Effects of induced muscle tension upon the visual evoked potential and motor potential: A replication*

DAVID F. DINGES† and ROGER L. KLINGAMAN††
Saint Louis University, St. Louis, Mo. 63103

The effect of induced muscle tension (IMT) upon the visual evoked potential (VEP) and the motor potential (MP) was studied in three male Ss. Electrodes were placed at the motor area (C_3) and the visual area (O_2). The averaged evoked potentials were recorded over several sessions under the following four conditions: (A) light alone, (B) resting, (C) squeezing dynamometer alone, and (D) light plus squeezing. This study was done in response to a previous study (Andreassi, Mayzner, Beyda, & Davidovics, 1970), which reported enhancement of the visual and motor potentials due to IMT and attributed it to "the arousing influence of the ascending reticular activating system (ARAS)." Enhancement of VEP due to IMT was found in this study. Because a visual response is present at the motor area, apparent enhancement of the MP could be attributed to either a neural event or an algebraic summation of the MP and VEP. Subsequent research is proposed.

The effects of induced muscle tension (IMT) upon the visual evoked potential (VEP) in humans has been studied in two previous experiments. Eason, Aiken, White, & Lichtenstein (1964) measured VEPs to flashes of light while Ss maintained a continuous force of 25 lb on a handgrip. IMT increased the amplitude of the VEPs to light flashes. VEPs were also increased in another S after he engaged in 40 sec of physical exercise.

Andreassi et al (1970) expanded the experiment of Eason et al (1964) by measuring both VEPs and motor potentials (MPs) during an IMT task. Consistent with Eason et al (1964), they found that the VEP was of greater magnitude with IMT than with light alone and that MP was of greater magnitude under IMT plus light than IMT alone. Furthermore, they found what they termed a MP response at the vertex when only a light flash was presented. It seemed quite plausible to us that this was not a MP but, rather, a visual evoked response, since Vaughan (1969) reports finding a VEP at the vertex using only a light stimulus. We felt that the use of a Grass photostimulator, with its usual "click," could have produced a muscle artifact or an auditory evoked response which was interpreted by Andreassi et al (1970) to be a MP response. If this vertex response was indeed a visual response, then a reinterpretation of the Andreassi et al results would appear to be in order. The present experiment replicates that of Andreassi et al, using more precise control of the visual stimulus, and thereby confirms the existence of visual activity at the vertex, which may ultimately effect the decisiveness of a neural enhancement hypothesis.

*This research was partially supported by Research Grant MH 14020-03 from the National Institute of Mental Health to Donald I. Tepas.

†Requests for reprints should be sent to David F. Dinges, Department of Psychology, St. Louis University, 221 North Grand Blvd., St. Louis, Missouri 63103.

††The authors wish to thank Donald I. Tepas for reviewing this paper and P. Klingenberg for assistance in preparation of this manuscript.

METHOD

Three male graduate students ranging from 22 to 24 years of age served as Ss. Two were naive to expected findings. None had visual defects other than corrected myopia. All Ss were right-handed.

Practice sessions were run for each S in which evoked response potentials were obtained prior to actual data collection. Ss were seated in a dark shielded room. A Maxwellian two-channel viewing system produced the visual stimulus. One channel supplied a 1½-deg spot with intensity of 25,000 mL and a 30-msec duration. The other channel supplied a 17-deg blue surround with an intensity of 25 mL. Andreassi et al (1970) used intensity No. 1 of a Grass PS 2 photostimulator as their visual stimulus, while their Ss sat in a room with ambient illumination at eye level of 40 fc. By using the Maxwellian view system, the E did not have to record the electroculargram (EOG) for possible eye movement artifact in the electroencephalogram (EEG), as Andreassi et al had. The EEG was recorded by means of two silver Grass EC5 cup-disk electrodes placed at O_2 and C_3, according to the "Ten-Twenty" International System (Jasper, 1958). The O_2 and C_3 electrode leads were referred to a Beckman biopotential electrode on the left mastoid. A Beckman electrode placed on the S's forehead served as a ground.

EEG potentials were recorded on a Grass Model 7 polygraph and were fed into a PDP 8/I digital computer to compute average potentials. The two monopolar EEG activity recordings were summated, using a 750-msec analysis time. One hundred and twenty stimuli were presented, and the resulting waveforms averaged at a rate of 1/sec for each trial. Upon completion of a given trial, the computed waveforms were traced out on a Hewlett-Packard 7004A X-Y plotter. Conditions under which data were collected and the instructions given the Ss under each condition were essentially the same as Andreassi et al (1970). (A) Light alone—S was instructed to "fixate on the flashing light and minimize body movement." (B) Resting—S was instructed to "close your eyes and relax." (C) Squeezing alone—S squeezed a Stoelting dynamometer handle at 10 kg of force. A 70-dB SPL (re .0002 dyne/cm²) 30-msec pure tone, produced by a Grason-Stadler 1,200 auditory stimulator, occurred once per second to assist the S in squeezing the handle. S was instructed to "close your eyes and concentrate on squeezing the handle immediately after each tone occurs." The sweeps of the PDP 8/I were triggered 250 msec after the tone was delivered. Andreassi et al triggered their computer as soon as the dynamometer was squeezed hard enough to complete a circuit. (D) Squeezing and light—S was instructed to "fixate on the flashing light and squeeze the handle immediately after each tone occurs." The tone came on and S would squeeze immediately after he heard it. The tone was followed 250 msec later by the light flash. The onset of the flash triggered the computer. This differs from Andreassi et al (1970), who triggered the light flash and the computer simultaneously when the S squeezed hard enough to complete a circuit. Each S was run for three sessions. Each session consisted of 12 trials (four conditions repeated three times). The order of presentation of the conditions was counterbalanced (ACBD, CBAD, BDAC, etc.).

RESULTS

The mean amplitudes for each of the major components (N_1-P_1, P_1-N_2, N_2-P_2) of the evoked potentials were computed for each condition for each S. The mean amplitude of the N_1-P_1 component was measured as the

Table 1
Mean Amplitude (in Microvolts) for Two Recording Sites

		N_1-P_1	P_1-N_2	N_2-P_2
		Evoked Response from O_2		
A	(Light Alone)	2.38	5.01	8.28
C	(Squeezing Alone)	(Mean Activity of 4 Microvolts)		
D	(Squeezing and Light)	2.88	5.39	9.29
B	(Rest)	(Mean Activity of 3 Microvolts)		
		Evoked Response from C_3		
A	(Light Alone)	2.56	3.89	8.74
C	(Squeezing Alone)	3.67	4.18	7.81
D	(Squeezing and Light)	3.12	4.67	10.48
B	(Rest)	(Mean Activity of 3 Microvolts)		

vertical distance from N_1 (the first negative trough) to the peak of the first positive component (P_1), while P_1-N_2 was taken as the vertical distance between the peak of P_1 to the trough of N_2, the second major negative component. N_2-P_2 was measured as the vertical distance between the trough of N_2 and the second major positive peak, P_2.

The mean amplitudes (pooled for all three Ss) of the averaged microvolt activity for the major components of the waveforms, recorded from both O_2 and C_3, under all conditions are shown in Table 1. An obvious IMT effect is evidenced by the fact that Condition D (squeezing and light) yielded the largest evoked potentials from both recording sites, except for the N_1-P_1 component of the MP. This finding is consistent with the results of Andreassi et al (1970) and Eason et al (1964), indicating an enhancement of the VEP with IMT. The VEP N_2-P_2 component is increased from 8.28 mV of average activity for Condition A (light alone) to 9.29 mV of average activity for Condition D (squeezing and light), an increase of 12%. This compares to a 15% increase found by Andreassi et al. The N_2-P_2 component of the MP is increased from 7.81 mV average activity for Condition C (squeezing alone) to 10.48 mV average activity for Condition D, an increase of 34%. This compares to a 75% increase found by Andreassi et al.

Figure 1 shows the individual waveforms of S EB during a single experimental session. The comparison of Conditions A and C indicates that Condition A *produced* a definable response at C_3, while Condition C *did not produce* a definable response at O_2. Recordings from both O_2 and C_3 for Condition D reveal an increase in amplitudes, as compared with Condition A. The average resting activity from the visual area and the motor area was 3 mV.

DISCUSSION

The finding of the present study is that the VEP is greater in magnitude with IMT, Condition D, than with light alone, Condition A. This finding is consistent with previous literature and the enhancement hypothesis suggested by Andreassi et al (1970). This hypothesis suggests that enhancement of the VEP is due to the arousing influence of the ascending reticular activating system.

The fact that amplitude measure N_2-P_2 of the motor potential was of greater magnitude under squeezing and light than under the squeezing alone condition (an increase of 34%) is inconclusive, since the motor area C_3 shows visual activity present in the record, aside from any motor activity (see Fig. 1). The similarity between the responses at O_2 and C_3 for Condition A clearly suggests that this is a visual response and not the motor response that Andreassi et al found. The presence of visual activity at C_3 precludes any final statement about enhancement of the motor potential. This is not the case in the visual area, since motor activity does not appear to be present in the visual area activity. Any increase in the MP amplitude under Condition D may or may not be explained by the ascending reticular activating system hypothesis or any neurally based explanation, since the MP result for D could be due to an algebraic summation of the two separate responses. Thus, the results do not allow for a decisive enhancement conclusion regarding the MP, as Andreassi et al (1970) suggest. In fact, the results do suggest a relatively simple explanation for this enhancement: the strong possibility that no "neural" enhancement occurred but simply that the MP was composed of a MP response and a visual response that had "added" together. As long as the motor area is subject to the presence of the VEP under the light alone condition, it is difficult to conclude "enhancement" of the MP under the light and squeezing condition. We are currently

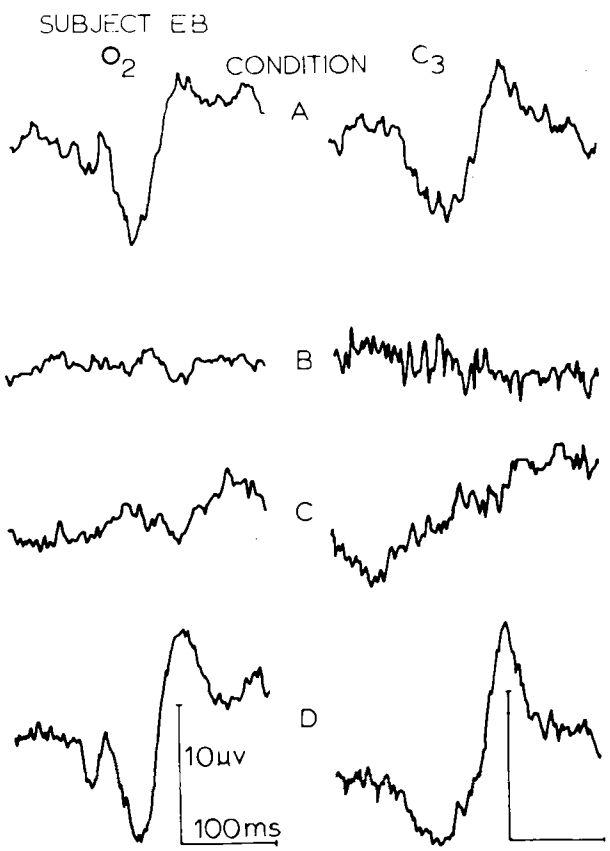

Fig. 1. Comparison of recordings from O_2 and C_3 for Conditions A (light flash alone), B (resting), C (squeezing alone), and D (light and squeezing). One session for S EB. Upward deflection represents a positive voltage at the active electrode.

conducting an experiment which should resolve the problem by subtracting the VEP under the light and squeezing condition and then comparing the MP under squeezing alone with the subtracted MP under light and squeezing.

REFERENCES

ANDREASSI, J. L., MAYZNER, E. S., BEYDA, D. R., & DAVIDOVICS, S. Effects of induced muscle tension upon the visual evoked potential and motor potential. Psychonomic Science, 1970, 20, 245-247.

EASON, R. G., AIKEN, L. R., WHITE, C. T., & LICHTENSTEIN, M. Activation and behavior: II. Visually evoked cortical potentials in man as indicants of activation level. Perceptual & Motor Skills, 1964, 19, 875-895.

JASPER, H. H. The ten-twenty electrode system of the International Federation. Electroencephalography & Clinical Neurophysiology, 1958, 10, 371-375.

VAUGHAN, H. G. The relationship of brain activity to scalp recordings of event-related potentials. In E. Donchin and D. B. Lindsley (Eds.), *Average evoked potentials.* Washington, D.C: NASA, 1969.