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THE EFFECTS OF AWARENESS ON CORTICAL EVOKED POTENTIALS TO CONDITIONED AFFECTIVE STIMULI

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ABSTRACT

A previous paper of ours (Begleiter, Gross, & Kissin, 1967) demonstrated that it was possible to condition affective meaning to meaningless figures (CS), and significantly alter visual evoked potential (VEP) amplitudes and latencies to them, without the *S*'s awareness of the CS–UCS relationship (Experiment I, totally unaware). In the present study some *S*s were deliberately informed that a CS–UCS connection existed; however, the exact nature of their relationship was not divulged (Experiment II, slightly aware). Other *S*s were explicitly informed of the correct CS–UCS contingency, and entire conditioning paradigm (Experiment III, fully aware). One physiological (VEP) and two behavioral (interflash interval and semantic differential) indices of conditioning were obtained during an extinction procedure, and demonstrated significant differences between CRs in Experiment II, but none in Experiment III. VEP amplitudes to positive and negative CSs were enhanced in Experiment II, and suppressed in Experiment I, in comparison to the neutral CS. This effect was most marked in responses to the negative CS. It is suggested that level of awareness of the CS–UCS contingency might be reflected in our physiological index of conditioning – VEP amplitude.

DESCRIPTORS: Visual evoked potentials, Affect, Conditioning. (H. Begleiter)

Increasing interest and experimentation with sensory evoked potentials have led in recent years to the realization that in addition to physical stimulus parameters, certain psychological phenomena can also be tapped via cortical evoked potentials. It is becoming increasingly evident that evoked potentials are capable of reflecting such subjective experiences as attentional shifts (Davis, 1964; Haider, Spong, & Lindsley, 1964; Gross, Begleiter, Tobin, & Kissin, 1965), and most dramatically, subtle differences in "meaning" without accompanying changes in the physical dimensions of the stimuli.

Begleiter, Gross, and Kissin (1967) studied the influence of affective meaning on visual evoked potentials. By means of conditioning procedures, previously meaningless figures (CS) were conditioned to affective responses elicited by positive, negative, or neutral words (UCS). The semantic differential scale (SD)

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and interflash interval (IFI) were used as indices of conditioning. Although conditioning occurred without awareness, both measures of conditioning yielded results in the same direction indicating that the three affective conditions differed significantly from one another. Cortical evoked potentials were obtained to each affective stimulus. Amplitudes were found to differ significantly across the three conditions, with the unpleasant stimulus eliciting the lowest evoked response and the neutral condition evoking the highest. Significantly shorter latencies were obtained to the unpleasant stimulus, whereas the latencies of the positive and neutral stimuli did not differ significantly from each other.

The role of awareness with regard to conditioning raises two quite separate issues. The first deals with the problem of whether awareness of the reinforcement contingency is necessary for conditioning to occur. This question is of course essentially the old problem of whether or not there is or can be learning without awareness. The findings of Razran (1938, 1940) certainly provide support for the contention that the effects of a reinforcer can be "entirely unconscious and automatic" (Dollard & Miller, 1950, p. 44). Many studies have indicated that evaluative meaning can be conditioned without the *S*'s awareness of the reinforcement contingency (Staats & Staats, 1957; Das & Nanda, 1963; Blandford & Sampson, 1964).

In addition, it has been demonstrated that conditioning can occur with the *S*'s awareness (Cohen, 1964). Two recent studies (Levin, 1961; Insko & Oakes, 1966) provide evidence that conditioning can occur with and without awareness. Levin (1961) demonstrated that *S*s who were unaware of both the correct contingency and the reinforcer showed as much conditioning as *S*s who were unaware only of the correct contingency. Insko and Oakes (1966) used the Staats and Staats (1957) procedure for conditioning affective meaning. In agreement with the results of Cohen (1964), it was found that awareness was correlated with conditioning; however, *S*s who were unaware also showed a significant conditioning effect.

The second issue is concerned with possible differences between conditioning with and without awareness — whether conditioning with awareness differs from conditioning without awareness, and if so, how they differ. In order to resolve this problem, it is necessary to find an index that can discriminate between conditioning with and without awareness. The present study used the identical procedure described above to investigate the influence of affective meaning on cortical evoked potentials under two conditions: (1) partial awareness of the CS–UCS relationship, (2) full awareness of the CS–UCS contingency and the conditioning paradigm.

Method

Subjects

Thirty-one college students with a mean age of 19 years were used in Experiment I. Thirty-one college students with a mean age of 19.7 years were used in Experiment II. Sixteen college students with a mean age of 19.2 years were used in Experiment III. All subjects were paid male volunteers.

Apparatus

After the *S*s received initial instructions emphasizing the need for concentration on the required tasks, electrodes were applied. The active monopolar lead was an electrode placed at O_2 (2.5 cm above the inion and 2.5 cm to the right of the midline, according to the 10–20 International system). The combination of the two ear lobes formed the reference electrode. The electrodes were silver-silver chloride disc electrodes, secured to the scalp with collodion. Resistances were kept below 5000 ohms.

The *S*s were seated in an acoustic enclosure (Industrial Acoustics Co., No. 1203A), looking directly into a viewing hood which was flush against the one-way vision mirror of the enclosure. On the other side of the glass window, a Grass PS-2 photo stimulator was mounted; it was located 50 cm from the *S*'s eyes and set at an intensity of 8. These precautions were taken in order to make the click of the photo stimulator inaudible to the *S*. While in the acoustic enclosure, the *S* could communicate with the *E* through a two-way communication system. The *S* was observable at all times through the one-way vision mirror.

The electroencephalographic (EEG) data were recorded by means of a Grass Model 7 P5A wide band AC EEG amplifier, whose low frequency cut-off filter was set at .15 cps. The driver amplifier high frequency cut-off filter was set at 75 cps.

Computation of the averaged evoked potentials was accomplished by means of the Mnemotron Computer of Average Transients (CAT 1000) with a 1024 msec epoch. The evoked potentials were displayed on a Tektronix Oscilloscope screen and photographed at different time bases from time zero to 1024 msec.

The conditioned stimulus used was a transparent white outline of a pentagon on a black background, four inches high and three inches wide. The transparent outlines of the pentagon were one-half inch in width. The stimulus card could be rotated to three positions differing from its initial position by an angle of 90°, 180°, and 270°. Three distinguishably different positions of the stimulus were used in the study. Each position of the figure was conditioned to one of the three affectively homogeneous sets of 20 words which were of positive, negative, or neutral value. Each position was randomly assigned to one of three conditions. Each stimulus (CS) was flashed for a duration of ten microseconds and was always above recognition threshold.

Conditioning

The *S*s were conditioned according to the method described by Staats and Staats (1957). This procedure involves a series of maneuvers designed to establish conditioning while diverting the *S*'s "awareness" away from the realization that he is being conditioned. The *S*s were told that they were going to take part in an experiment designed to study two different types of learning to examine the effectiveness of each, as manifested by the cortical evoked potentials. Two steps were used in these maneuvers, both preliminary to the conditioning itself.

Step 1. The first learning task used geometric figures as stimuli. Four irregular and complex geometric figures were flashed in random order, each four times.

At the conclusion, the *S*s were instructed to reproduce on paper all the figures that they could recall.

Step 2. In the second task the *S*s had to learn a set of 20 words. Each word was presented orally by the *E* one time, with approximately 2 sec intervals between words. The *S*s were instructed to repeat the word aloud immediately after it was presented, and to continue to pronounce the word to themselves until the next word was given. The words were taken from the list used by Staats and Staats (1957) in their study on semantic conditioning (design, carry, limit, walk, hand, game, nail, watch, play, shoot, give, variety, color, paint, handle, water, chain, breeze, etc.).

After the 20 words had been presented, the *S*s were instructed to write down all the words that they could recall. These two tasks were used to train the *S*s in the procedure and to orient them properly for the next phase of the experiment where the actual conditioning took place.

Step 3. The *S*s were told that the primary purpose of the experiment was to study "how both of these kinds of learning take place together."

In this task the position of the line figure in the form of a pentagon served as the conditioned stimulus (CS), immediately followed by the meaningful word (UCS). The UCS word was different for each conditioning trial, but all the UCS words following a given CS possessed a common core of meaning: pleasant: beauty, win, gift, sweet, honest, smart, rich, friend, valuable, pretty; unpleasant: thief, bitter, ugly, sad, worthless, sour, enemy, cruel, dirty, disgusting; neutral: pencil, word, table, train, line, dot, string, sand, box, clay.

Immediately after presentation of the visual CS, one of the UCS words was pronounced by the *E*, after which the *S* repeated the word aloud. This procedure was randomly repeated for a total of 60 trials.

The result of the conditioning procedure was that the common core of meaning, e.g., pleasant, unpleasant, was eventually elicited by the presentation of the CS alone.

Instructions

The following instructional sets were used in order to explore how the amount of information received by the *S* would influence the conditioning of affective stimuli.

Experiment I. This procedure is described above, and has already been reported in detail by Begleiter et al. (1967).

Experiment II. Immediately preceding step 3 of the conditioning procedure, the *S*s were told that "there is a relationship between the figures and the words." It should be noted that the nature of the relationship was neither revealed nor explained to the *S*.

Experiment III. Just before step 3 of the conditioning procedure, the specific relationship between the figures and the words was made explicit to each *S*. The *S* was also told that part of the experiment was to investigate the influence of words (UCS) upon the figures (CS).

Indices of Conditioning

Three dependent variables were used as indices of conditioning. It should be noted that none of these measures were used during the conditioning procedure.

These measures were used immediately after completion of the conditioning procedure.

A. *Physiological Index.* Immediately after the conditioning procedure, three averaged evoked potentials were obtained. The *S* was asked to look directly into the viewing hood in order to see the stimulus. Each stimulus (CS) was flashed a total of 70 times. The flashes were presented at the rate of 1 flash/1.6 sec. The order of presentation of the three CSs was randomized across *S*s; each *S* was assigned to one of the possible orders yielding six combinations. The distribution of *S*s across the six orders was as follows:

ORDER:	1	2	3	4	5	6
Number of *S*s in Expt. II:	5	5	5	5	6	5
Number of *S*s in Expt. III:	3	2	3	2	3	3

The visual evoked response obtained is multiphasic and regularly consists of five components: two peaks (negative) and three troughs (positive). This yields four successive peak-to-trough amplitudes, measured in terms of the perpendicular distance between the successive peaks (designated A to D), a total duration of the response which corresponds to the interval from time zero to the positive peak up to about 300 msec, and four successive latencies measured from time zero (designated as 1 to 4). A detailed procedure for the measurement of averaged potentials is given by Begleiter et al. (1967).

B. *Behavioral Index I.* In their original study Staats and Staats (1957) used the semantic differential (SD) as the sole index of conditioning. In the present study the interflash interval (IFI) was used in addition to the SD.

The two-flash threshold is measured by determining the shortest interval of time between two successively presented pulses of light that allows a *S* to report seeing two flashes. In human *S*s this two-flash threshold has been related to specific psychological states (Roth, 1961), psychiatric disability (Venables, 1964), and the level of cortical arousal (Venables & Warwick-Evans, 1967). Consequently, this technique was used to measure the effects of affective conditioning (Begleiter et al., 1967).

After the visual evoked response determinations, the threshold of fusion of pairs of light flashes (IFI) was obtained by the method of limits for each of the three stimuli (CS), which were again presented in the same order.

C. *Behavioral Index II.* After the IFI threshold determinations, the *S*s were asked to rate each (CS) figure on a semantic differential rating scale — a seven point bipolar scale (pleasant — unpleasant). In this procedure the *S* was asked to rate the way he "felt" about the (CS) figures, since this "might have affected the way he learned them."

Determination of Awareness

In order to determine the level of the *S*'s awareness with regard to the conditioning paradigm, a lengthy interview (30 minutes) was conducted with each *S* at the end of the experiment.

The following operational criteria were used to determine the level of the *S*'s awareness.

1. The S's impression of the experiment. The *S* was not aware and/or could not verbalize the true purpose of the experiment.

2. CS–UCS connection. The *S* was not aware and/or could not verbalize the relationship between CS and UCS.

Results

Experiment I

In a previous experiment (Begleiter et al., 1967) no information regarding the true purpose of the experiment and the CS–UCS contingency was revealed to the *S*. *S*s did not display any awareness of a CS–UCS relationship according to our criteria of awareness, in the post-experimental interview (totally unaware). The visual evoked potential (VEP) data obtained in this experiment are illustrated in Figures 5, 6, and 7.

Experiment II

In the second experimental group, the *S*s were deliberately made aware that a relationship existed between the CS and UCS; however, the exact nature of this relationship was not divulged. The *S*s were interviewed at the end of the experiment. They reported that in the course of the conditioning procedure, they became aware of the correct CS–UCS contingency; however, none of the *S*s were aware of the true purpose of the experiment (slightly aware).

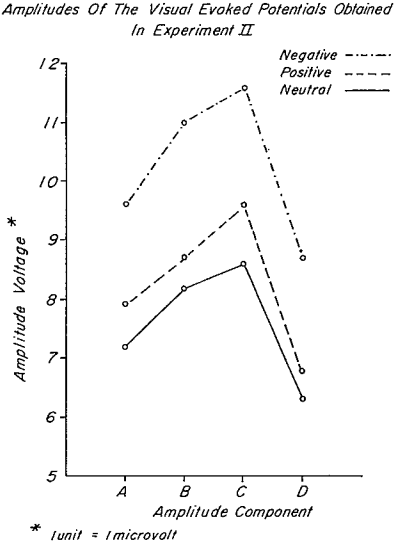

FIG. 1. Comparison of mean amplitudes of the visual evoked potentials to negative, positive and neutral conditioned stimuli in Experiment II (slightly aware *S*s). Differences in the three affective conditions for all amplitudes were statistically significant at the .01 level of probability.

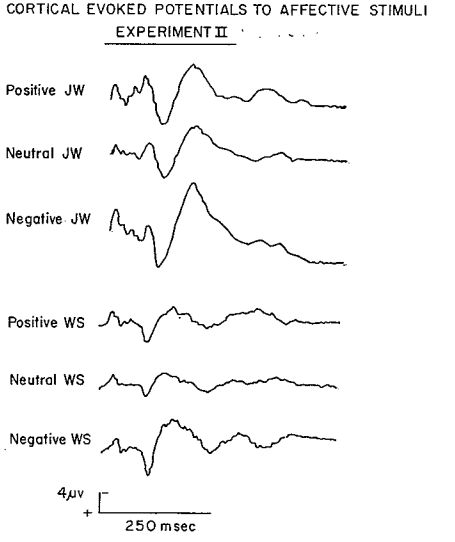

FIG. 2. Cortical evoked potentials to affective conditioned stimuli in two slightly aware *S*s (Experiment II). Most striking are the differences between the responses to the negative and neutral stimuli, particularly in amplitudes C and D. (Upward deflections are negative.)

TABLE 1

Characteristics of the visual evoked potentials obtained with pleasant, neutral, and unpleasant stimuli in experiment II

Stimuli	Amplitude*				Latency**			
	Measure	Mean	SD	*F*	Measure	Mean	SD	*F*
Pleasant		7.9	2.8			57.3	7.7	
Neutral	A	7.2	2.6	21.51†	I	59.3	8.0	NS
Unpleasant		9.6	3.6			58.6	7.7	
Pleasant		8.7	3.2			95.8	11.1	
Neutral	B	8.2	3.1	29.52†	II	96.3	11.4	NS
Unpleasant		11.0	3.5			97.6	11.4	
Pleasant		9.6	4.1			123.8	15.9	
Neutral	C	8.6	2.9	23.67†	III	125.1	15.8	NS
Unpleasant		11.6	4.7			126.0	17.1	
Pleasant		6.8	3.5			168.0	18.1	
Neutral	D	6.3	2.9	21.03†	IV	170.0	18.9	NS
Unpleasant		8.7	4.5			167.7	15.7	
Pleasant						217.2	12.1	
Neutral					Duration	218.8	14.4	NS
Unpleasant						220.0	14.6	

* Expressed in microvolts.

** Expressed in milliseconds.

† $p < .01$.

All amplitudes were significant across stimulus conditions. Subsequent analyses of differences in individual pairs of amplitude means yielded the following results: The pleasant and unpleasant conditions, and the neutral and unpleasant conditions differed significantly from each other for all amplitudes ($p < .01$). See Figures 1 and 2.

In contrast to the significant differences for latency measures obtained in Experiment I to the three affective stimuli, none of the latency differences were significant in this experiment. These results are shown in Table 1.

The IFI threshold means for all three conditions gave an F (2, 60) = 15.25, $p < .01$. Differences between the positive and negative conditions, and neutral and negative conditions were significant at $p < .01$. The difference between the positive and neutral condition was also statistically significant, $p < .05$. The SD mean ratings for all three stimuli yielded an F (2, 60) = 57.8, $p < .01$; all three means differed significantly from one another, $p < .01$.

Experiment III

Ss in the third experiment were explicitly informed before the conditioning trials of the correct CS–UCS contingency, and the true purpose of the experiment. The *Ss* indicated total awareness of every facet of the conditioning paradigm in the post-experimental interview (fully aware).

TABLE 2

Characteristics of the visual evoked potentials obtained with pleasant, neutral, and unpleasant stimuli in experiment III

Stimuli	Amplitude*				Latency**			
	Measure	Mean	SD	*F*	Measure	Mean	SD	*F*
Pleasant		7.9	2.6			58.6	7.4	
Neutral	A	7.6	1.7	NS	I	59.7	7.4	NS
Unpleasant		7.6	2.0			57.4	7.5	
Pleasant		8.5	3.4			92.8	9.3	
Neutral	B	8.0	4.2	NS	II	94.1	12.8	NS
Unpleasant		7.8	3.7			92.8	9.8	
Pleasant		7.8	3.1			122.5	15.2	
Neutral	C	8.3	3.6	NS	III	125.6	21.9	NS
Unpleasant		8.2	3.1			122.2	14.1	
Pleasant		6.1	2.4			161.5	21.4	
Neutral	D	6.2	3.5	NS	IV	175.0	23.1	NS
Unpleasant		6.3	2.7			160.0	18.7	
Pleasant						215.0	22.9	
Neutral					Duration	222.2	20.2	NS
Unpleasant						212.0	20.5	

* Expressed in microvolts.

** Expressed in milliseconds.

The results of Experiment III are summarized in Table 2. None of the characteristics of the VEP were statistically different across the three conditions. See Figures 3 and 4. The IFI and SD means were not statistically different across the three conditions.

Comparisons Across Experiments

The VEP amplitude data for the positive, negative and neutral conditions were compared across Experiments I, II, and III. The results are summarized in Table 3, and shown graphically in Figures 5, 6, and 7.

None of the differences in latencies to a given stimulus across Experiments I, II and III were statistically significant.

The analysis of variance for the IFI threshold means obtained under the three experiments did not yield significant F ratios.

The semantic differential mean ratings for each condition, positive, negative and neutral, were compared across the three experiments:

Positive Condition — F (2, 75) = 3.54, significant at $p < .05$. The means between Experiments I and III, and those between Experiments II and III differed significantly at $p < .05$. Negative Condition — F (2, 75) = 3.36, significant at $p < .05$. In this case the differences between Experiments I and III, and Experiments II and III were found to be significant at $p = .05$. Neutral Condition — F (2, 75) = .23, not significant at $p = .05$.

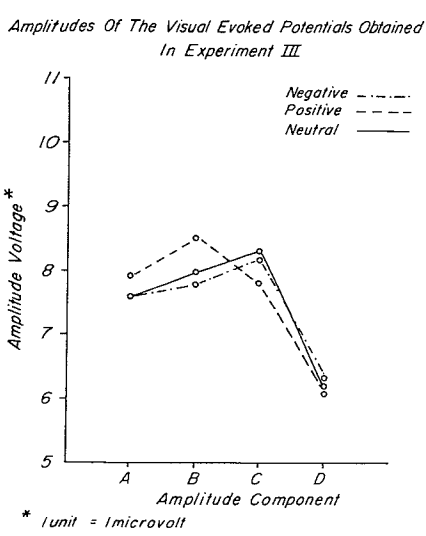

FIG. 3. Comparison of mean amplitudes of the visual evoked potentials to negative, positive and neutral conditioned stimuli in Experiment III (fully aware *S*s). Differences in the three affective conditions for all amplitudes were not statistically significant.

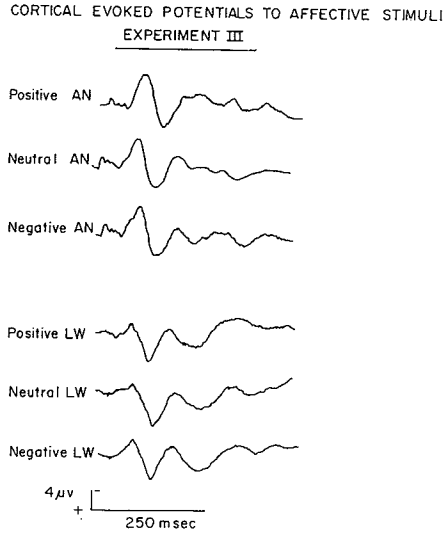

FIG. 4. Cortical evoked potentials to affective stimuli in two *S*s in Experiment III (fully aware). Note the intra-subject similarity of responses to all three affective stimuli. (Upward deflections are negative.)

TABLE 3

Summary results of anovas comparing the VEP amplitudes for the positive, negative and neutral conditions across experiments I, II and III

Amplitudes	Positive		Negative		Neutral	
	F (2, 60)	*p*	*F* (2, 60)	*p*	*F* (2, 60)	*p*
A	.52	NS	10.95**	.01	1.56	NS
B	.88	NS	12.17**	.01	.76	NS
C	4.57*	.01	12.50**	.01	.61	NS
D	5.29*	.01	19.98***	.01	.74	NS

* *t* significant at $p < .05$ between Expts. I and II.
** *t* significant at $p < .05$ between Expts. I and II, Expts. I and III.
*** *t* significant at $p < .05$ between all successive pairs.

DISCUSSION

Conditioning of the affective component of words (UCS) to previously meaningless figures (CS) was attempted using three different experimental procedures in order to manipulate the extent to which the *S* would be aware of the CS–UCS relationship during conditioning. The amount of information the *S* received prior to the conditioning procedure was carefully manipulated by the instructions, which were varied for each experimental group.

The physiological data suggest that the controlled manipulation of the state of awareness of the conditioning paradigm is clearly reflected in the amplitudes

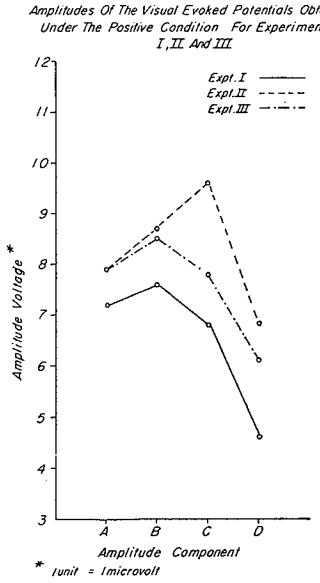

FIG. 5. Comparison of mean amplitudes of the visual evoked potentials to the positive stimulus in Experiments I (unaware), II (slightly aware), and III (fully aware). Differences in amplitudes C and D were significant at the .01 level of probability across experimental situations.

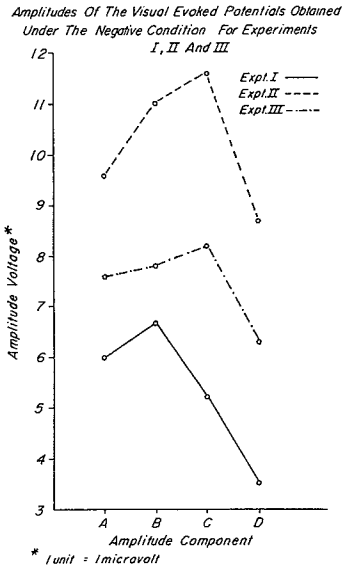

FIG. 6. Comparison of mean amplitudes of the visual evoked potentials to the negative stimulus in Experiments I (unaware), II (slightly aware), and III (fully aware). Differences for all amplitudes were statistically significant at the .01 level of probability across experimental situations.

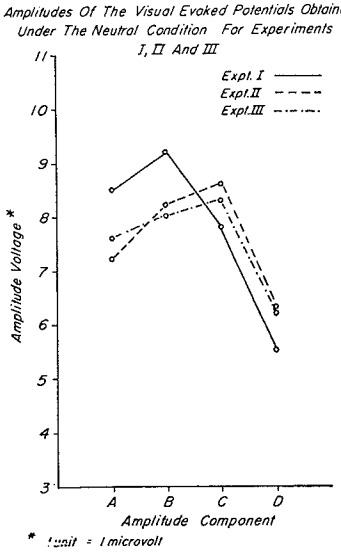

FIG. 7. Comparison of mean amplitudes of the visual evoked potentials to the neutral stimulus in Experiments I (unaware), II (slightly aware), and III (fully aware). Differences for all amplitudes across experimental conditions were not statistically significant.

of the VEP to the three CSs — each experimental group of *S*s responding quite differently from both the others. The effect on amplitudes seems to differ for each affective condition — hardly influencing responses to the neutral stimulus, and producing the most pronounced effect on the response to the negative figure. Of the three affective states (positive, neutral and negative), neutral comes closest to "no affect" — perhaps explaining why the VEP amplitudes to the neutral stimulus remained quite stable across the three experimental conditions, regardless of the awareness-unawareness dimension.

In the third experiment (fully aware), the amplitudes to both the positive and negative stimuli approximated those to the neutral figure in all three experiments, with no significant differences occurring among the three affective conditions. The neutral condition can almost be conceptualized as a baseline with regard to VEP amplitudes across the three experimental situations, and the evoked response data to the other affective conditions can be more meaningfully discussed using neutral as a point of reference.

Conditioning without the *S*'s awareness (Experiment I) seemed to have the general effect of suppressing responses to the positive and negative CSs to amplitude levels lower than that of the neutral condition; this decrease in VEP amplitudes was most marked to the negative figure. On the other hand, an overall enhancement of the VEP amplitudes above that of the neutral condition occurred in Experiment II — again affecting the negative responses to a greater extent than the positive. The net result was a reversal in order effect of the VEP amplitudes in Experiment II as opposed to Experiment I.

Studies dealing with attention and evoked response (Haider, Spong, & Lindsley, 1964; Sakano & Pickenhain, 1966; Satterfield, 1965; Spong, Haider, & Lindsley, 1965) have indicated that the second component of the evoked response reflects attentional shifts more clearly than the first component. Likewise, it should be noted on the basis of this study that the late component of the evoked response (amplitudes C and D) appears to be more sensitive to changes in information processing than the earlier component. A statistical comparison of Experiments I and II reveals that while all the amplitudes demonstrate the striking difference in the negative condition, only amplitudes C and D reflect significant differences in the positive response as well. It is suggested that the earliest evoked response events may reasonably be taken to reflect processes connected with the transmission of information into the nervous system, while the later events may be considered to reflect activities related to information processing.

On both behavioral indices of conditioning (IFI, SD) identical results were obtained in the first and second experimental groups. The positive CS elicited the lowest IFI threshold, and SD rating, while the negative CS yielded the highest.

The third experimental group (fully aware) did not demonstrate significant differences between affective CSs on any of the conditioning indices utilized.

Experiments attempting to deal with awareness of the reinforcement contingency must necessarily rely on subjective verbal reports of the *S*, as he is the only one in possession of this information. This dependence on the *S*'s verbalizations is based on the assumption that unless the *S* can correctly label the CS–UCS

contingency, he is not aware of it. A study by Levy (1967) demonstrated that the verbal report of the *S* is not always reliable, and it is often difficult to assess the extent of the *S*'s awareness. While, admittedly, a verbal interview with the *S* is not an ideal method to reveal the *S*'s awareness, the present study also used this procedure to assess awareness. However, additional support for the level of awareness of the *S* is tentatively given by our physiological data. Wieland, Stein, and Hamilton (1963) reported that it is possible to condition an increase in heart rate in anticipation of an electric shock without the *S* being aware of the CS–UCS relationship. *S*s who verbally reported awareness exhibited more conditioning and less generalization than those who did not. Although the experiment relied on the verbal report of the *S*, the physiological data differentiated the aware from the unaware *S*s. Similarly, in the present study a different pattern of VEP amplitudes was apparent, depending on the *S*'s level of awareness of the CS–UCS contingency.

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