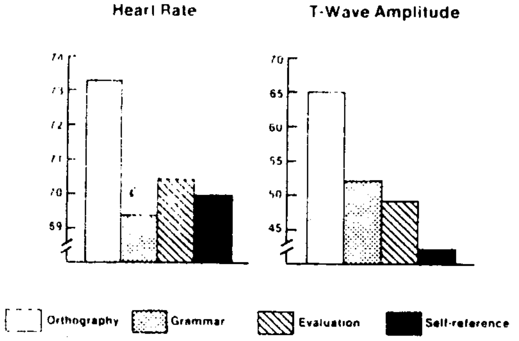

Figure 2. Mean heart rate and T-wave amplitude as a function of Task.

ing ($\overline{X}$ = .42) than during evaluative processing ($\overline{X}$ = .49), $F(1/17)$ = 8.20.

As noted above, changes in general somatic tension as well as changes in attention have been found to affect phasic HR. However, the differences in HR observed in the present study are more likely to reflect attentional processes than somatic or metabolic demands, since HR was highest for the task that was associated with the least somatic activity (see Tables 1-4 and Figure 2). More telling, the correlation between HR and each measure of somatic activity was small, ranging from −.16 to +.19. The phasic HR responses, therefore, seem not to reflect apparent somatic-cardiac coupling, but rather they point to the existence of greater attentional demands for the simple semantic than nonsemantic tasks (cf. Lacey & Lacey, 1970). Consistent with this notion, the somatic responses over the *OOC* and *MF* regions suggested that individuals were scrutinizing the visual stimulus more during semantic than nonsemantic processing.

Furedy and his colleagues (e.g., Heslegrave & Furedy, 1979; Scher et al., 1984) have argued that the TWA is sensitive to momentary changes in sympathetic activation, with reductions in the amplitude of the TWA reflecting increased sympathetic activity. Moreover, they have argued that the TWA is sensitive to differences in the stress accompanying cognitive processing. Several effects obtained in previous research would seem to support this view. Specifically, TWA was smaller and reported task demands were greater during: a) semantic than nonsemantic processing, b) self-referent than evaluative processing, and c) the processing of negative than positive trait words. Inspection of Figure 2, however, reveals an exception to this account: TWA was larger during the grammatical than self-referent task even though the former was clearly rated as being the most difficult. Although it is conjecture at this point, it may be that task-evoked variations in TWA mark the level of CNS integration evoked by orienting tasks in this paradigm. According to this view, the grammatical task may well have required repeated effortful examinations of the trait word, but the self-referent task invoked a more selective and complexly organized set of cognitive processes, requiring higher levels of selective cortical functioning or "wakefulness" and resulting in an attenuation of TWA. The procedures outlined by Luria and Vinogradova (1959) provide a means of testing this interpretation.

General Discussion

The results extend previous research in several respects. Consistent with past research, recall was inferior, response latencies were shorter, and reported cognitive demands were lower when orthographic rather than semantic processing was engaged (Craik, 1979) and when evaluative rather than self-referent processing was engaged (Cacioppo & Petty, 1981b). In addition, recall tended to be better even though response latency was shorter when positive rather than negative words were processed (see Ferguson et al., 1983). A dissociation between response latency and recall was also apparent when the effects of the tasks of grammar and self-reference were inspected (see Figure 1). Forming judgments about the grammatical classification of trait words took longer and was rated as more cognitively demanding than forming judgments about the self-descriptiveness of the words, yet encoding efficacy was clearly better and TWA was smaller in the latter task. These results suggest that the relatively high level of recall obtained when subjects thought about the self-descriptiveness of trait words is attributable to the accessible and well articulated nature of relevant memory structures rather than to the time or effort subjects expended in thinking about the incoming stimuli. Results of the analyses of facial EMG activity provide further evidence for this characterization, showing both that the tasks were differentiated by low-level somatic responses and that the nature of the EMG activity predicted reported cognitive effort better than recall.

In addition, the mnemonic effectiveness of the evaluative in contrast to the orthographic or grammatical task observed in the present study (as assessed by Newman-Keuls tests, p's$<$.05) is in agreement with Ferguson et al.'s (1983) argument that evaluative processing is "an important dimension underlying the influence of well-organized schemata on the encoding and retrieval of personally relevant information" (p. 260), if not incoming information generally (Zajonc, 1980). The present data further argue, however, that formulating evaluative and self-referent judgments is distinctive, with judgments about the self-descriptiveness of trait words engaging a more complexly organized and integrated domain of knowledge. Cacioppo and Petty (1981b), for instance, found that deciding whether trait adjectives were good or bad took less time and resulted in lower recognition confidence than did deciding whether or not trait adjectives were self-descriptive. These observations were essentially replicated in the present experiment: forming judgments of the positive or negative meaning of trait words took less time, produced poorer recall, and were rated as being less cognitively demanding than did forming judgments about the self-descriptiveness of the words. The present study extended previous research, however, in showing explicable somatovisceral differentiation of these simple cognitive tasks. We found, for instance, that TWA, which has been empirically linked to the complexity of information processing, was smaller during self-referent than evaluative tasks; and that the form of IEMG activity over the perioral region, which has been found to vary as a function of silent language processing in general and controlled language processing in particular, discriminated evaluative from self-referent processing. These differences are not large, but they are reliable. Together, these data clearly indicate that although the evaluative dimension may be central in the organization of memory, it is not sufficient to account for the manner in which people relate trait information to existing knowledge domains when performing self-referent tasks. Instead, these data suggest that the categorization of trait words along a single evaluative (good/bad) dimension is simpler and more global than the categorization of words in terms of their self-descriptiveness.

The present results also clarify what cognitive operations are influencing the low-level somatic responding that has been observed previously during silent problem solving. One of the criterial attributes of skilled behaviors is skeletomotor coordination and fluency (MacKay, 1982). Edfeldt (1960), for example, observed that "good" readers exhibited lower levels of somatic activity over the perioral region than "poor" readers, that reading a simple or familiar text resulted in lower levels of perioral EMG activity than reading a difficult text, and that reading a clearly printed text produced lower levels of perioral EMG activity than reading a blurred text. Results of other studies, however, including the contrasts in the present experiment between the semantic and orthographic tasks, have hinted that perioral EMG activity is associated with better recall (e.g., see review by Garrity, 1977).

The inclusion in the present study of the relatively effortful but mnemonically ineffective grammatical task, a verbal assessment of cognitive effort, and additional somatic recording sites proved fortuitous in this regard. As relating incoming stimuli to existing domains of knowledge becomes more practiced or automated, one would expect that the form and amplitude of somatic activity would change to minimize interference and maximize the coordination and fluency of the processing sequence; in addition, the cognitive effort involved in performing the task should decrease and encoding efficacy should increase. Although the variability across tasks was high, correlational analyses supported this reasoning; results suggested that although somatic activity was not tied solely to psychological events, changes in somatic responding nevertheless tended to vary more closely with the subjects' deliberate manipulations of the incoming information than with storage processes per se. Also interesting were the findings that the task effects were observable across the facial musculature, and that the somatic midpoint emerged significantly later over the forearm used to respond to the visually presented trait words—suggestively matching the traces one might expect from input, processing, and output task-stages. These data portray a greater degree of temporal organization and coordination of stimulus processing that has typically been recognized in studies of electromyographic activity.

Together, these data suggest that the ongoing changes in somatic activity provide better markers of the moment-by-moment effortful (or controlled) cognitive operations engaged while performing tasks than of the long-term memorial consequences of tasks (although the TWA data are interesting in regard to being a marker of encoding efficacy). The use of somatovisceral responses to track the nature, intensity, and timing of psychological events (e.g., deliberations regarding trait words) is, of course, particularly interesting in light of recent research questioning the veracity, comprehensiveness, and representativeness of verbal data bearing on these processes (Ericcson & Simon, 1980; Nisbett & Wilson, 1977). Although more research should be conducted before a set of somatovisceral markers is advanced for tracking cognitive (and affective) operations across time, the ability demonstrated in the present study to differentiate orthographic, grammatical, evaluative, and self-referent processes is encouraging.

These data also suggest that *evaluations* can be formulated independent of affective displays, if not affect generally. For instance, subjects in the present study showed no signs of affect when they evaluated the hedonic meaning of trait words. This result is conceptually similar to that reported by Englis et al. (1982). Subjects in Englis et al. played a stockmarket game with another person. Subjects tried to guess which market indices would rise or decline and were rewarded with money for correct guesses but were punished with mild finger-shock for incorrect guesses. During the game, subjects viewed another "subject" on a videomonitor. (All subjects actually were exposed to a videotape of a confederate.) Some subjects found when the confederate smiled their own guess was correct and they were rewarded, and when the confederate expressed pain their own guess was incorrect and they were punished. Other subjects observed the opposite: When the confederate smiled their own guess was incorrect and they were punished, but when the confederate expressed pain their own guess was correct and they received a reward. After completing the game, subjects simply watched a videotape of the confederate. Surface EMG over the *corrugator supercilii, masseter,* and *orbicularis oculi* muscle regions was monitored continuously during the game and postgame periods. Englis et al. reported that when the confederate and subject shared outcomes, mean amplitude of the EMG activity over the monitored regions was higher in both phases of the experiment when the confederate exhibited a pained than when the confederate exhibited a happy facial expression. On the other hand, this profile of EMG activity was reversed when the outcomes of the confederate and subject were asymmetrical. Thus, although subjects evaluated the hedonic nature of the confederate's facial expression, the subjects' own facial expression varied not as a function of this evaluation but rather as a function of the personal hedonic consequences signalled by the confederate's facial expression. It would seem, then, that evaluations can be formulated in a cold and calculated manner with mixed, congruent, incongruent, or no affective arousal. Thus, there is growing psychophysiological evidence to suggest that evaluation and affect are not synonymous.

In sum, the results supported the major experimental hypotheses: 1) the form rather than the mean amplitude of perioral IEMG activity differentiated evaluative and self-referent processing; 2) perioral IEMG activity covaried more closely with indices of cognitive deliberation than long-term memory processes; 3) the form of IEMG activity over the preferred forearm was similar for evaluative and self-referent processing, arguing against a general arousal account, and indeed preferred forearm IEMG activity showed a specific task-evoked response of its own, rising more sharply and later in the processing epoch when performing simple nonsemantic than semantic tasks; and 4) TWA varied as a function of the type of cognitive task performed. Little evidence was found, on the other hand, to support the hypothesis that accessing or evaluating the meaning of positive or negative trait words is sufficient to evoke emotional facial displays or for the notion that the differential phasic HR responses to orienting tasks are attributable to cardiac-somatic coupling.

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