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Conscious and nonconscious processes: An ERP index of an anticipatory response in a conditioning paradigm using visually masked stimuli

PHILIP S. WONG,[a] HOWARD SHEVRIN,[a] AND WILLIAM J. WILLIAMS[b]

[a] Department of Psychiatry, University of Michigan, Ann Arbor
[b] Department of Electrical Engineering & Computer Science, University of Michigan, Ann Arbor

Abstract

This study investigates the nonconscious elicitation of a previously conditioned response by using a differential conditioning paradigm with visually masked affectively valent facial schematics. Electrodermal (skin conductance response [SCR]) and brain (event-related potential [ERP]) activity were main dependent measures. Following a preconditioning phase in which subjects viewed energy masked pleasant and unpleasant facial schematics, conditioning with an aversive shock was established to unmasked presentations of an unpleasant face in a partial factorial design. A postconditioning phase of masked presentations, when compared with the preconditioning phase, revealed how the conditional effect within awareness might affect the same stimuli when presented outside awareness. An adaptive staircase technique was used to establish individual threshold levels, which represented a methodological advance over procedures typically used in visual masking research. The results revealed that responses to the CS+ (unpleasant face) changed significantly in predicted directions from preconditioning to postconditioning phase when compared with responses to the CS− (pleasant face). The SCR results systematically replicated recent Ohman, Dimberg, and Esteves (1988) findings, with the pattern of responses resembling a resistance to extinction effect. A new finding emerged for the brain responses. For the CS+, distinct slow wave activity occurred just before the point at which the shock had been delivered in the conditioning phase; no such activity was found for the CS−. This slow wave activity is similar to what has been described by others as an expectancy wave. The results indicate that an anticipatory process, as indexed by different physiological systems, can be elicited entirely outside awareness. Implications are discussed in regard to the nature of conscious and nonconscious processes.

Descriptors: Conscious and nonconscious processes, Conditioning, Visual masking, Facial schematics, ERP, SCR, Anticipatory response

In the past 40 years, a handful of studies have demonstrated that a previously learned autonomic conditional response can be elicited by stimuli presented outside awareness. The Lazarus and McCleary (1951) subception study, stimulated by McGinnies' (1949) study on perceptual defense, demonstrated electrodermal responsivity to visually masked presentations of previously conditioned stimuli. Using a dichotic listening paradigm, Corteen and colleagues (Corteen & Dunn, 1974; Corteen & Wood, 1972) demonstrated that words conditioned previously to shock elicited greater electrodermal responsivity when presented in the nonattended ear during a shadowing task. Using visual stimuli, Ohman and colleagues (Ohman, 1988; Ohman, Dimberg, & Esteves, 1988) demonstrated the preattentive elicitation of conditional responses. Ohman et al. first conditioned angry and happy faces to aversive shocks in a standard acquisition series. The conditional stimuli then were presented in a pattern masked paradigm, which rendered them perceptually inaccessible. The masked stimuli elicited a conditional response, as indexed by electrodermal activity (skin conductance response [SCR]). The effect was strongest for angry faces, a finding consistent with other evidence suggesting that angry faces are especially salient from a biological or evolutionary perspective (Dimberg, 1986).

The exact nature of the effect, however, is controversial. In a follow-up to the Corteen et al. studies, Dawson and Schell (1982) demonstrated that electrodermal responses to the conditional stimuli were connected with shadowing errors, suggesting that undetected shifts of attention to target stimuli in the nonattended ear were associated with electrodermal responsivity. Dawson and Schell also discovered, however, that subjects who had the target words presented to the nonattended ear exhibited the effect even when shifts in attention were taken into account. This unexpected finding suggested that other sources

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Address reprint requests to: Philip S. Wong, Department of Psychology, New School for Social Research, 65 Fifth Avenue, New York, NY 10003.

of variance, such as laterality of presentation, can influence the degree to which an SCR is elicited by previously conditioned stimuli when these stimuli are presented outside awareness.

Although the existence of the phenomenon has been controversial because of difficulties in determining whether something is truly inaccessible to awareness, the results appear to support the conclusion that some kind of effect exists. As Dawson and Schell (1985) noted however, additional research on the parameters of this effect is needed before more conclusive statements can be made regarding its existence and generality. If the effect can be established, it may be important for issues such as the relation of conscious and nonconscious processes to learning and attention (Ohman et al., 1988).[1]

The methodological problems in these studies raise serious questions about the true inaccessibility of the stimuli; for example, do undetected rapid attentional shifts in the listening paradigm account for the effect (e.g., Holender, 1986)? The attentional shift argument may never be addressed successfully, because this would require an inclusive index of attention tracking both overt and covert shifts. The question of visual perceptual inaccessibility is almost as difficult; however, recent advances in techniques are promising.

The present study investigated the nonconscious elicitation of a previously conditioned response by using a visual masking technique to render stimuli perceptually inaccessible in a conditioning paradigm similar to that used in the Ohman et al. studies (Ohman, 1988; Ohman et al., 1988). The main goals of the study were (a) to replicate systematically the Ohman et al. (1988) central finding of a nonconscious elicitation of a previously conditioned response, based on electrodermal activity, and (b) to incorporate a measure of brain activity with the goal of expanding our understanding of the effect by examining an additional physiological system.

At the heart of the experiment was a differential conditioning technique involving pleasant and unpleasant facial schematics, with electrodermal (SCR) and brain (event-related potential [ERP]) activity serving as the main dependent measures. First, a preconditioning baseline phase was administered in which subjects viewed energy masked (subliminal) facial schematics. Second, conditioning was established within awareness (supraliminally, on unmasked presentations) using a paired-stimulus paradigm, in which an unpleasant face was linked to an aversive shock and a pleasant face was not, in a partial factorial design. Third, a postconditioning phase of masked presentations was administered. The effect of conditioning then was assessed by comparing the postconditioning phase to the baseline preconditioning phase to gauge how the conditional effect established within awareness might be evident when the stimuli were presented outside awareness.

Methodological improvements were made by using an adaptive staircase technique to establish an individual threshold duration for subjects (for presentation during the preconditioning and postconditioning phases). These improvements allowed for greater precision in the visual masking technique than often found in other studies.

Many studies suggest that the affective valence of the stimulus is an important dimension in monitoring above- and below-threshold effects. Faces with negative or unpleasant expressions, for example, are particularly powerful (Dimberg, 1986; Ohman & Dimberg, 1978).[2] For these reasons, the threshold task emphasized the affective valence of the stimuli. The conditioning experiment also was affected by this previous research; pairing an unpleasant face with an aversive shock was thought more likely to give rise to an effect than pairing a pleasant face with a shock. Although the partial factorial design limits the generalization of the conditioning effect to unpleasant stimuli, it maximizes the likelihood of demonstrating an effect. This goal was particularly important because of uncertainty associated with whether the SCR findings would be replicated or if any ERP differences would exist.

Method

Subjects

Subjects were recruited through advertisements in a university community for a psychology study on perception. Remuneration was $15 for approximately 3.5–4.0 hr. Subjects were screened for general health and for handedness. Those with a history of neurological disorder or who were currently experiencing significant problems with their physical or emotional health were excluded. Subjects were scheduled for a laboratory appointment and were asked to come to the appointment well rested and to refrain from drinking alcoholic beverages the evening prior to the experiment.

In total, 31 subjects participated – 8 in a preliminary study (not reported here) and 23 in the main study. All subjects were right-handed men, with vision correctable to 20/20. The mean age of subjects was 20.8 ($SD = 1.4$) years.

Of the 23 subjects in this study, 6 were eliminated: 2 because of artifactual data (excess muscle tension and movement) and 4 because of resistance to conditioning. This rate of resistance to conditioning is consistent with the rate reported in other studies (e.g., Dawson & Biferno, 1973). Analyses are reported for the remaining sample of 17.

Procedure

An overview of the experimental procedure is presented in Table 1.

The data collection sequence in the conditioning experiment (precon, con, and postcon phases) was as follows. A tone (T1) signalled the beginning of a trial, and the subject responded by saying *ready* (T2) when he was looking at the fixation point. Four to 6 s after T2, the data collection cycle began. Prestimulus recording was for 400 ms and the S1–S2 interval was 2,500 ms. The recording epoch extended for another 100 ms after S2. S1 denotes presentation of a masked or unmasked facial schematic, depending on the experimental phase. S2 denotes the shock/no-shock event. The total data collection cycle was 3.0 s in duration, with the intertrial interval varying between 10 and 15 s. Individual presentations were automated and required no interaction with the experimenter.

During a trial in any condition, subjects were instructed to remain as still as possible, look at the fixation point, and keep

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[1] *Conscious* and *nonconscious* are used descriptively to refer to global, systematic properties of the mind. *Awareness* refers to a more specific property of the conscious system and may be subdivided further to include a distinction between perceptual awareness and knowledge-based awareness.

[2] The facial schematics used in this study represent generically pleasant and unpleasant emotional expressions. Studies reported by Ohman and others have been more specific regarding the emotional expression studied, for example, faces are angry or happy.

Table 1. *Overview of the Experiment*

I. Introduction: orientation to the laboratory, informed consent, mental status and vision screening.
II. Self-report measures: Spielberger, Gorsuch, Lusheve, Vagg, and Jacobs (1983) State-Trait Anxiety Inventory and Osgood semantic differential rating scale (Osgood, May, & Miron, 1975) for a group of facial schematics, including the stimuli used in the experiment.
III. Physiological recording preparation: scalp, electrodermal, and aversive shock electrodes attached; subject placed in a soundproof, electrically shielded, temperature controlled recording booth; status of recordings established.
IV. Aversive shock stimulus level established.
V. Individual visual threshold level established and tested with a forced-choice identification task using one set of facial schematics (one pleasant and one unpleasant face).
VI. Instructions for individual trial presentations administered.
VII. Two presentations each of the pleasant and unpleasant faces in masked and unmasked conditions to acquaint the subject with the procedure.
VIII. Masked preconditioning (precon) phase: 24 random presentations each of the pleasant and unpleasant face.
IX. Unmasked conditioning (con) phase: one preparatory presentation each of the stimuli, followed by 24 random presentations each of the pleasant and unpleasant face. Unpleasant face was paired with shock on 20 of 24 trials (probability of shock was 0.83). Conditioning effect established by differential SCR responsivity on four catch trials not paired with shock.
X. Masked postconditioning (postcon) phase: 24 randomized presentations each of the pleasant-unpleasant face.
XI. Individual visual threshold level retested using forced-choice identification task.
XII. Subject unhooked, completes additional self-report measures, debriefed, paid, and dismissed.

Total laboratory time was approximately 3.5–4 hr, including approximately 30 min per phase (precon, con, postcon).

eye blinks to a minimum. Subjects were told that at some point soon after saying *ready* there would be a quick flash of something on the screen, which might or might not be followed by a shock several seconds later. Subjects were reminded periodically to keep looking at the fixation point and to try to minimize eye blinks during trials.

Visual Stimuli, Apparatus, and Masking Technique

The pleasant and unpleasant facial schematics were developed in consultation with a medical illustration specialist to control for purely perceptual stimulus characteristics such as lines and angles. Two equivalent sets of stimuli were used in the experiment; each set consisted of one pleasant and one unpleasant schematic. One set was used in the visual threshold procedure and the other in the actual conditioning experiment, with sets counterbalanced among subjects. Prior to the experiment, the two sets of stimuli were mixed among other similar facial schematics not used in the study and were rated on affective valence using an Osgood measure adapted for visual stimuli (Osgood et al., 1975). A Category (2) × Set (2) analysis of variance was not significant, which indicated both scales were equivalent.[3]

The stimuli were presented on 3- × 5-in. white cards in two fields of a three-field Gerbrands Model T3-8 tachistoscope. The CS+ and CS− fields were counterbalanced between subjects; the third field was used as a fixation field. Field brightness was tested for luminance level and pulse width and equated for each field. Luminance levels for the fields were 5 footlamberts; ambient room light conditions were approximately the same. The stimuli were circles subtending 1.9° visual angle in diameter. Stimulus duration for the masked (subliminal) presentations was set individually according to the results of the visual threshold procedure. Stimulus duration for the unmasked (supraliminal) presentations was 50 ms. Presentations of individual CS+ and CS− trials were randomized, with each experimental phase—preconditioning, conditioning, and postconditioning—consisting of 48 random presentations (24 each of CS+ and CS−).

The stimuli in this study were presented under different conditions from those in the Ohman et al. (1988) study. Ohman et al., like many other investigators, used a pattern masking technique; in this study, an energy masking technique was used. Energy masking has been employed successfully by several investigators (e.g., Marcel, 1983a, 1983b; Shevrin, 1973, 1988). These two techniques for rendering stimuli perceptually inaccessible are quite different in many respects and may produce different effects. The techniques, however, are functionally similar in that the person cannot "see" the masked stimulus.

Visual Threshold Technique

The literature on establishing that a stimulus is perceptually inaccessible is marked by controversy. Because this manipulation is central to operationalizing perceptual awareness, the technique used in this study is explained in detail below and represents a departure from that of most studies using masked stimuli. The discussion will encompass three issues: (a) threshold task: what exactly is asked of the subject? (b) threshold level: what region of the psychometric response function is targeted as threshold for the parameters used (in this case, duration)? and (c) threshold test: with what degree of certainty is a subject's performance in the targeted threshold region on the response function?

The threshold task was a forced-choice two-alternative identification task based explicitly on the affective dimension of the stimulus (pleasant vs. unpleasant). The work of Zajonc (e.g., Murphy & Zajonc, 1993; Zajonc, 1980), Ohman (e.g., Ohman, 1986, 1988; Ohman et al., 1988), and others provides evidence suggesting that the processing of masked stimuli is strongly influenced by the affective valence (or perhaps more generally, the significance) of the stimuli; affective valence surpasses neutral stimulus dimensions in influence. A positive result would consist of showing that subjects cannot discriminate the unpleasant from the pleasant face more often than would be expected by chance during a threshold test but exhibit greater than chance discrimination for the SCR and ERP measures. This pattern of response (which is essentially a dissociation effect) would provide converging evidence of the nature of nonconscious processing of emotionally significant stimuli.

Prior to establishing an individual threshold level, subjects were shown the two schematics in the tachistoscope. For each stimulus presentation, the subject was asked to decide whether the facial expression was pleasant or unpleasant. Subjects were told each facial expression would be presented an equal number of times in random order, that their responses should be distributed equally, and to guess if uncertain about a response.

A host of methodological problems have been identified with regard to setting a threshold level in visual masking research.

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[3] All statistical tests reported regard a significance level of $p < .05$ (two-tailed) as consistent with rejection of the null hypothesis. For repeated measures analyses, the Huynh-Feldt correction procedure is applied (Huynh & Mandevill, 1979).

For example, because individual thresholds vary, use of a single threshold for all subjects could result in considerable error variance being added to an experiment. Most experimenters, however, use one threshold level for all subjects (primarily because of experimental expediency). Ohman et al. (1988), for example, used a pattern masking technique and settled on a 30-ms stimulus onset asynchrony (SOA) for all subjects. The prime stimulus (illuminated for 30 ms) was an affectively valent face and the mask (target) stimulus was a neutral face. Ohman et al. reported that 2 of 30 subjects in one threshold test guessed the correct emotional expression of the prime on two test trials. However, in a forced-choice identification task, subjects performed nonsignificantly above chance levels (indicating that they were at what Cheesman & Merikle, 1984, have termed the *subjective* threshold).

Of central technical importance is the extent to which one demonstrates where the stimulus display characteristics used in the experiment fall on an individual's psychometric response function for the specific task. Merikle (1982) pointed to some of the problems concerning response bias in the assessment of threshold for several studies that can result in incorrect elevation of the threshold level. Careful attention to the properties of the masking technique is also needed. Differences in light and dark adaptation, for example, can give rise to greater or lesser perceptual sensitivity (Purcell, Stewart, & Stanovich, 1983), which could result in misleading conclusions.

In an effort to deal with these problems, we used a two-stage visual threshold procedure that addressed both individual threshold level and threshold test issues as rigorously as possible: (a) an individual threshold level was determined using an adaptive staircase method and (b) subjects were tested at this level at the beginning of the experiment and retested at the end of the experiment.

Establishing Individual Thresholds

An adaptive staircase technique was used to determine an individual threshold level, defined as the stimulus duration at which the probability of a correct response was chance in a forced-choice two-alternative identification task. Although this technique has its roots in the early psychophysical conception of threshold, it incorporates the notion of response probability, a point of contact between signal detection and threshold theories (Cornsweet, 1962; Levitt, 1971; Levitt & Rabiner, 1967; Wetherill & Levitt, 1965). Although it has been used infrequently recently (however, see Groeger, 1988), the method is an efficient way of estimating points on a psychometric function. The algorithm used to locate threshold was developed by Levitt and Rabiner (1967) and is considered to be especially good in placing observations at the 0.5 level in a two-alternative task.[4]

Testing Threshold Levels

The test and retest for threshold level consisted of 40 trials each using the same identification task instructions as in the threshold determination procedure. These tests monitored the accuracy of the threshold level before and after the experiment.

The mean threshold duration for chance identification was 2.35 ms ($SD = 0.61$ ms; range, 2–4 ms). The mean correct for the 40-trial pretest was 20.59 ($SD = 2.79$; range, 16–25) and for the posttest was 21.24 ($SD = 3.44$; range, 15–27). A discordancy test for single outliers (Barnett & Lewis, 1984; Snodgrass, Shevrin, & Kopka, 1993) was applied to the extreme low and high values in the sample to determine whether or not a subject was performing within an expectable chance distribution. Each outlier value was assessed for discordancy relative to its immediate sample (i.e., a value in the pretest condition was evaluated relative to the pretest sample); in addition, each value was assessed relative to the combined pre- and posttest samples. None of the extreme values qualified for outlier status ($p > .05$), indicating that all subjects performed at expectable chance levels (neither too high nor too low) on the pre- and posttest trials and in the combined trials. The pre- and posttest trials also were subjected to an analysis of variance, which was not significant ($p = .59$).

Subjects were carefully questioned about their subjective visual experiences during pre- and posttests and during the two phases of masked presentations (precon and postcon phase). None of the subjects reported seeing an internal feature of the circle with any certainty.

Physiological Measures

SCR

Skin conductance was recorded from electrodes attached to the medial phalanges of the index and middle fingers of the nonpreferred hand (left). Silver–silver chloride electrodes spanning an area of 1.0 cm^2 were attached with a 0.05 molar NaCl electrolyte medium (Fowles et al., 1981) after alcohol cleansing of the phalanges. A constant voltage system was used, with 0.5 V applied across the electrodes and the output recorded on a Grass DC amplifier.

All SCR measures were based on responses to the same 24 presentations used in the ERP averages unless otherwise stated.[5] An individual SCR was considered to be any change in conductance level (delta C) greater than 0.1 μmho between the prestimulus level and 1–4 s after S1 (first-interval response). The delta C values are quite liable to skewed distributions (Venables & Christie, 1980); therefore, square-root transformations of delta C were used for all measures. Four SCR measures were used: probability (number of responses per 24 presentations), amplitude (per number of responses), magnitude (per 24 presentations), and latency to onset (Venables & Christie, 1980).

Conditioning was established according to a subject's SCR scores for the four catch or test trials in the conditioning phase (e.g., Ohman et al., 1988). On these trials, which occurred randomly throughout the conditioning phase, the presentation of the unpleasant face was not followed by a shock. SCR score for each test presentation was compared with that for the pleasant face presentation, which occurred immediately before or after

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[4] The technique involved recording responses to stimulus presentations using the identification task at any one *step* (duration), over a series of increasing or decreasing steps (of 1 ms). An increase or decrease in step direction was determined using a best-of-three approach at each step, that is, two of three correct responses at a step led to a decrease in step, and two of three incorrect responses led to an increase. The criterion for establishing the desired response level was eight reversals in step direction over the series, with the "mid-run" estimation technique used on every other reversal to determine the level (Levitt, 1971). The final threshold level was set at the lower integer bound; for example, if threshold was determined to be at 3.7 ms, the threshold duration used in the experiment was 3 ms.

[5] SCR analyses of 12 presentations per stimulus category (by block) also were undertaken; an equivalent analysis is not possible for ERP responses because of signal–noise ratio limitations inherent in averaging.

it. If the SCR metrics (e.g., magnitude [delta C]) were significantly larger for the unpleasant face than for the pleasant face over the four test trials, then conditioning was considered to have been established.

For each SCR metric on the catch trials, an analysis of variance was highly significant, with unpleasant responsivity greater than pleasant (amplitude delta C: $F[1,16] = 15.47$, $p = .001$; magnitude delta C: $F[1,16] = 36.27$, $p < .001$).

ERP

For the ERP, the differential conditioning paradigm is an adaptation of a paired-stimulus paradigm in which two events (S1 and S2) are linked by some task (Rockstroh, Elbert, Canavan, Lutzengerger, & Birbaumer, 1989). The S1–S2 link is used to establish a range of expectancies or preparatory states reflected in ERPs. These states are manipulated by altering the task or information values of either S1 or S2. Typically, however, the information value of S1 is varied (e.g., tone, loudness, warning signal), and a differential motor response to S2 is required. The brain activity measured during the S1–S2 interval is divided roughly into two time periods: up to 1 s post-S1 and from 1 s post-S1 to the S2 (which includes the slow-wave [SW] region).

In paradigms with S1–S2 intervals under 2 s, SW activity has been studied extensively as the contingent negative variation (CNV) (e.g., Walter, Cooper, Aldridge, McCallum, & Winter, 1964). The CNV has been described as indexing a range of psychological factors, such as expectancy (e.g., Walter et al., 1964), attention (e.g., Tecce, 1972), and motivation-arousal (e.g., Rebert, McAdam, Knott, & Irwin, 1967). A separation of the CNV into components can be obtained with longer interstimulus intervals (3–8 s; see Rohrbaugh et al., 1986). These components have been divided into early and late regions, and variously labeled the iCNV or o-wave (early) and tCNV or e-wave (late) (Rockstroh et al., 1989). The iCNV typically has been linked to the processing of the S1–S2 contingency, whereas the tCNV has been linked with either the S2 motor response (e.g., Gaillard, 1977) or S2 significance (Klorman & Ryan, 1980; Simons, Ohman, & Lang, 1979).

Fewer studies have employed a paired-stimulus conditioning paradigm with early ERP region activity as the dependent measure (Begleiter, Gross, & Kissin, 1967; Begleiter & Platz, 1969; Dykman, 1987; Paige, Newton, Reese, & Dykman, 1987). These studies have yielded mixed results, with some demonstrating amplitude differences in the visual evoked P300 component during conditioning (Begleiter et al., 1967) and others finding inconsistent differences (Paige et al., 1987). None of these studies have used aversive stimuli, however, which may be a critical dimension in eliciting differential responsivity (Backs & Grings, 1985; Garrett, 1981).

All of the studies reported thus far have used stimuli that are perceptually accessible to the person. Monitoring ERPs in response to masked (subliminal) presentations of stimuli is less common, although the method has been used over the years by a number of investigators. One of the first such studies was reported by Shevrin and Rennick (1967), followed by a series of studies by Shevrin and coworkers dealing with a variety of nonconscious processes (Shevrin, 1973, 1978, 1988; Shevrin & Fritzler, 1968; Shevrin et al., 1992). Additional studies have demonstrated brain responses that discriminate emotional stimuli (Kostandov & Arzumanov, 1977, 1986) and hemispheric differences in processing masked stimuli (Brandeis & Lehmann, 1986). Although most studies have used visual stimuli primarily, subliminal somatosensory stimuli also can be detected in a brain response (Libet, Alberts, Wright, & Feinstein, 1967). Although ERPs for masked stimuli have been clearly identified, little or no work using a conditioning paradigm with masked stimuli has been published to date.

Standard Grass Instrument silver–silver chloride electrodes were used to measure ERPs. Prior to electrode application, sites were cleaned with a mild abrasive solution; electrodes were then affixed with Grass electrode paste. Recording sites were Cz, Oz, P3, and P4 using the International (10-20) Electrode Placement System, with linked earlobes as reference and left mastoid as ground. Electrode impedance was under 10 kohms. Eye activity was monitored by electrodes placed on the outer canthus and suborbital ridge of the right eye. Recordings were monitored online by a Grass Model 8-24, digitized at 250 Hz, and stored in computer disc files for off-line analysis. The high frequency cutoff was 70 Hz. The Grass AC amplifiers were modified to provide a time constant of 5.3 s, with a low-frequency cutoff of 0.03 Hz.

All ERP SW measures were based on an average of 24 presentations (per stimulus category for each experimental phase). Individual ERPs were median filtered to remove significant artifactual outliers (Justusson, 1981).[6]

Individual trials contaminated by artifacts (eye blinks, muscle tension, or any suspicious activity that would render a trial unusable) were rejected by visual inspection and replaced online. Repeat trials were subject to a Category (2) × Experimental Phase (3) analysis of variance. The means for each cell ranged from 1 to 2.7. There was a significant main effect of experimental phase ($F[2,32] = 4.99$, $p = .01$, $\epsilon = 0.8785$); the contrasts indicated that the precon versus postcon difference was the main determinant of the phase effect ($F[1,16] = 7.56$, $p = .01$), with precon greater than postcon. The initial accommodation to the experimental procedure apparently was accompanied by an increase in subject movement, blinks, and so forth, which elevated repeats in the early trials, especially in comparison with later trials. None of the other tests were significant.

Aversive Shock Procedure

Stimulating electrodes were attached to the distal phalanges of the index and ring fingers of the preferred hand (right). The stimuli were single 200-ms constant-current square-wave pulses delivered by a Grass Model S-88 Stimulator and completely isolated from ground by a Stimulus Isolation Unit (SIU-7).

The intensity level of the stimulus was determined by each subject, and identified as the level at which the sensation felt annoying or unpleasant. Subjects were told that the sensation should not be painful in any way; in no case did the levels go beyond 5 mA. Subjects rated the degree to which the stimulus was unpleasant or annoying on a 9-point scale (9 = high; 1 = low) during threshold determination and after the conditioning experiment. These threshold methods parallel those used by Garrett (1981).

The mean pretest rating was 6.1 ($SD = 0.6$), and the mean posttest rating was 4.9 ($SD = 1.3$). An analysis of variance was significant ($F[1,16] = 14.28$, $p = .002$), suggesting that a de-

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[6] Isolated voltage values, which represented extreme deviations from surrounding samples, were removed. The median filter output is a more accurate representation of the data.

crease in shock unpleasantness occurred over time. This result is likely associated with a habituation effect.

Self-Report Anxiety Measures

The Spielberger et al. (1983) STAI-state anxiety inventory was administered before and after the experiment. This scale was used primarily to assess any immediate effects of the experimental paradigm on a subject's state-anxiety level. No significant differences emerged.

Results

ERP Findings

Conditioning Phase: P300 Component Measure

The prestimulus voltage levels for the unpleasant and pleasant stimuli were analyzed for significant differences between stimulus categories. An Electrode (4) × Category (2) analysis of variance yielded a significant main effect of electrode ($F[3,48] = 18.53$, $p < .001$, $\epsilon = 0.4679$). No other effects were significant. The P300 for each category was calculated, correcting for prestimulus values within electrode, by taking the maximum positive voltage value between 248 and 548 ms post-S1. This procedure allowed for a within-subject unpleasant-pleasant comparison, taking prestimulus level into account at each electrode. An Electrode (4) × Category (2) analysis of variance of the peak amplitude (P300) measure yielded a highly significant main effect for stimulus category ($F[1,16] = 19.35$, $p < .001$). The peak amplitude of the P300 component for the unpleasant stimulus was greater than for the pleasant stimulus. This effect was found for all electrodes. See Figure 1 for the conditioning phase grand averages.

An Electrode (4) × Category (2) analysis of variance on the latency of the P300 amplitudes yielded only a significant main effect for electrode ($F[3,48] = 3.70$, $p = .02$, $\epsilon = 0.9995$). The mean latency of the peak amplitude was, in order from shortest to longest, Cz (320 ms), Oz (332 ms), P3 (340 ms), and P4 (343 ms). There were no significant differences between P3 and P4; however, the comparisons Cz-Oz ($F[1,16] = 3.4$, $p = .08$), Cz-P3 ($F[1,16] = 9.63$, $p = .007$), and Cz-P4 ($F[1,16] = 6.9$, $p = .02$) were either significant or marginally significant. These results indicate that the P300 peak was evident first at Cz, then at Oz, and last at P3-P4.

Preconditioning Versus Postconditioning Phase: Slow Wave Region

Based on results from a preliminary study, it was hypothesized that evidence for differential ERP processing of stimuli

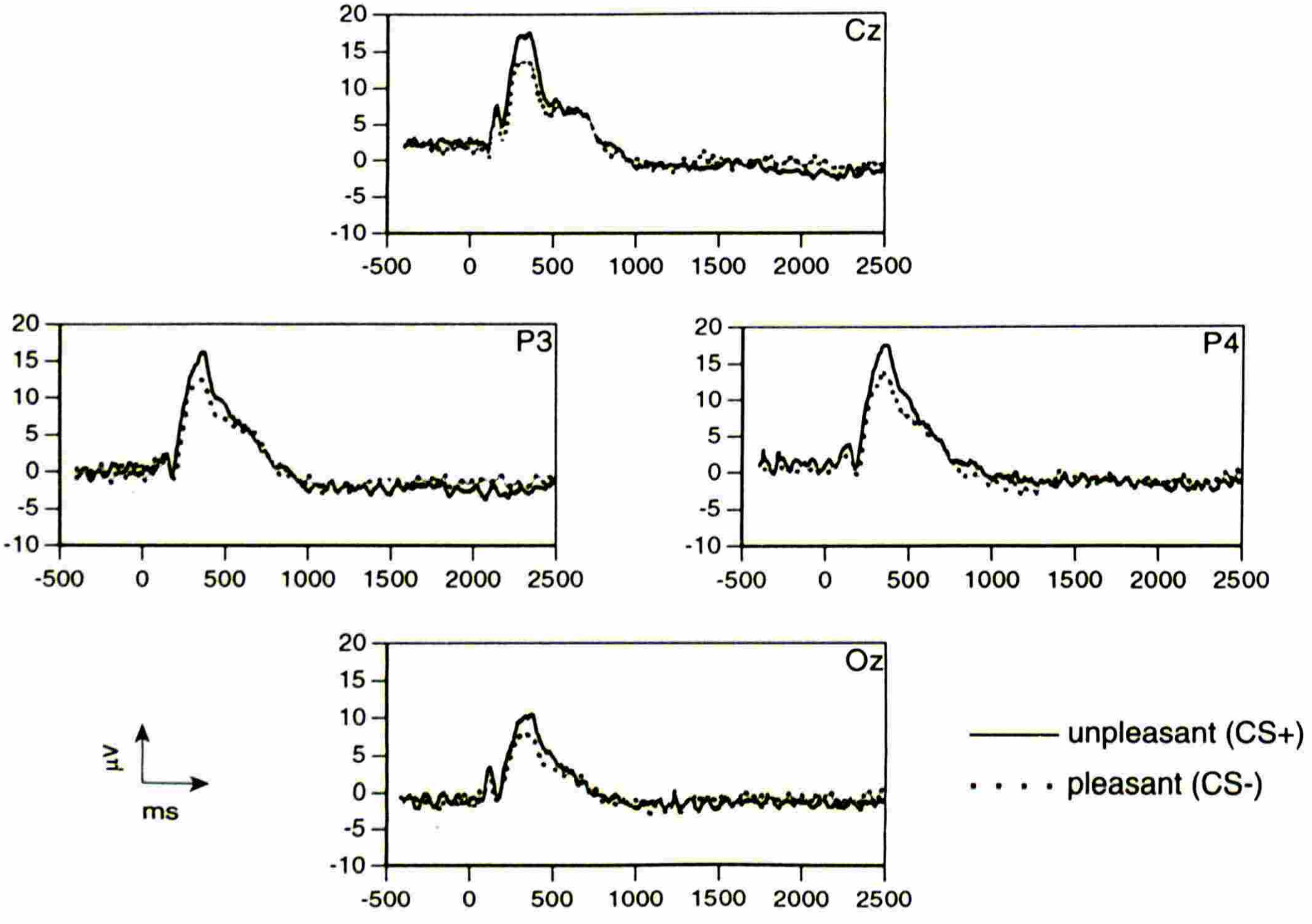

Figure 1. Grand averages for the conditioning phase. S1 (pleasant-unpleasant face) presented at time 0; S2 (shock-no shock event) occurred at time 2,500. Unpleasant face is linked to an aversive shock (probability = .83). Note the significant P300 amplitude differences between pleasant and unpleasant.

previously conditioned under full perceptual awareness would emerge in a comparison of the postcon versus precon phases of masked presentations. Specifically, it was hypothesized that this effect would be evident in a greater ERP slow wave occurring just prior to the S2 event for the shock-linked stimulus (unpleasant) than for the nonlinked stimulus (pleasant).

A slow wave morphology similar to that found in the preliminary study was evident. Grand averages for the entire data window for the precon and postcon phase are presented in Figure 2. The negative to positive shift for the unpleasant stimulus is most apparent in the postcon phase roughly 500 ms before the S2 would have appeared. In contrast, the average for the pleasant stimulus does not exhibit such a structure. Figure 3 presents an expanded view of the SW region.

Two separate measures were developed to analyze the slow wave activity occurring between 2,000 and 2,500 ms post-S1: (a) an area component measure and (b) a prestimulus-referenced negative component measure.

Area component analyses. The component area in the interval just prior to S2 was calculated on the individual subject averages by (a) identifying the most negative peak voltage value and its latency in a time window from 2,100 to 2,300 ms post-S1, (b) identifying the most positive peak voltage value and its latency in a time window from 2,300 to 2,500 ms post-S1, and (c) determining the component area under the negative-to-positive deflection (positive peak voltage as reference) (see Figure 4).

The a priori hypothesis based on results from the preliminary study was that the area under the unpleasant stimulus average would increase more from precon to postcon than the area under the pleasant stimulus average. Consistent with this hypothesis, an Electrode (4) × Prepost (2) × Category (2) analysis of variance yielded a highly significant Prepost × Category interaction ($F[1,16] = 20.41$, $p < .001$). No other tests were significant, including the Electrode × Prepost × Category interaction, indicating that the area effect is present at all electrodes (Cz, P3, P4, Oz).

A number of post hoc analyses were run to identify the factors that contributed to the significant interaction.[7] The main analysis consisted of contrasts between precon and postcon phase within affect category. The contrast of greatest interest was for the unpleasant stimulus comparison, which yielded a highly significant effect, with the postcon area component larger than the precon component ($F[1,16] = 9.59$, $p = .007$) in the predicted direction. The pleasant stimulus contrast also was significant, but in the opposite direction—the area in the precon phase was larger than in the postcon phase ($F[1,16] = 7.84$, $p = .02$).

The second analysis consisted of contrasts between affect categories, within precon and postcon phase. Here, the contrast of greatest interest was for the postcon comparison. As anticipated, the postcon contrast was highly significant, with the unpleasant area component larger than the pleasant area component ($F[1,16] = 22.75$, $p < .001$). The reverse relationship was found for the precon contrast, with pleasant area larger than unpleasant area ($F[1,16] = 6.8$, $p = .02$).

Overall these analyses were consistent with the hypothesis that the unpleasant component area would reflect greater change after conditioning than would the pleasant component area. Although the unpleasant area increased markedly after conditioning, a smaller change also was observed (but in the opposite direction) for the pleasant area.

Additional analyses were undertaken to explore the degree to which individual elements of the area measure—the negative peak voltage value (uncorrected for prestimulus voltage) and latency and the positive peak voltage value latency—contributed to the differences. These additional analyses revealed that the area differences were complexly determined, although trends consistent with the main hypothesis could be identified. An Electrode (4) × Category (2) × Prepost (2) analysis of variance for the negative peak voltage value of the area component measure yielded a significant Electrode × Category × Prepost interaction ($F[3,48] = 3.92$, $p = .01$, $\epsilon = 0.9507$). Post hoc contrasts demonstrated a statistically significant effect at only Cz ($F[1,16] = 10.68$, $p = .005$), although all other electrodes showed a similar pattern. For the contrast between experimental phase and affect category, the voltage values for the unpleasant stimulus were significantly more negative in the postcon series than in the precon series ($F[1,16] = 10.67$, $p < .01$). The pleasant stimulus values did not change. This increase in negativity for the unpleasant stimulus is consistent with the occurrence of an e-wave. For the contrast between affect category and phase, there was a precon phase effect, with the voltage values more negative for pleasant than unpleasant stimulus ($F[1,16] = 5.61$, $p < .05$). No difference was found in the postcon phase, although the means were in the opposite direction favoring the unpleasant stimulus (and in a direction consistent with the hypothesis). Latency of both the negative and positive peak voltage also contributed to the area component differences but in complex ways. An Electrode (4) × Category (2) × Prepost (2) analysis of variance for the latency of the negative peak voltage yielded a significant Prepost × Category interaction ($F[1,16] = 6.93$, $p = .02$). In the postcon phase, the negative voltage latency was significantly earlier for the unpleasant face than for the pleasant face ($F[1,16] = 13.29$, $p = .002$). For the pleasant face, postcon latency was significantly later than precon latency ($F[1,16] = 11.66$, $p = .004$). No other differences were found. An Electrode (4) × Category (2) × Prepost (2) analysis of variance for the latency of the peak voltage also yielded a significant Prepost × Category interaction ($F[1,16] = 6.54$, $p = .02$). The latency of the peak voltage for the unpleasant face was significantly later in the postcon than the precon phase ($F[1,16] = 4.6$, $p < .05$). In the postcon phase, the peak voltage latency was significantly later for the unpleasant face than for the pleasant face ($F[1,16] = 4.49$, $p = .05$). No other differences were found.

Prestimulus-referenced negative component analyses. Because an aspect of the slow wave component processes included a negative voltage deflection, a measure of this deflection was applied to the data using standard component methodology. First, the average prestimulus voltage level (−400 to 0 ms) was examined across electrodes. An Electrode (4) × Prepost (2) × Category (2) analysis of variance yielded significant main effects for electrode ($F[3,48] = 23.71$, $p < .001$, $\epsilon = 0.5481$) and prepost ($F[1,16] = 20.31$, $p < .001$), as well as an Electrode × Prepost interaction ($F[3,48] = 4.26$, $p = .04$, $\epsilon = 0.4908$). The results indicated that prestimulus levels vary according to the prepost phase of the experiment and electrode location. No other effects were significant, including stimulus category. Given these interactions, the prestimulus-referenced negative component

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[7] All post hoc contrasts used the Scheffé-type method; otherwise, simple effects were tested (O'Brien & Kaiser, 1985).

measure was calculated using prestimulus levels within phase and by electrode.

Second, the average prestimulus value (within phase and electrode) was subtracted from the most negative voltage value between 2,100 and 2,300 ms post-S1. The hypothesis was that the postcon unpleasant component value would be more negative than the postcon pleasant value, whereas the precon unpleasant versus precon pleasant values would not differ in the same direction.

An Electrode (4) × Prepost (2) × Category (2) analysis of

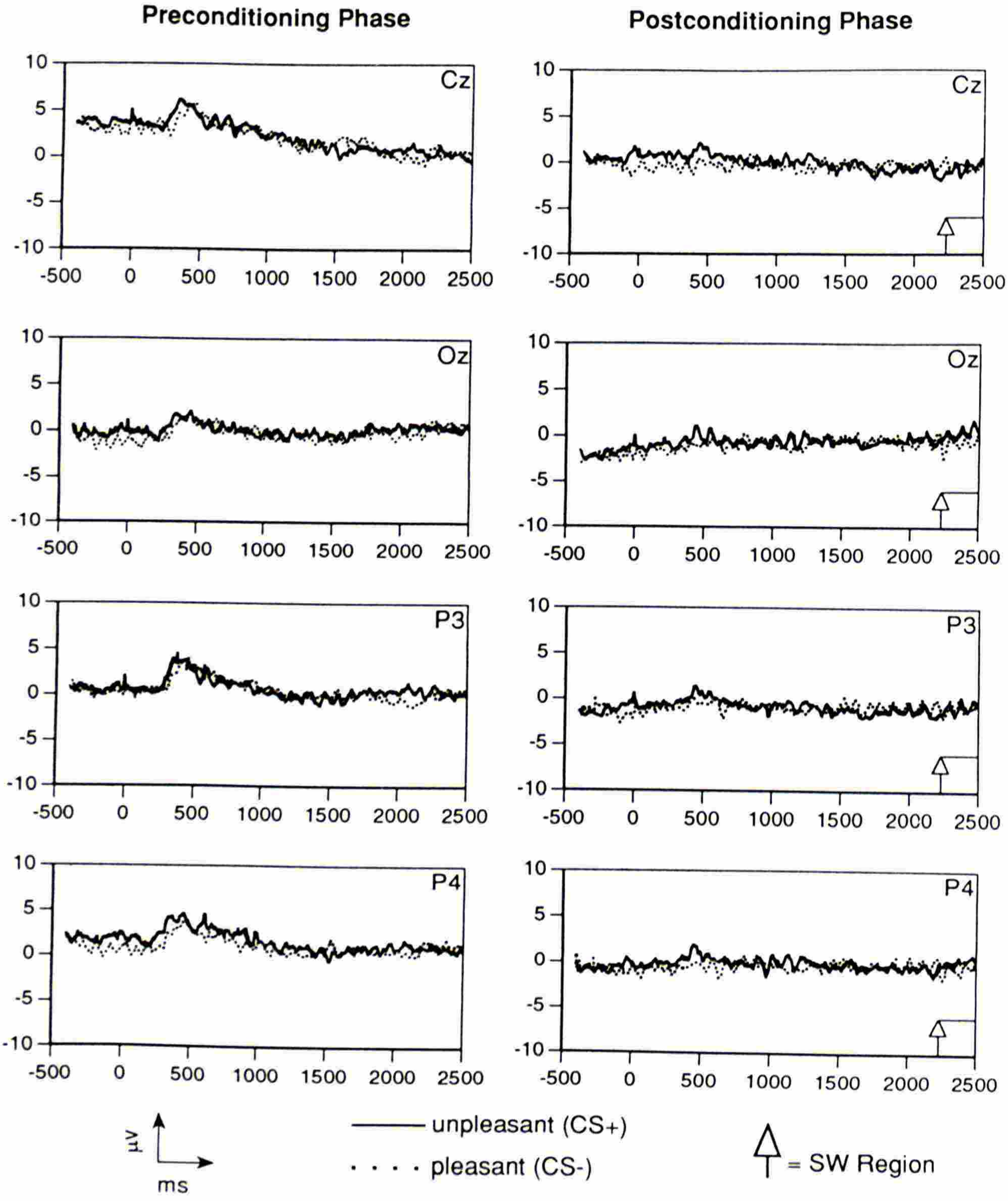

Figure 2. Grand averages for the preconditioning and postconditioning phases. S1 (pleasant–unpleasant face) presented at time 0; S2 (shock–no shock event) occurred at time 2,500. In the postconditioning phase, the arrow marks the SW onset for CS+ and the horizontal line delimits the region of differential activity. See Figure 3 for a magnified view of the differential activity.

variance yielded a significant three-way interaction ($F[3,48] = 2.72$, $p = .05$, $\epsilon = 0.9007$), consistent with the hypothesis. Post hoc contrasts of the individual electrodes yielded a significant Prepost × Category interaction only for Cz ($F[1,16] = 4.52$, $p = .05$) in the expected direction. All other electrodes effects were not statistically significant, although inspection of the means indicated that the direction of the differences was consistent with the predicted effect.

Thus, once the average prestimulus voltages are taken into account, a negative voltage deflection emerges as a significant

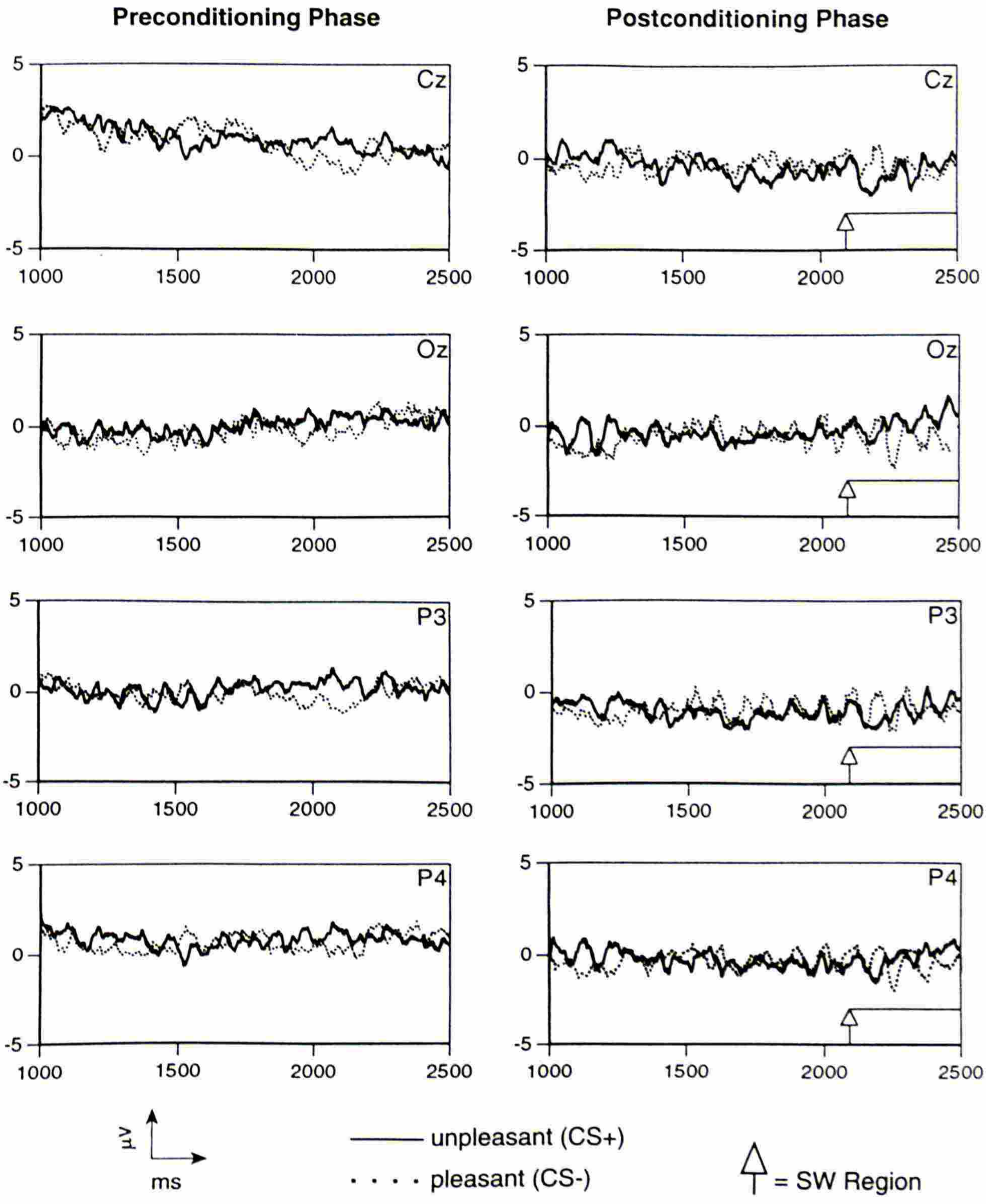

Figure 3. Grand averages for the SW region (1,000–2,500 ms poststimulus) in the preconditioning and postconditioning phases. S1 (pleasant–unpleasant face) presented at time 0 (not shown here); S2 (shock–no shock event) occurred at time 2,500. In the postconditioning phase, the arrow marks the SW onset for CS+ and the horizontal line delimits the region of differential activity.

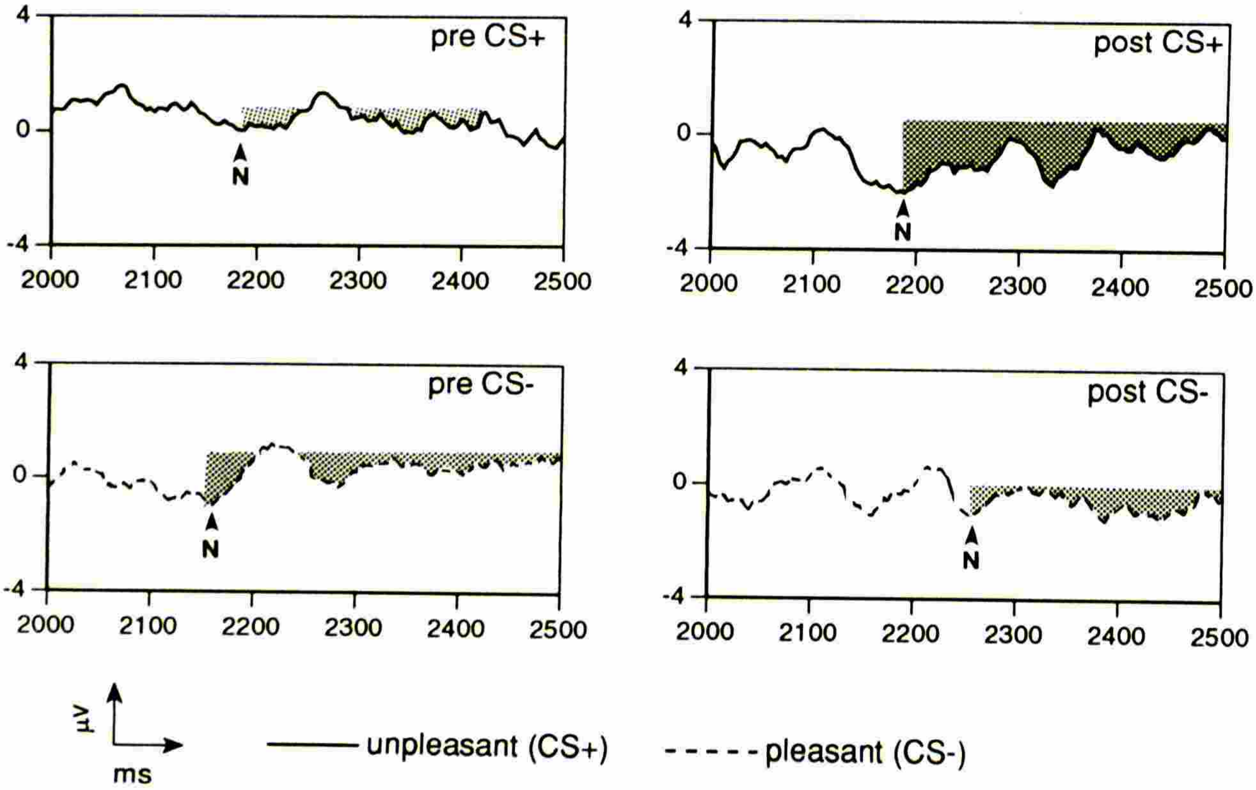

Figure 4. Illustration of slow wave (SW) component measures applied to electrode Cz grand averages. N identifies the negative peak used for the prestimulus-referenced negative component analysis. Shaded area reflects the area component analysis for the region 2,000–2,500 ms poststimulus. The post-CS+ condition has a significantly more negative peak and greater area than the other conditions, reflecting the SW differential identified in the study.

factor in the SW activity occurring just prior to the anticipated shock–no shock event (S2).

Summary. The slow wave region analyses using the area component and the prestimulus-referenced negative component measures are consistent with the hypothesis. SW changes between precon and postcon phase occurred primarily as a function of the shock-linked stimulus (unpleasant face) and can be characterized by a negative to positive voltage deflection just prior to the S2 event. A main factor contributing to the greater unpleasant area component in the postcon phase is an increased negativity, which is consistent with the occurrence of a tCNV or e-wave process. The prestimulus-referenced negative component analyses provided converging evidence for the importance of this increased negativity in the SW effect observed. An unanticipated finding in the area component measure was a greater area for the pleasant stimulus in the precon phase (which then decreased slightly in the postcon phase). There is no a priori reason to have anticipated these results for the pleasant stimulus, although possible explanations exist.[8]

Overall, the brain response to the unpleasant stimulus indicates that the unmasked (supraliminal) conditioning effect was "carried over" to the masked (subliminal) postcon phase. Subjects appear to react as if they "expect" or "anticipate" a shock when presented with the shock-linked unpleasant stimulus, even in the absence of perceptual awareness of that stimulus.

SCR Findings

The SCR measures were included to replicate some of the original Ohman et al. (1988) findings. The main a priori hypothesis for the SCR paralleled that for the ERP: that there would be a greater amount of electrodermal activity for the shock-linked unpleasant stimulus than for the nonlinked pleasant stimulus in the postcon versus the precon phase.

The a priori contrast for the SCR probability measure was significant ($t[17] = 1.93$, $p < .05$), which supports the main hypothesis. A Category (2) × Prepost (2) analysis of variance yielded a Category × Prepost interaction that also was marginally significant in the expected direction ($F[1,16] = 4.16$, $p = .058$). Inspection of the means indicated that the direction of differences are consistent with the main hypothesis: from precon to postcon the SCR probability of response to the unpleasant

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[8] The greater SW area for the pleasant stimulus in the precon phase is not primarily a function of the pleasant stimulus itself but of a smaller area for the unpleasant stimulus. Why is the area for the unpleasant stimulus smaller than that for the pleasant stimulus in the precon phase? A smaller area result can be due to greater low amplitude–high frequency activity, without low-frequency shifts. The same conditions could appear in the postcon phase, with the only difference between conditions emerging in the increased low-frequency SW activity for the unpleasant stimulus. Why these features would appear when they do is another issue, perhaps related to the instructional set or to some interaction between instructional set and stimulus factors. Additional exploration of this phenomenon is needed.

stimulus increased, whereas the probability of response to the pleasant stimulus did not (the probability decreased) (Figure 5, top).

The a priori contrast for the SCR amplitude measure was marginally significant ($t[17] = 1.65$, $p = .06$) and was consistent with the main hypothesis. A Category (2) × Prepost (2) analysis of variance yielded a main effect of prepost ($F[1,16] = 4.42$, $p = .052$), with precon larger than postcon. There also was a main effect of category ($F[1,16] = 4.36$, $p = .053$), with unpleasant larger than pleasant. The Category × Prepost interaction, however, was not significant. Inspection of the means indicated that although there were main effects, these are probably an outgrowth of an interaction. The primary change was a decrease from precon to postcon in the amplitude of the responses to the pleasant stimulus, whereas the unpleasant response amplitude remained constant (Figure 5, bottom).

A Category (2) × Prepost (2) analysis of variance was performed on the SCR latency values. None of the effects were significant.

The contrast for the SCR magnitude measure was not significant, which was inconsistent with the main hypothesis. A Category (2) × Prepost (2) analysis of variance was performed on the magnitude values. None of the effects were significant.

A parallel analysis was performed on the amplitude, probability, and magnitude measures using SCR block as a variable: Block (2) × Category (2) × Prepost (2). For the amplitude analysis, no effects of block were significant. There was a significant Prepost × Category interaction ($F[1,16] = 6.65$, $p = .02$), which parallels the results reported above. For the probability analysis, there was a significant main effect for block ($F[1,16] = 6.01$, $p = .03$), with Block 1 greater than Block 2. A marginally significant Prepost × Category interaction was obtained ($F[1,16] = 4.16$, $p = .058$), which parallels the results reported above. For the magnitude analysis, there was a main effect for block ($F[1,16] = 4.78$, $p = .04$), with Block 1 greater than Block 2, which parallels the block results for the probability analysis. Overall, the only significant effects of block indicated that the probability and magnitude of SCR scores decreased from Block 1 to Block 2, which is an expected result.

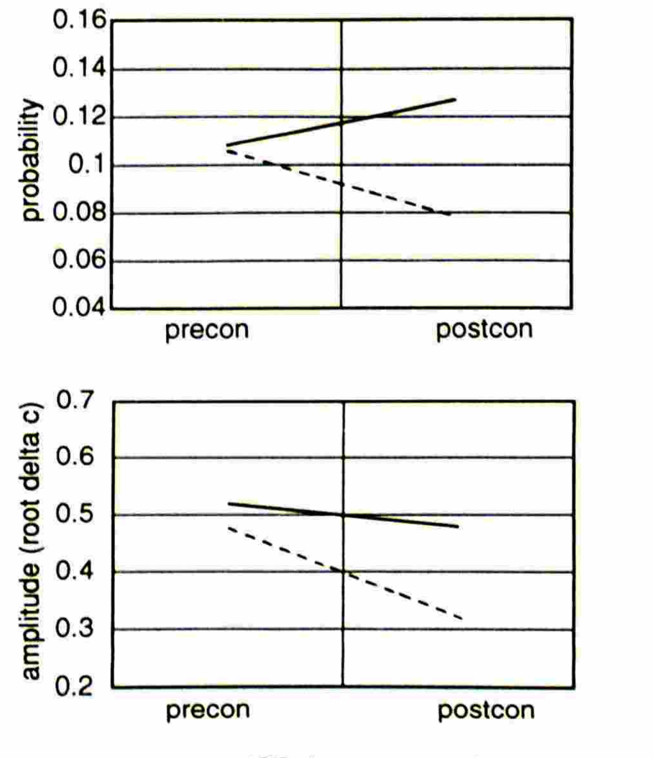

Figure 5. SCR grand mean probability (top) and amplitude (bottom). Note the decrease in probability and amplitude of responses to CS− and the relative stability of responses to CS+ from preconditioning to postconditioning phases.

In summary, the SCR findings based on the probability and amplitude measures provide independent support for the Ohman et al. (1988) findings and for the experimental hypothesis that stimuli conditioned previously within awareness can elicit conditional responses when presented outside awareness.

Discussion

The results of the study provide information on the relationship between conscious and nonconscious processes as indexed by physiological measures. Subjects first learn a simple relationship between two events under conditions of full perceptual awareness. In subsequent presentations of the conditional stimuli, subjects respond physiologically as if expecting a similar relationship between the events, even when perceptually unaware of having been presented with the stimuli. Thus, it seems that an expectancy process can be elicited entirely without awareness. Previous studies have demonstrated a similar effect with SCR, but with some methodological problems in determining visual threshold that have rendered the effect equivocal. The present study addresses these methodological problems, replicates the effect with SCR, and demonstrates for the first time that a brain measure can index an anticipatory process elicited nonconsciously.

Brain Activity

Slow wave activity occurred in the masked, postconditioning phase just prior to the time at which the S2 (shock–no shock) event occurred in the unmasked conditioning phase; this SW effect is similar to what others have described as an expectancy wave (Rohrbaugh et al., 1986) or the terminal phase of the CNV (Rockstroh et al., 1989). The present data also support the belief that this expectancy wave develops primarily in response to an emotionally significant S2 (Rockstroh et al., 1989; Rohrbaugh et al., 1986). The findings are consistent with those reported by Shevrin and co-workers (Shevrin, 1973, 1978, 1988; Shevrin & Fritzler, 1968; Shevrin & Rennick, 1967; Shevrin et al., 1992), which demonstrated that the ERP can index nonconscious processes.

The slow wave region analyses using the area component and the prestimulus-referenced negative component measures are consistent with the experimental hypothesis. The change in SW activity between the preconditioning and postconditioning phase occurred primarily as a function of the shock-linked unpleasant stimulus and can be characterized by a negative-to-positive voltage deflection just prior to the S2 event. Significant area component differences appeared across all electrodes, although the prestimulus-referenced negative component measure revealed the greatest difference at Cz. To the extent that the slow wave activity effect is mediated primarily by an initial negative voltage deflection, one can conclude that the overall effect is strongest at Cz and evident at other electrode sites in attenuated form.

The morphology of the slow wave response is similar to that of the tCNV or e-wave responses found in paired stimulus paradigms. There are several differences, however, between results from the present experiment and those described elsewhere. Previous descriptions of the tCNV have identified a general negativity that precedes the S2 (e.g., Garrett, 1981; Simons et al., 1979). The morphology of the response identified in this study includes this negativity but also includes a positive-going voltage component immediately before the S2. Thus, the differences observed in this study are more complex in nature than the differences observed elsewhere (which involved more of an absolute difference in negativity).

These differences may be due to several factors. First, in most cases, the ERP profiles used in other studies resulted from reducing the data over a wide time interval to one average value (in effect decreasing the sampling rate and acting as a low-pass filter). This data reduction procedure of taking one average value to represent a long time interval results in a loss of structure, which is less likely to occur when using ERP profiles that are not reduced in the time dimension. The use of raw, unaltered averages for an ERP profile (as done in this study) may allow for greater resolution of the slow wave morphology. Second, the S1–S2 interval in this study also is shorter than in long-interval studies. These longer interstimulus intervals, which can be up to 8 s (e.g., Backs & Grings, 1985), in theory should allow for greater separation of early and late CNV components. The relatively short interstimulus intervals used in this study may not result in complete separation of these early and late components. Third, SW activity was elicited by masked stimulus presentations rather than by the usual unmasked presentations, which may also contribute to the SW properties found in this study. In general, however, the morphology of the SW activity in this study is similar to the tCNV or e-wave and appears to be a closely related process.

As noted by Simons (1986), there also is evidence suggesting that the tCNV or e-wave is associated with the affective significance of the S2. Historically, paired-stimulus paradigms have linked a motor response to the S2, suggesting that the tCNV process was involved in motor preparation. Several recent studies (Klorman & Ryan, 1980; Simons et al., 1979), however, have demonstrated that under appropriate conditions, a tCNV appears to be related to the affective significance of the S2. Although the tCNV can be somewhat elusive (i.e., the eliciting conditions are not well defined; Simons, 1986), the affective significance of the S2 is relevant. The present study is certainly consistent with this emerging picture of the functional significance of the tCNV or e-wave and of its connection with affectively significant stimuli.

The P300 component findings in this study also are intriguing. Amplitude differences in the P300 range have been linked to conditioning effects (Begleiter et al., 1967), although recent evidence has been equivocal (e.g., Paige et al., 1987). Few studies reported to date, however, have used a shock stimulus as an unconditioned stimulus or have used emotionally valent conditional stimuli. Investigators typically use stimuli such as tone bursts and monetary rewards and various neutral stimuli to establish conditioning. The amplitude differences found here may provide further support for the hypothesis that the P300 reflects processing of significant stimuli in a complex manner (e.g., Donchin & Coles, 1988).

Electrodermal Activity

The SCR data provide parallel, converging evidence that the conditioning effect established within awareness can be elicited by subsequent masked presentations of the conditional stimuli. The results also provide independent systematic support for the Ohman et al. (1988) findings.

In the SCR analysis, the probability and amplitude measures revealed differential activity, whereas latency and magnitude did not.[9] Based on the probability and amplitude measures, the main hypothesis was supported and the findings of Ohman et al. (1988) were replicated, although the effect was small in view of the lack of significance found in the magnitude measure.

A consideration of the probability and amplitude measures jointly helps in understanding the effect. From precon to postcon phase, the probability of an SCR for the unpleasant stimulus increased and the amplitude of the response remained stable. For the SCR for the pleasant stimulus, both probability and amplitude decreased. This decrease in SCR for the pleasant face may be a function of a typical extinction process, whereas SCR for the unpleasant face appears to reflect a resistance to extinction. This differential pattern of stimulus responsivity is consistent with the well-known resistance to extinction effect for SCR for certain kinds of conditional stimuli when presented within awareness (Ohman, Erixson, & Lofberg, 1975).

General Considerations

A significant difference between this study and many others is that the stimuli for the preconditioning and postconditioning phase are presented under masked conditions. What has been established as an effect for unmasked presentations of stimuli may not necessarily apply directly to masked presentations. With SCR, for example, the time course of the resistance to extinction effect for unmasked stimuli may be different from the time course of an equivalent effect for masked stimuli. The same question holds for ordinary extinction: would repeated masked presentations of the conditional stimuli eventually lead to a genuine extinction effect, or can extinction occur only for unmasked presentations? Future work can explore these specific parameters, with special focus on issues such as the degree to which effects demonstrated under conditions of full perceptual awareness apply in a similar manner to conditions in which a subject is perceptually unaware of what is presented.

Although the results of the study provide initial evidence that brain processes can index a nonconscious anticipatory process, additional studies clearly are needed to explicate the effect. Future research, for example, can explore the degree to which the effect is the sole result of conditioning or of some combination of conditioning and preexisting differences between stimuli.

The central aspect of this study and of many others that have examined conscious and nonconscious processes is an experimental manipulation aimed at rendering stimuli unavailable to a person for processing in one domain and demonstrating that stimulus processing is in fact occurring in another domain (a dissociation phenomenon; see Erdelyi, 1985). In this study, a forced-choice identification task based on affective valence was used in the pre- and postthreshold test to establish null respon-

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[9] This difference between metrics, particularly between probability amplitude and magnitude, is not unusual (Prokasy & Kumpfer, 1973), and there is some controversy about which measure is more appropriate (Venables & Christie, 1980).

sivity via behavioral performance (percent correct on the task). This null responsivity was taken as indication that there was no differential awareness of the stimuli. At the same time, however, the physiological indicators demonstrated that stimulus processing was happening, which is evidence that another process that is indirect and by inference nonconscious was also active.

The results from this study suggest that there may be other dissociations of potential interest. These dissociations are embedded in the paradigm and are not as easy to demonstrate but are of theoretical interest. For example, although an expectancy response is activated in the absence of a subject's awareness of the eliciting stimulus, is the subject necessarily also unaware of the expectancy process itself? Although a conclusive answer cannot be given, some anecdotal evidence is available. When asked about their experience, subjects did not describe any anticipatory feelings in the postconditioning phase. This finding suggests that another dissociation occurs, in which a subject is unaware of the actual response to the stimulus in addition to being perceptually unaware of the stimulus itself. Awareness of the response to the stimulus can be considered equivalent to what might be termed an automatic attention response (Dawson & Schell, 1985; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), in which the nonconscious elicitation of a conditional response creates an interrupt signal in the conscious system (resulting in a shift of attention or some other conscious system activity). Based on the anecdotal data from this study, however, an interrupt signal was not evident in awareness. This example and others like it indicate that dissociative phenomena can work in multiple ways, depending on the factors of interest, the measurement parameters involved, and the time course associated with the processing of these factors.

Another example of the many variations in dissociative phenomena can be found in the study by Dawson, Schell, and Banis (1986; see also Dawson & Schell, 1987). Dawson et al. (1986) tested the hypothesis that the resistance to extinction effect is a noncognitive (i.e., nonconscious) process that occurs independently of cognitive (i.e., conscious) expectancies. Dawson et al. conditioned subjects to biologically prepared phobic stimuli, such as pictures of snakes or spiders, while monitoring on a trial-by-trial basis via a button pressing task a subject's cognitive expectancy regarding whether or not the unconditioned stimulus would occur. This task can be described as picking apart explicit knowledge or awareness of expectancy. The results demonstrated that cognitive expectancy is a central factor in the resistance-to-extinction effect, which is correlated with a subject's conscious expectations regarding whether or not the shock will occur. Thus, Dawson et al. (1986) argued against the notion that the resistance-to-extinction effect is noncognitive (i.e., nonconscious) and, by extension, against the idea of biological preparedness with certain stimuli (e.g., Ohman & Dimberg, 1978; Ohman et al., 1975; Seligman, 1970, 1971).

In contrast to the Dawson et al. studies, which emphasized the role of conscious processes, the results from the present study indicate that nonconscious processes also are at work. The exact manner in which nonconscious factors interact with conscious factors is still an open question, however. Several examples illustrate different aspects of this question. Suppose one were to use the Dawson et al. awareness probe task in the postconditioning phase of the present study and were to find, contrary to the anecdotal evidence, that a subject's conscious expectation of a shock is indeed correlated with the emergence of the physiological response. This result would indicate that even though a subject is perceptually unaware of the conditional stimuli, explicit knowledge of an expectancy emerges later (which would be, in effect, a temporal dissociation). Such a result would be consistent with the automatic attention response hypothesis of Shiffrin and Schneider (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). However, if the results were to indicate that subjects in fact had no awareness of an anticipatory response, which is what is suggested by the anecdotal evidence in this study, there would be support for the notion that an expectancy process can occur completely without awareness.

Subjects in the present study were perceptually unaware of stimuli, whereas in most other studies (such as the Dawson et al., 1986, study), stimuli were presented in full perceptual awareness. Awareness of the kind measured by Dawson et al. (a knowledge-based awareness) may be qualitatively different from the awareness measured in the present study (a more purely perceptual awareness). Further exploration of these differences may identify specific convergent and divergent properties associated with conscious and nonconscious processes. The technique developed in the present study provides many possible avenues for such exploration in the context of conditioning phenomena that are revealed through different physiological systems.

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