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EVOKED CORTICAL RESPONSES TO AFFECTIVE VISUAL STIMULI

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ABSTRACT

The influence of affective meaning on visual evoked responses was investigated in male college students. By utilization of conditioning procedures, previously meaningless figures (CS) acquired affective loadings, e.g., positive, negative, and neutral. The semantic differential scale and critical flicker interval (CFI) were used as indices of conditioning. Although conditioning occurred without awareness, both measures of conditioning yielded results in the same direction, and all three affective conditions differed significantly from one another. Averaged evoked responses were obtained for each affective stimulus. Amplitudes were found to differ significantly from one another in all three conditions, the unpleasant stimulus eliciting the lowest evoked response, and the neutral condition evoking the highest amplitude. Significantly shorter latencies were obtained for the unpleasant stimulus, whereas the latencies of the positive and neutral stimuli did not differ significantly from each other. The results suggest a direct influence of the emotional centers (limbic system) on the visual perception of affective stimuli. Further studies were suggested to clarify the role of awareness and the specific modalities involved in conditioning.

DESCRIPTORS: Visual evoked potentials, Affect, Semantic conditioning, Critical flicker interval (H. Begleiter).

In recent years, a great many studies have focused on the relationship between the evoked response and its behavioral and experiential concomitants in humans.

Some investigators have reported inconsistent findings on the effects of attention on the cortical evoked response (Hernandez Peon & Donoso, 1959; Jouvet, Schott, Courjon, & Allegre, 1959; Geisler, 1960). However, Davis (1964) described an increase in the amplitude of the auditory evoked response in comparing it during reading and during a high effort discrimination task, whereas Gross, Begleiter, Tobin, and Kissin (1965) reported a significant increase in the amplitudes of the auditory evoked response during click counting as opposed to reading. Furthermore, Garcia-Austt, Bogacz, and Vanzulli and Haider, Spong, and Lindsley (1964) reported that increasing attention to a light stimulus resulted in increased amplitudes of the visual evoked response.

Chapman and Bragdon (1964) manipulated the visual stimuli and reported larger evoked responses to the relevant stimuli than to the irrelevant stimuli. Sutton, Braren, Zubin, and John (1965) reported differences in evoked potentials attributable to the *S*'s degree of uncertainty with respect to the sensory modality of the stimulus to be presented. They postulated that the evoked potential wave

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form may reflect two kinds of influences: one related to the character of the stimulus, the other related to the attitude of the *S* toward the stimulus. Finally, Brazier, Killam, and Hance (1961) reported a series of experiments demonstrating the influence of past experience on the reactivity of the brain to standard stimuli.

Dustman and Beck (1963) demonstrated the long-term stability of the visually evoked potentials in man. Furthermore, other investigators have established the validity of the visual evoked response recorded from the scalp of man being of cerebral origin and free from myogenic contamination (Katzman, 1964; Domino and Corssen, 1964; Kooi and Bagchi, 1964; Schwartz and Shagass, 1964; Domino, Matsuoko, Waltz, & Cooper, 1964).

The purpose of the present experiment was to investigate the nature of the responses evoked by the presentation of visual stimuli possessing different affective content. The experimental question is whether pleasant, neutral, and unpleasant stimuli have differential effects on the evoked response.

METHOD

Thirty-one male college students with a mean age of 19 yr were used as *S*s. After they received initial instructions emphasizing the need for concentration on the required tasks, electrodes were applied. The active monopolar lead was an electrode placed 2.5 cm above the inion and 2.5 cm to the right of the midline. The combination of the two ear lobes formed the reference electrode. The *S*s were then 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 PS2 photo stimulator was used; it was located 50 cm from the *S*'s eyes and set at an intensity of 8.

The stimulus used was a simple line figure devoid of meaning, resembling the over-all shape of an arrow. The stimulus could be rotated to three positions differing from its initial position by various angles: 90°, 180°, 270°. Only three distinguishably different forms of the stimuli were used in the study. Each rotational position of the figure was associatively conditioned to one of three affectively homogeneous sets of 20 words which were of positive, negative, or neutral value. Each of the three positions was randomly assigned to one of the three conditions.

Osgood and Suchi (1955) report that a large portion of the total variance in *S*s' judgment of meaning can be accounted for in terms of three factors of meaning: evaluative, potency, and activity. Words that were heavily loaded with the evaluative factor provided the meaning responses to be conditioned in the present study.

The *S*s were conditioned according to the method described by Staats and Staats (1957). The UCS words were taken from their word list. This method involved a series of maneuvers designed to establish conditioning while they diverted the *S*'s awareness away from the realization that he was being conditioned. The *S*s were told that they were to participate in an experiment concerned with studying two different types of learning, to see the effectiveness of each. One learning task was to concern geometric figures, and the other, words.

Four irregular and complex geometric figures were flashed in random order; each figure was presented four times. At the conclusion, the *S*s were instructed to reproduce on paper all the figures that they could recall.

The *S*s then had 20 words presented to them which they were to learn. Each word was presented orally by the *E* one time, with approximately 2-sec intervals between words. After the word was presented by the *E*, the *S*s were instructed to repeat the word aloud immediately and then continue to pronounce the word to themselves until the next word was given. The words were rather neutral, of no special type. 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 presented 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.

The *S*s were then told that the primary purpose of the experiment was to study "how both of these kinds of learning take place together." In order for the conditioning to take place without the *S*'s awareness, it became necessary to introduce a change in the original conditioning procedure. The *S*s had to be told that they had done poorly on recalling the words in the previous task; consequently, they were to pay careful attention to them in the task to follow. They were also told that they had done well with the geometric figures and that simple figures were now going to be used.

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

Immediately after the presentation of a visual CS, one of the 20 UCS words was pronounced by the *E*, after which the *S* repeated the words aloud. This procedure was randomly repeated for a total of 60 trials. The *S*s were told that they could learn the symbols by just looking at them, but that they should concentrate on pronouncing the words aloud and to themselves, since there would be many words, presented only once.

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.

After the conditioning procedure an averaged evoked response to 70 flashes was obtained for each of the three stimuli. The order of the three runs was randomized and the stimulus was presented at the rate of 1 stimulus every 1.5 sec.

The evoked response was displayed on an oscilloscope screen and photographed at different time bases from time zero to 250, 500, and 2500 msec. The EEG data were recorded by means of the Grass Model 7 polygraph, and the Model 7P5A wide band AC EEG amplifier, whose low frequency cut-off filter was set at 75 cps. The driver amplifier high frequency cut-off filter was set at 75 cps, and the 60-cps filter was on. The gain of the preamplifier was set to clip surges of activity greater than 100 μv referred to input.

Computation of the averaged evoked potentials was accomplished by means of the magnetic drum average response computer (MDARC) (Tobin, 1961). The system response is effectively limited by the MDARC, which responds from 3 to 50 cps.

Little has been written of the explicit criteria for the measurement of the characteristics of the human evoked response. Peak to peak or peak to trough measments have been described by several authors for determining amplitudes of the visual evoked response; the latency of peaks and troughs has also been described by these authors for determining the temporal characteristics.

Because of the complexity of the wave forms, the above criteria *per se* are often insufficient. For example, there is the problem of the configuration of those components that have negative peaks. Most often their configuration is relatively simple and resembles what Giblin (1964) alludes to in describing somatosensory responses as a V form; in others the configuration resembles what he has described as a W form. An additional problem in measurement arises from the fact that occasionally there is a plateau instead of a peak.

On the basis of our experience and that of others (Kooi and Bagchi, 1964) the following criteria have evolved: when a W configuration is present, the highest of the two peaks is chosen for the amplitude and latency determinations of that component. When a plateau is present, the midpoint is chosen for latency determination.

With the above exceptions, 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-peak 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 at approximately 220 msec, and four successive latencies measured from time zero (designated as 1 to 4).

After the visual evoked response determinations, the threshold of fusion of pairs of light flashes (critical flicker interval) was obtained by the method of

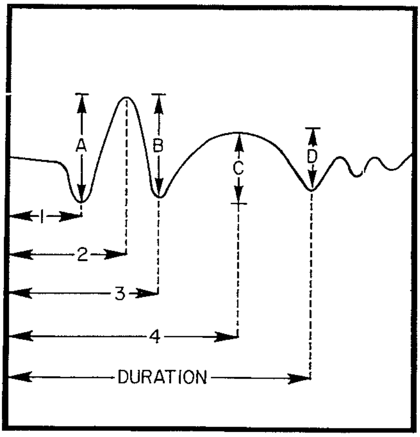

FIG. 1. Schematic illustration of response

limits for all three stimuli (CS), which were again presented in random order. Finally, the *S*s were asked to rate each (CS) figure on a semantic differential type scale (pleasant-unpleasant). Upon completion of the experiment, all *S*s were interviewed to determine their degree of awareness with regard to the conditioning.

RESULTS

The characteristics of the visual evoked response are summarized in Table 1. Analysis of variance for each of the four amplitudes of the evoked response obtained under the three experimental conditions yielded results as follows: amplitude A, F (2,60) = 23.86, $p<0.001$; amplitude B, F (2,60) = 22.79, $p<0.001$; amplitude C, F (2,60) = 19.66, $p<0.001$; amplitude D, F (2,60) = 28.87, $p<0.001$.

Analysis of differences in individual pairs of treatment means (Lindquist, 1953) yielded the following results: amplitudes A and D, all three conditions (pleasant, neutral, unpleasant) differ significantly from one another, $p<0.01$; amplitudes B and C, all three conditions differ significantly from one another, $p<0.02$.

Analysis of variance for each of the four latencies and durations obtained under the three experimental conditions yielded results as follows: latency I, F (2,60) = 9.33, $p<0.001$; latency II, F (2,60) = 8.38, $p<0.001$; latency III, F (2,60) = 17.04, $p<0.001$; latency IV, F (2,60) = 9.35, $p<0.001$; duration, F (2, 60) = 6.35, $p<0.001$.

Analysis of differences in individual pairs of treatment means yielded the following results. Differences between the positive and negative conditions and be-

TABLE 1

Characteristics of the visual evoked response obtained with pleasant, neutral, and unpleasant stimuli[a]

Amplitude

	A[b]			B			C			D		
	P	N	U	P	N	U	P	N	U	P	N	U
Mean....	7.22	8.54	6.00	7.61	9.22	6.67	6.80	7.78	5.19	4.58	5.51	3.54
SD......	3.24	3.49	2.71	3.38	4.06	3.25	3.27	3.10	2.55	1.88	2.08	1.24

Latency

	I			II			III			IV			Duration		
	P	N	U	P	N	U	P	N	U	P	N	U	P	N	U
Mean....	61.6	63.5	55.2	94.9	95.9	88.8	127.6	128.8	118.5	168.2	173.1	160.6	219.9	221.9	211.7
SD......	13.8	13.7	14.4	13.6	13.9	14.1	17.8	17.8	17.7	22.9	26.0	27.2	18.1	18.9	18.6

[a] Mean values for latencies are expressed in milliseconds. Mean values for amplitudes are expressed in raw scores; 10 = 4 μv.

[b] P = pleasant; N = neutral; U = unpleasant.

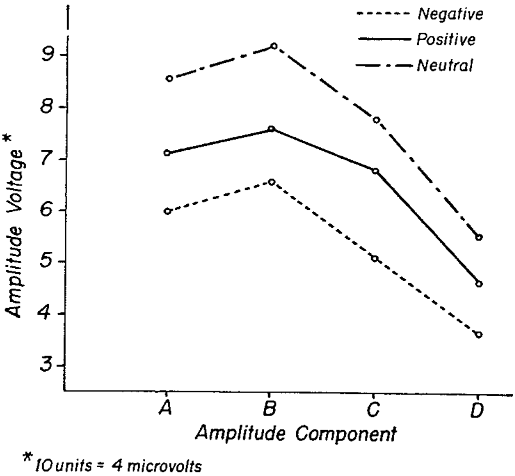

FIG. 2. Comparison of mean amplitudes of the visual evoked responses to the negative, positive, and neutral stimuli. Differences in amplitudes A and D were statistically significant at the 0.01 level of probability. Differences in amplitudes B and C were significant at the 0.02 level of probability.

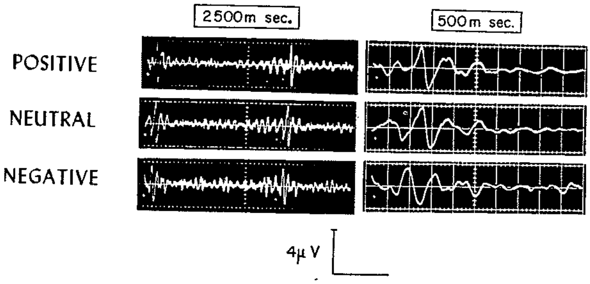

FIG. 3. The data illustrate the results of affective conditioning on the visual evoked response of a subject, and demonstrate most of the changes in amplitudes and latencies described in the text. Most striking are the lower amplitudes and shorter latencies of the response to the negatively loaded stimulus (downward deflections are positive).

tween the negative and neutral conditions were significant for all latencies and durations, $p<0.01$. Differences between the positive and neutral conditions were never significant.

The CFI threshold means for all three conditions are as follows: positive = 60.3 msec; neutral = 63.6 msec; negative = 67.8 msec; F (2,60) = 18.98, $p<0.001$. All three means differ significantly from one another, $p<0.01$.

The semantic differential mean ratings for the three figures are as follows: positive = 2.25; neutral = 4.16; negative = 5.54. The F ratio is significant at $p<0.01$, and all three means differ significantly from one another, $p<0.01$.

Finally, all subjects were questioned about the purpose of the experiments. None of the *S*s included in the present study indicated awareness of a relationship between the words and the visual stimuli.

DISCUSSION

The results of the present study demonstrate that affective meaning, grafted onto a visual stimulus without the individual's awareness, can significantly alter the cortical evoked response to that stimulus. Furthermore, each affective quality, positive, negative, or neutral, behaves differently in its effect on the visual evoked response. The findings have established significantly lower amplitudes for negative and positive stimuli compared to the neutral stimulus.

These results demonstrate that presentations of affective stimuli elicit neurophysiological changes which indicate that some connections between the visual system and the emotional centers exist. Many studies have established that in addition to olfactory functions, the limbic system is also implicated in emotional behavior and the regulation of neuroendocrine mechanisms (Papez, 1947; MacLean, 1949). Recently, Cuenod, Casey, and MacLean (1965) were able to demonstrate the presence of visual connections with the limbic cortex located in the retrosplenial region and posterior hippocampal gyrus, which in turn are a source of afferents to the hippocampus. In keeping with our results, it should be noted that in waking humans with electrodes implanted in the optic tract and visual cortex, Guerrero-Figueroa, Guerrero-Figueroa, and Heath (1964) observed a marked diminution of both potentials during a 1/sec repetitive stimulation of the midbrain reticular formation, which also produced emotional responses. These same authors obtained changes of retinal and cortical visual evoked potentials by appropriate verbal suggestion.

Since the significantly lower amplitudes for negative and positive stimuli, compared to the neutral stimulus, indicate some sort of inhibitory action for the affective stimuli, can one conclude that changes in the responses recorded at the scalp reflect changes in the number of cortical neurons responding to the stimulus?

Amassian, Waller, and Macy (1964) state that large surface responses can be recorded at a depth of anesthesia which reduces evoked discharge by cortical neurons. Therefore, it is suggested that the amplitude of surface potentials is a poor index of the number of discharging neurons. The authors mention that it is quite conceivable that the amplitude of the surface response may decrease when the number of discharging neurons increases. If such a change in state of consciousness occurred that the background level of excitatory bombardment of cortical neurons was increased, a test volley arriving at the cortex would then act upon membranes which were closer to the equilibrium potential of the excitatory postsynaptic potential. The net effect might be to increase the number of neurons which discharge, but to reduce the amplitudes of synaptic potentials, and consequently to reduce the amplitude of the surface response. It is concluded that the amplitude of the surface response is presumably a complex function of synaptic potentials and after-potentials in many cortical elements.

The present findings indicate significantly shorter latencies for the negative stimulus compared to the positive and neutral stimuli. This would suggest that the organism manifests vigilance for anxiety-producing stimuli, as reflected in the much shorter latencies for the negative stimulus. Perhaps this indicates facilitory activity involved in the speed of transmission, resulting from possible excitation of central arousal systems of the brain. It is suggested that an alerting stimulus may also be responsible for the provocation of the "orienting reflex" proposed by Sokolov (1960).

Although the subjects were not aware of the relationship between the UCS and the CS, the semantic differential scales indicate that conditioning had taken place, differentiating significantly between the positive, negative, and neutral conditions.

The results obtained with the two-flash resolution task are in agreement with the above findings, since all three conditions are significantly different from one another. Furthermore, the order effect is the same for both the semantic differential and the critical flicker interval.

It must be noted that the critical flicker interval threshold was lowest for the positive stimulus and highest for the negative stimulus, and the mean value for the neutral stimulus occupied a position of magnitude which fell between positive and negative. However, the mean values for the amplitudes and latencies of the visual evoked response exhibited a different order effect. At present, we have no valid explanation to offer for the discrepancy in order effect which exists between the critical flicker interval and the cortical visual evoked response.

In order to elucidate which of several possible mechanisms brought about the change in the cortical evoked response, we are presently investigating the role of specific modalities, and the effect of the subject's awareness of the conditioning.

Since Hernandez Peon, Jouvet, & Scherrer, (1957) predicted that the amplitude of sensory evoked potentials in the waking brain is related to the significance of the stimulus, a few studies have been able to confirm this relationship. However, in light ot our findings, it appears important to consider the amplitude of the cortical evoked potential not only as a reflection of the level of attention, but also as an indication of the affective value of the stimulus.

The relationship between the cortical evoked response and affect appears to hold great promise for a better understanding of the relation between the psychogenic determinants of perception and the accompanying neurophysiological events.

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