

AD-A051 329

NAVAL HEALTH RESEARCH CENTER SAN DIEGO CALIF  
VISUAL EVOKED POTENTIAL CHANGE DURING INFORMATION PROCESSING: C--ETC(U)  
APR 75 D M SEALES

F/6 5/10

UNCLASSIFIED

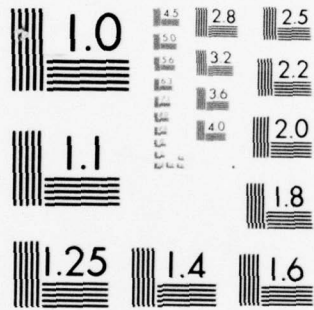
NAVHLTHRSCHC-75-29

NL

| OF |  
AD  
A051329




END  
DATE  
FILMED  
4 -78  
DDC



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

AD A 051329

6

VISUAL EVOKED POTENTIAL CHANGE DURING INFORMATION PROCESSING:  
CORRELATES OF COGNITION OR REACTIVE CHANGE.

2

9 Interim rept.

D. M. SEALES

20 David M. / Seales

11 Apr 75

12 33p.

14

NAVHLTHRSCHC  
REPORT NO. 75-29

AD No.  
DDC FILE COPY

26 MR 00001

27 MR 0000101

DDC  
MAR 16 1978  
RESOLVED  
F



NAVAL HEALTH RESEARCH CENTER

SAN DIEGO, CALIFORNIA 92152

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND

BETHESDA, MARYLAND

DISTRIBUTION STATEMENT A

Approved for public release;  
Distribution Unlimited

391 642

JOB

VISUAL EVOKED POTENTIAL CHANGE DURING INFORMATION PROCESSING: CORRELATE OF  
COGNITION OR REACTIVE CHANGE<sup>1</sup>

D. M. Seales

Psychophysiology Division, Naval Health Research Center, San Diego,  
California 92152 (U.S.A.)



<sup>1</sup>Experiment I of this work was carried out in partial fulfillment of the requirements for the degree, Doctor of Philosophy in Psychology, while the author was working within the Department of Psychology, University of California at Los Angeles. Experiment II was supported by the Bureau of Medicine and Surgery, Department of the Navy, under Work Unit MR000.01.01-6010.

The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or as reflecting the views of the Navy Department.

ACCESS	
1 IS	Section <input checked="" type="checkbox"/>
DDC	B H Section <input type="checkbox"/>
NAVY	<input type="checkbox"/>
DIS I CA ION	
PV	
DISTRIBUTION/AVAILABILITY CODES	
SPECIAL	
A	



Visual evoked potential (VEP) changes have been sought in relation to specific aspects of information processing such as whether a stimulus is a blank flash or a number (Chapman and Bragdon 1964), the word "circle" or "square" equated for area (John et al. 1967), a verbal or nonverbal stimulus (Buchsbaum and Fedio 1969, 1970), and a sense or nonsense syllable (Shelburne 1972, 1973). These types of variables are often referred to as "higher order" or "cognitive". However, the time period of the VEP during which cognition-related changes are generally reported to occur (200 to 600 msec) has been studied extensively in the past decade in relation to less specific aspects of information processing such as information delivery, stimulus significance, and shifts in expectancy and cortical arousal (see reviews by Karlin 1970; Tecce 1972; Tueting and Sutton 1973). Indeed, determining the precise influence of less specific aspects of processing is a continuous problem in the search for VEP correlates of cognition.

Lindsley et al. (1974) reported that potentials evoked by patterns changed when the patterns were assigned a "code-number" meaning. A late positive component (240 to 400 msec) decreased in amplitude and increased in half-period duration maximally at the occiput. Because this "P2-effect" was a decrease in amplitude occurring maximally at the occiput, the change seemed dissociable from both the CNV (Walter et al. 1964) and the P300 wave (Sutton et al. 1965), events which generally increase in amplitude maximally at or near the vertex in situations involving greater attention and stimulus significance.

The purpose of the present investigation was to determine more precisely the information processing correlates of the "P2-effect". Two experiments are reported. Experiment I employed recording techniques identical

to those of Lindsley *et al.* (1974) but used new subjects, stimuli and tasks. It was concerned specifically with whether the late positive component of the VEP would show an increased amount of change: (1) with increased task complexity, indexed by reaction time, and (2) over the hemisphere preferentially involved in either language (left) or visuospatial (right) information processing. Experiment II was the same as Experiment I except for one major change: the time constant of the EEG recording system was greatly increased. Experiment II investigated the occurrence and the influence of slow wave shifts (SWSs) in the information processing situations of Experiment I.

#### METHOD OF EXPERIMENT I

Subjects were 10 experimentally naive, right-handed, college males (ages 18 to 30 years), with normal or corrected vision. Each subject signed an "informed consent" form. Degree of handedness was determined after the experimental session by means of a questionnaire (Hécaen and Ajuriaguerra 1964). Subjects sat in a comfortable chair in a darkened, sound-attenuated, electrically shielded room in front of a computer-controlled remote display scope (DEC Model VR-12), with head positioned by a chin rest and a viewing hood. White noise masked extraneous sounds. The display area of the scope (12 cm by 18 cm) was uniformly and dimly illuminated to provide a constant adaptation level (4 log units above subjective threshold) and contained a centrally located, continuously lighted fixation cross. The stimuli consisted of letter-pairs (*e.g.*, BB, db, hH, Db) formed by green dot displays (2.7 log units above subjective threshold, with the adaptation field lighted). Letter-pair stimuli (0.7 by 1.2 degrees of visual angle 76 cm from the eyes) were presented foveally, with a duration of 1 msec. The

nominal inter-trial interval (ITI) between the simultaneous, side-by-side presentation of both letters of a letter-pair stimulus varied randomly between 2 and 4 sec, plus the time required by the subject's response.

The experimental situation was adapted from a study by Posner and Mitchell (1967). Subjects performed three tasks: SIGHT, SIZE, and NAME. The SIGHT task (always the first and last condition) was a simple reaction time situation. Subjects made a key response "as soon as" they saw the letter-pair stimulus. The SIZE and NAME tasks (counterbalanced as the second and third conditions) were choice reaction time situations. In the SIZE and NAME tasks, subjects indicated whether the two letters were "the same or different size" (upper or lower case), or had "the same or different names", respectively. Each of the four conditions consisted of 96 trials, with 48 practice trials before each SIGHT task, 96 before the SIZE and NAME tasks. Response was the slight dorsiflexion of either the index or middle finger to raise a lever attached to a microswitch.

Electrical activity was recorded on a Grass Model 6 electroencephalograph (80% down at 1 and 70 c/sec; t.c. = 0.12 sec). Grass gold cup electrodes were placed at O1, O2 and Cz of the International 10-20 electrode system as well as at two bilateral sites midway between P3 and C3 (this midway position noted here as "WL"), and between P4 and C4 ("WR"). These sites were chosen to overlie (approximately) visual association cortex bilaterally (O1, O2), midline motor cortex (Cz), and a section of Wernicke's area in the left hemisphere (WL; Brodmann's areas 39 and 40) as well as the homologous area of the right hemisphere (WR). Linked earlobes served as reference. Electrode resistance was between 5K and 10K ohms. EOG activity recorded from sites superior and lateral to the left eye measured both horizontal and vertical eye activity.



Data were recorded on EEG paper and on magnetic tape (Ampex FR-1300 tape recorder) for off-line analysis on a PDP-12 computer and accompanying Houston X-Y Plotter. EEG and reaction time data of trials affected by eye, muscle, incorrect response, or other artifact (approximately 12%) were deleted from analysis. Acceptable trials were digitized (256 points per sec), and were averaged together in 1-sec epochs (starting 50 msec before stimulus presentation) for each condition for each subject. In addition, individual subject averages were combined into composite averages of all 10 subjects. Prominent evoked potential components were chosen as P80-120, N150-170, P200-400 and N500-900. For purposes of statistical test (student's  $t$  with  $df = 9$ , and Wilcoxon's  $T$  with  $df = 10$ ) P200-400 was quantified in terms of: (1) peak positivity and (2) latency of the return to pre-stimulus baseline following peak positivity. All statistical tests were one-tailed unless otherwise stated. "Baseline" was the average amplitude value of the 50 msec of EEG immediately preceding stimulus presentation. Subjects did not make a sufficient number of mistakes to allow a separate evoked potential analysis of those trials associated with response error.

RESULTS OF EXPERIMENT I

Reaction time and task complexity. For every subject, reaction time increased through the SIGHT, SIZE and NAME tasks, implying that task complexity increased similarly. The reaction times of the 1st SIGHT and 2nd SIGHT conditions ( $304 \pm 67$  msec and  $313 \pm 57$  msec, respectively) were not significantly different ( $t = 0.723$ , two-tailed). The mean reaction time of the SIZE task ( $873 \pm 198$  msec) was significantly slower than that of the 1st SIGHT task ( $t = 9.226$ ), and the mean reaction time of the NAME task ( $1092 \pm 299$  msec) was significantly slower than that of the SIZE task ( $t = 4.704$ ).

The alpha level of significance (0.05) was divided by three, the total number of planned comparisons between means, according to the conservative method of Bonferroni (Miller 1966). The rank-order "T" statistic of the Wilcoxon Signed-Ranks test confirmed the results of the  $t$ -tests.

VEPs and cerebral lateralization of function. There were no significant hemispheric asymmetries in either the peak amplitude or the latency of return to baseline of P200-400 at either the occipital (O1, O2) or parietal (WL, WR) sites. In further analyses of Experiment I, VEPs from only the O1, WL and Cz recording sites are presented.

VEPs and task complexity. Fig. 1 illustrates comparisons of composite and individual subject VEPs of the 1st SIGHT (solid line) and the SIZE (dotted line) conditions. In the comparison of composite averages at O1 (top left), it is apparent that P200-400 changes in the SIZE condition, and that the manner of the change resembled the "P2-effect" of Lindsley *et al.* (1974) namely, a decrease in the amplitude and an increase in the half-period duration of the late positive component. In addition, in the present study, the latency of onset of the late positive component was slightly longer in the SIZE task. The "P2-effect" was evident also in the composite VEPs recorded from Wernicke's area (WL; top center). However, as in the original study, the effect was not as marked as at the occiput. The composite VEPs obtained from the vertex site (Cz) were qualitatively different from those observed at Wernicke's area (WL) and at the visual association cortex (O1). There was, however, a positive component which occurred at approximately the same time as P200-400 at the more posterior sites, and the composite VEP comparisons (top right) showed a reduction of this component in the SIZE task.



Table I presents the peak amplitude values and the latencies of return to baseline of P200-400 at the O1, WL and Cz sites as obtained from the VEPs of the 10 individual subjects. Of the various differences noted in composite VEPs between the 1st SIGHT and SIZE tasks, only the P200-400 amplitude change at O1 was statistically significant ( $t = 3.349$ ) at the 0.05/6 level of significance (6 tests: 1st SIGHT versus SIZE, and SIZE versus NAME at O1, WL and Cz). The change in latency of return to baseline at O1 approached but did not exceed the strict level of significance criterion. The Wilcoxon Signed-Ranks test confirmed these results. In Fig. 1, the VEP averages of subject LD (bottom row) are most representative of the changes seen in the composite averages. Those of subject TG (middle row) are least representative. At all electrode locations, P200-400 activity during the NAME task was not significantly different from that during the SIZE task (NAME task VEPs not illustrated).

One further difference in the VEPs recorded during the 1st SIGHT and SIZE conditions was a shifting of the long-latency N500-900 component toward longer peak latency in the SIZE task. This occurred at all sites in 7 subjects and at the vertex site in the remaining 3. The N500-900 shift can be seen in the VEPs of subjects LD and TG of Fig. 1.

#### DISCUSSION OF EXPERIMENT I

The results of the present experiment do not indicate that any specific aspect of cognitive information processing causes or is correlated with the P200-400 change even though the change takes place undoubtedly at the same time as cognitive information processing. The P200-400 component decreased in amplitude significantly at the occiput, and showed a trend at that site toward an increase in half-period duration. These two changes occurred to

an equal extent in both the SIZE and NAME tasks, and were symmetrically distributed. The symmetry of the change in both tasks indicates that the "visuospatial" and the "language-related" aspects of these discrimination tasks play little or no role in the production of the change. This interpretation is supported by the bilaterally symmetrical nature of the "P2-effect" in the Lindsley et al. (1974) study in relation to the processing of simple patterns both as figures devoid of handy verbal description and as figures associated with a (verbal) number-code. The observation that the added complexity of the letter-name discrimination task does not affect the degree of the P200-400 change is further support for the interpretation that the P200-400 component is not influenced by whatever cognitive processes characterize and distinguish between the SIZE and NAME tasks. In all, the P200-400 change has been observed in five complex information processing situations: the SIZE and NAME tasks of the present experiment, and the three tasks of the Lindsley et al. (1974) experiment in which subjects performed a pattern discrimination, learned a pattern-number-code association, and "read out" the learned pattern-number-code association. The fact that the P200-400 change has been essentially the same in all five of these tasks is evidence in itself that the change is not related to the specific cognitive requirements of any individual task.

At this point it may be helpful to change tack, and view the P200-400 change in terms of a more general aspect of information processing such as reactive change of cortical arousal (Karlin 1970). When viewed in terms of the reactive change hypothesis, the three tasks of Experiment I reduce to two psychological situations. The SIGHT task is one situation where stimulus reception and immediate response conclude a trial. This results in the

rapid lowering ("reactive change") of cortical arousal. The SIZE and NAME tasks are the other psychological situation. Stimulus reception initiates a relatively prolonged period of information processing, terminated by a finger response. It seems reasonable to suspect that these two psychological situations produce different types of shifts in cortical arousal and in expectancy, along with the cognitive information processing. Unfortunately, the fast time constant of Experiment I (0.12 sec) and the restricted analysis epoch (1000 msec) did not allow an evaluation of the P200-400 change in terms of the SWSs generally associated with changes in cortical arousal and expectancy. Experiment II was performed to determine the occurrence and the influence of SWSs in the information processing situations of Experiment I.

#### METHOD OF EXPERIMENT II

The major methodological difference between Experiment I and Experiment II was the lower frequency response of the EEG recording system in the second experiment. Bandpass was 50% down at 0.02 and 50.0 c/sec (t.c. = 8 sec) instead of 80% down at 1 and 70 c/sec (t.c. = 0.12 sec). Beckman Biominature electrodes (suitable for low frequency recording) were used instead of Grass gold cup electrodes. In addition, the analysis epoch was lengthened to 4200 msec: 2050 msec of pre-stimulus EEG and 2150 msec of post-stimulus EEG. Because of the 2 to 4 sec ITIs, this analysis epoch created an overlap in the averaged VEP between the post-stimulus activity of one trial and the pre-stimulus activity of the next. Overlaps ranged from a maximum of approximately 1800 msec to none at all. Although inadequate from the point of view of time locking, this procedure was designed to include in each averaged VEP the predominant trend of the slow wave activity throughout each condition before and after each stimulus presentation.



Separate measures of SWS amplitude were obtained for the pre- and post-stimulus activity. The pre-stimulus measure was taken from the 400 msec at the beginning of the analysis epoch to the 400 msec just before the stimulus. The post-stimulus measure was taken from the 50 msec just before the stimulus (as in Experiment I) to the 200 msec of maximum negativity (excluding N150-170) following the stimulus. The "baseline" illustrated in Fig. 1 and 2 corresponds to the average value of the 50 msec preceding stimulus presentation.

Minor differences in methodology occurred because Experiment II was performed in a different laboratory. Subjects were 10 Navy enlisted men (ages 17 to 21 years). A different handedness questionnaire was used (Croviitz and Zenner 1962). Subjects viewed the monitor scope (19 cm by 14 cm) of a closed-circuit TV system which provided an adaptation field and a fixation point. The letter-pair stimuli consisted of white dots on the monitor scope screen. All subjects received the tasks in the order SIGHT, SIZE, NAMÉ, SIGHT.

EEG was amplified by a Beckman Dynograph Type R polygraph, and was filtered through Krohn-Hite analog filters (Model M30-B) before being recorded by a Hewlett-Packard tape recorder (Series 3907-C). Due to the requirement in this experiment for uncontaminated EEG in the 2 sec both preceding and following stimulus presentation, from 21% to 71% of the 96 trials in each condition were deleted from analysis.

#### RESULTS OF EXPERIMENT II

Reaction time and task complexity. The reaction time results of Experiment II were essentially the same as those of Experiment I, indicating that the information processing tasks were accurately reconstructed in the different laboratory setting of Experiment II.

Slow wave shifts and the P200-400 change. SWSs occurred throughout the evoked potential averages of all subjects. Fig. 2 illustrates composite and individual subject VEPs of the 1st SIGHT (solid line) and SIZE (dotted line) conditions at the O1, WL and Cz electrode sites. In the 2050 msec preceding stimulus presentation, some subjects showed negative-going EEG, some showed essentially level EEG and others slightly positive-going EEG. A single value was obtained for each subject by summing the pre-stimulus amplitude values across the five electrode sites and the four conditions. In Table II (upperhalf), subjects are rank-ordered from those at the top with greatest overall pre-stimulus negativity to those at the bottom with least. Note that the 4 subjects whose averaged VEPs are illustrated in Fig. 2 ranked first, fourth, eighth and tenth in overall pre-stimulus negativity.

The largest and most consistent negative-going SWSs occurred following stimulus presentation. These shifts were observed as the N500-900 component of the Experiment I VEPs, but were truncated there by the fast time constant. Table II (lower half) gives amplitude values of the post-stimulus SWSs as derived from the averaged VEPs of Fig. 2.

The P200-400 change was evident in the composite averages (Fig. 2) in much the same form as in Experiment I. However, neither characteristic of the P200-400 change (decrease in amplitude; increase in half-period duration) was significant at any electrode site.

#### DISCUSSION

Experiments I and II investigated the information processing correlates of the "P2-effect" (Lindsley et al. 1974). This change originally appeared to be related to task complexity and thereby to cognition. When an



unsuccessful attempt was made to correlate the change with task complexity and with lateralized cerebral processing (Experiment I), it became apparent that the change is related to more general aspects of processing such as arousal and expectancy. Experiment II sought and found SWSs in the paradigms of Experiment I. It is concluded that the "P2-effect" (the P200-400 change) can be explained adequately in terms of shifts in cortical arousal and in expectancy, without reference to specific aspects of cognitive information processing.

Experiment II revealed a subtle pattern of SWSs unobservable in Experiment I. For example, subject TT (Fig. 2) showed a negative-going SWS preceding stimulus reception. This was followed by post-stimulus positivity. Finally, there was a negative-going SWS similar in form and amplitude distribution to the CNV, preceding response. Contrast this record with that of subject MB (Fig. 2). Here, the only deviation from baseline was the post-stimulus positivity. The negative-going SWS which did occur following stimulus reception proceeded only as far as the pre-stimulus baseline. This comparison suggests that subjects performed with individually variant ranges of cortical arousal. In terms of the CNV "ceiling" hypothesis (Knott and Irwin 1973; Low and Swift 1971), subject TT worked well below his neurophysiological CNV "ceiling" and showed a relatively wide range of SWSs. Subject MB, on the other hand, maintained a level of cortical arousal constantly near his maximum ability or motivation to produce shifts in the negative direction. Other subjects showed intermediate ranges.

With the concept of ranges of cortical arousal in mind, it is possible to explain the P200-400 change and some of its inter-subject variability. In the SIGHT task, the post-stimulus average consisted generally of a

positive component (200 to 300 msec) usually of a sharp "V" shape, and of a negative-going component (300 to 450 msec) which sometimes attained pre-stimulus baseline. The reactive change hypothesis predicts this sharp positive deflection soon after stimulus reception; the large amplitude at the occiput possibly results from summation with the late positive wave of the input-specific VER. However, the hypothesis also predicts that the positivity will be sustained for some time until mental preparation for the next trial. In the results of Experiment I, the fast time constant (0.12 sec) would not have allowed the accurate recording of such a sustained positivity. Control studies in Experiment II determined that the physical act of responding ( $296 \pm 43$  msec) contributed to the negative shift at 300 to 450 msec. Following this negativity, however, there was the predicted shifting of the EEG in the positive direction for subjects such as TT, MC and KS (Fig. 2, solid lines). Subject MB, with presumably the highest sustained level of cortical negativity throughout the experiment, showed only a trace of this 300 to 450 msec negativity (at Cz). His EEG then returned in the negative direction to the sustained baseline, in preparation for the next stimulus.

The psychological situation was quite different in the SIZE and NAME tasks. Subjects processed the information delivered by each letter-pair stimulus before deciding and responding "same" or "different". The general pattern of the averaged VEP following stimulus reception was a positive wave quite variable in amplitude, shape and width (200 to 550 msec) followed by a clearly observable negative-going SWS preceding response. Closer examination of the SIZE task post-stimulus positivity revealed that it sometimes occurred in the form of two positive peaks separated by a negative peak

(Fig. 2: KS, OI; MB, Cz; dotted lines). The first positive peak was usually a sharp, V-shaped wave (200 to 300 msec) much like that observed in the SIGHT task. The second positive peak (300 to 550 msec) was generally broader, trailing off into the aforementioned negative-going SWS preceding response ( $796 \pm 104$  msec). This second component resembled the late positive component (LPC) of Ritter and Vaughan (1969) in both shape and latency. It is the variable occurrence of the second positive peak which probably accounts for the original report of the "P2-effect". The influence of the second positivity is to increase the width of the entire complex of post-stimulus positivity in the composite (and in some individual) VEPs of the SIZE and NAME tasks. Of all the changes observed in the present data, the LPC is the most likely correlate of cognitive information processing. Karlin (1970) however, explained the LPC as possibly a momentary mental relaxation or lapse because the subject knows no new stimulus will arrive before a response is made.

The other characteristic of the P200-400 change, the decrease in amplitude, is more difficult to explain. The pre-response negativity appears to be part of the explanation. Loveless (1973) and Rebert (1974) concur that a CNV arises at a latency of 365 to 400 msec following stimulus reception. Wilkinson and Spence (1973) show a CNV arising at 200 to 300 msec in a situation of continued expectancy. And Karlin and Martz (1973) show a lower amplitude positivity (greater negativity) at about 300 msec in a situation of continued expectancy. In Fig. 2, the SIZE task VEPs of subjects TT, MC and KS show the LPC aspect of the post-stimulus positivity raised varying amounts in the negative direction by the developing pre-response negativity. This, however, does not explain why positivity as early as 200 msec becomes



rounded and smaller in amplitude. This aspect of the P200-400 change appears to be an artifact of averaging individual subject VEPs into a composite VEP. Only 3 of 10 subjects showed rounding of the post-stimulus positivity into a single, wide wave. And for these 3 subjects, amplitude was not decreased. Thus, it appears that the precise point of reactive change becomes more variable when information must be extracted from a stimulus. Donald (1970) demonstrated that the latency of post-stimulus CNV resolution becomes longer as the subject's involvement with a stimulus becomes more complex.

Two aspects of the results of Experiment II are at variance with the arousal interpretation. First, the LPC occurs in the SIGHT task VEPs of some subjects (Fig. 2, subjects MC and MB, Cz). Second, the large negativity preceding response in the SIZE and NAME tasks appears to a lesser degree at a comparable latency in the SIGHT task VEPs (Fig. 2, WL, composite average). These infrequent events in the SIGHT task VEPs are possibly the result of a troublesome fact of information processing investigations: subjects think. Subjects may have thought about the letter-pair stimuli after responding to their presentation in the SIGHT task. Some subjects reported such mental activity, but records of subjective comments were not considered reliable enough for systematic analysis.

The interpretation of the P200-400 change in terms of reactive change of cortical arousal and in terms of expectancy has ramifications for other investigations of evoked potentials and cognition. Tueting and Sutton (1973) discuss whether the post-stimulus positivity known as the P300 wave occurs independently of CNV resolution, in combination with it, or indeed at all. The question of CNV-P300 dissociability may have been settled

affirmatively by the demonstration of variations in amplitude of P300 waves with pre-stimulus CNV amplitude held constant (Donald and Goff 1971; Donchin *et al.* 1972). But Wilkinson (1974) suggested that a new element be considered in this discussion: the degree to which the psychological situation surrounding the reception of a stimulus tends to resolve the pre-stimulus level of cortical arousal. That is, equal amplitude CNVs may not be resolved always to the same extent. The results of Experiment II demonstrate (as did those of Karlin and Martz 1973; Wilkinson and Spence 1973) that continued or noncontinued expectancy following stimulus reception is one circumstance which substantially alters the pattern and degree of post-stimulus positivity.

Further, Experiments I and II demonstrate the manner in which a short time constant and/or a short analysis epoch may lead to misinterpretation of results. A short time constant does not allow the full and accurate expression of SWSs. One may conclude from the artifactual absence of SWSs that arousal and expectancy remain constant when they do not. A short analysis epoch does not allow determination of a subject's inter-trial or "resting" level of EEG. One may conclude (and usually does) that the few milliseconds of EEG preceding stimulus reception represent "baseline" activity when they often do not. One may also assume erroneously that all subjects perform at the same relative level of cortical arousal, and thus ignore an important source of individual variation.

Finally, the present work may be of help to others involved specifically in the search for VEP correlates of cognitive information processing. Shelburne (1972, 1973), for example, reported a VEP change quite similar to the P200-400 change. He related his finding to the subject's "decision



making process", and ruled out the influence of CNV resolution partly because the maximal differences did not occur until 450 to 500 msec following stimulus presentation. Alternatively, the late positive enhancement could be explained, as in the present study, in terms of reduction of the level of cortical arousal sustained throughout the rather long trials. Since the low frequency pass of the recording system in both studies was already sufficiently low (0.1 c/sec), the cortical arousal hypothesis could be investigated by extending the analysis epoch to search for each subject's resting level of EEG. Otto (1974) reported a prolonged positive shift in a situation involving cognition. He interpreted it as a "protected P300". Thinking in terms of cortical arousal between and throughout trials, it seems equally reasonable to interpret the variable post-stimulus positivities as momentarily reduced cortical arousal. In short, variations in cortical arousal and in expectancy must be investigated in more detail as they relate to VEP changes during cognitive information processing.

## SUMMARY

1. Two experiments investigated a change in the late positive activity (200 to 550 msec) of the visual evoked potential (VEP). This "P2-effect", maximal at the occiput, appeared related to cognitive aspects of information processing. Results did not support an interpretation of the P2-effect in cognitive terms (Experiment I) but rather in terms of shifts in cortical arousal and in expectancy (Experiment II).
2. In both studies, subjects viewed letter-pair stimuli, e.g., HH or bD, responding when they saw a stimulus (SIGHT task), or when they determined whether the two letters were the same or different in either size or name (SIZE and NAME tasks). EEG was recorded from vertex and from homologous bilateral occipital and parietal sites.
3. Reaction times increased from the SIGHT to the SIZE to the NAME task, objectifying the increase in task complexity.
4. The P2-effect occurred with the increase in task complexity from the SIGHT to the SIZE task, but did not increase further in the NAME task or show asymmetry in relation to lateralized processing. In Experiment II, slow wave shifts were observed during and surrounding the trials of Experiment I. These slow waves revealed subject-specific ranges of cortical arousal. The P2-effect appeared to result primarily from continued or non-continued expectancy following stimulus reception.
5. This work demonstrates the difficulty involved in controlling for and evaluating the effects of shifts in cortical arousal and in expectancy during cognitive information processing. The results are relevant to the question of CNV-P300 dissociability, and support alternate explanations of previously reported VEP changes.

**ACKNOWLEDGMENTS**

The author wishes to express his appreciation to Drs. Laverne C. Johnson, Ardie Lubin, and LCDR John F. House, MSC, USN, for their advice in the preparation of this manuscript.

## REFERENCES

- Buchsbaum, M. and Fedio, P. Visual information and evoked responses from the left and right hemispheres. Electroenceph. clin. Neurophysiol., 1969, 26: 266-272.
- Buchsbaum, M. and Fedio, P. Hemispheric differences in evoked potentials to verbal and nonverbal stimuli in the left and right visual fields. Physiol. and Behav., 1970, 5: 207-210.
- Chapman, R. and Bragdon, H. Evoked responses to numerical and non-numerical visual stimuli while problem solving. Nature, 1964, 203: 1155-1157.
- Crovitz, H. F. and Zenner, K. A group-test for assessing hand- and eye-dominance. Amer. J. Psychol., 1962, 75: 271-276.
- Donald, M. W. Direct-current potentials in the human brain evoked during *timed cognitive performance*. Nature, 1970, 227: 1057-1058.
- Donald, M. W. and Goff, W. R. Contingent negative variation and sensory evoked responses: Their interaction and relationship to auditory discrimination. Electroenceph. clin. Neurophysiol., 1973, Suppl. 33: 109-117.
- Donchin, E., Gerbrandt, L. K., Leifer, L. and Tucker, L. Is the contingent negative variation contingent on a motor response? Psychophysiology, 1972, 9: 178-188.
- Hécaen, H. and Ajuriaguerra, J. Left-handedness: Manual Superiority and Cerebral Dominance. Grune and Stratton, New York, 1964: 24.
- John, E. R., Herrington, R. N. and Sutton, S. Effects of visual form on the evoked response. Science, 1967, 155: 1439-1442.
- Karlin, L. Cognition, preparation, and sensory-evoked potentials. Psychol. Bull., 1970, 73: 122-136.
- Karlin, L. and Martz Jr., M. J. Response probability and sensory-evoked



- potentials. In S. Kornblum (Ed.), Attention and performance IV. Academic Press, New York, 1973: 175-184.
- Knott, J. R. and Irwin, D. A. Anxiety, stress and the contingent negative variation. Arch. gen. Psychiat., 1973, 29: 538-541.
- Lindsley, D. B., Wilson, G. F. and Seales, D. M. Brain potentials and information processing. Electroenceph. clin. Neurophysiol., 1974, 36: 213. (Abstract)
- Loveless, N. E. The contingent negative variation related to preparatory set in a reaction time situation with variable foreperiod. Electroenceph. clin. Neurophysiol., 1973, 35: 369-374.
- Low, M. D. and Swift, S. J. The contingent negative variation and the "resting" D. C. potential of the human brain: Effects of situational anxiety. Neuropsychologia, 1971, 9: 203-208.
- Miller, R. G. Simultaneous statistical inference. McGraw-Hill, New York, 1966: 67-70.
- Otto, D. A., Houck, K., Finger, H. and Hart, S. Event related slow potentials in aphasic, dyslexic, and normal children during pictorial and letter-matching. Proc. 3rd Int. Cong. on Event Related Slow Potentials of the Brain, 1974, in press.
- Posner, M. I. and Mitchell, R. F. Chronometric analysis of classification. Psychol. Rev., 1967, 74: 392-409.
- Rebert, C. S. Vertex waves. CNV latency, and the completion of sensory tasks. Paper presented at the International Symposium on Cerebral Evoked Potentials in Man, Brussels, April, 1974.
- Ritter, W. and Vaughan Jr., H. G. Averaged evoked responses in vigilance and discrimination: A re-assessment. Science, 1969, 164: 326-328.



- Shelburne Jr., S. A. Visual evoked responses to words and nonsense syllable stimuli. Electroenceph. clin. Neurophysiol., 1972, 32: 17-25.
- Shelburne Jr., S. A. Visual evoked responses to language stimuli in normal children. Electroenceph. clin. Neurophysiol., 1973, 34: 135-143.
- Sutton, S., Braren, M., Zubin, J. and John, E. R. Evoked potential correlates of stimulus uncertainty. Science, 1965, 150: 1187-1188.
- Tecce, J. J. Contingent negative variation (CNV) and psychological processes in man. Psychol. Bull., 1972, 77: 73-108.
- Tueting, P. and Sutton, S. The relationship between pre-stimulus negative shifts and post-stimulus components of the averaged evoked potential. In S. Kornblum (Ed.), Attention and performance IV. Academic Press, New York, 1973: 185-207.
- Walter, W. G., Cooper, R., Aldridge, V. J., McCallum, W. C. and Winter, A. L. Contingent negative variation: An electric sign of sensori-motor association and expectancy in the human brain. Nature, 1964, 203: 380-384.
- Wilkinson, R. T. The effect of selective attention upon CNV resolution and the stimulus related evoked potential. Paper presented at the International Symposium on Cerebral Evoked Potentials in Man, Brussels, April, 1974.
- Wilkinson, R. T. and Spence, M. T. Determinants of the post-stimulus resolution of contingent negative variation (CNV). Electroenceph. clin. Neurophysiol., 1973, 35: 503-509.

TABLE I

(Exp. I) Peak amplitudes (microvolts) and latencies of return to baseline (msec) of P200-400 at O1, WL and Cz for the 10 subjects.

Subject	Amplitude					
	O1		WL		Cz	
	1st SIGHT	SIZE	1st SIGHT	SIZE	1st SIGHT	SIZE
KH	5.2	4.4	8.4	7.1	7.8	6.6
DJ	9.5	7.8	4.4	4.4	2.2	3.8
JH	8.2	7.6	7.9	6.1	7.6	8.3
PG	6.1	4.7	5.0	4.1	3.3	5.1
DB	4.4	3.3	3.8	3.4	1.6	3.8
RS	10.0	7.8	4.6	5.6	8.3	4.0
TG	3.2	4.0	5.2	2.7	8.7	5.0
LD	9.8	7.3	8.3	7.9	11.1	7.6
MT	9.5	7.7	7.0	5.6	4.1	5.7
PA	6.1	0.9	1.8	3.5	2.8	2.7
Mean	7.2 *	5.6	5.6	5.0	5.8	5.3
S.D.	2.5	2.4	2.2	1.7	3.3	1.8

Subject	Latency (of return to baseline)					
	O1		WL		Cz	
	1st SIGHT	SIZE	1st SIGHT	SIZE	1st SIGHT	SIZE
KH	364	556	404	524	340	512
DJ	364	400	228	232	288	220
JH	340	408	356	384	308	344
PG	440	356	348	332	308	316
DB	420	436	440	424	208	220
RS	336	540	312	368	312	336
TG	240	656	300	404	300	408
LD	348	444	340	376	364	372
MT	444	448	436	420	320	416
PA	324	216	288	280	300	216
Mean	362	446	345	374	305	336
S.D.	61	120	68	81	41	98

\*Significantly different at the .05/6 level.

TABLE II

(Exp. II) Average maximum amplitudes (microvolts) of pre- and post-stimulus slow wave shifts at O1, WL and Cz for the 10 subjects. Subjects rank-ordered from most overall pre-stimulus negativity (TT) to least (MB).

Subject	Pre-stimulus SWS					
	O1		WL		Cz	
	1st SIGHT	SIZE	1st SIGHT	SIZE	1st SIGHT	SIZE
TT	-4.0	-2.3	-5.9	-6.6	-2.6	-5.2
CC	-1.8	-1.4	-1.6	-0.9	-2.3	-1.3
MT	+0.9	+2.6	+1.5	+0.6	-2.4	-0.8
MC	+0.5	+0.2	-0.9	-4.3	-3.9	-2.9
RD	-0.2	-0.3	+0.1	+0.2	-0.4	+0.8
ER	-0.1	+0.6	-0.6	-0.5	+0.5	-0.4
BK	-0.8	-1.9	+0.7	-1.4	+0.7	-1.6
KS	+1.8	+0.7	+1.9	+1.0	+1.0	-1.1
RJ	-1.2	+1.6	+0.3	+1.0	+1.2	+1.2
MB	+0.3	-0.8	+1.2	-0.1	+0.3	+1.4

Subject	Post-stimulus SWS					
	O1		WL		Cz	
	1st SIGHT	SIZE	1st SIGHT	SIZE	1st SIGHT	SIZE
TT	-0.8	-1.1	-5.7	-1.7	-6.2	-4.2
CC	-0.7	-2.8	-1.8	-5.3	-1.6	-1.7
MT	-2.3	-1.5	-5.0	-4.2	-1.0	-9.3
MC	+4.0	-0.6	-1.3	-0.3	-0.6	-2.3
RD	+0.4	-2.1	-0.7	-5.1	-0.2	-5.6
ER	-3.8	-2.8	-7.6	-4.3	-2.5	-4.3
BK	+1.2	-3.1	-0.6	-6.0	-1.1	-6.2
KS	-0.6	-1.4	-2.2	-6.3	-2.0	-5.7
RJ	-2.3	-6.5	-4.7	-6.2	-2.9	-4.9
MB	-0.4	-0.7	-1.5	-1.6	-0.5	-2.7
Mean	-0.5	-2.3	-3.1*	-4.1*	-1.9	-4.7*
S.D.	2.1	1.7	2.4	2.2	1.8	2.3

\*Significantly different from zero in the negative direction at the .05/20 level (.0005).



## FIGURE LEGENDS

- Fig. 1: (Exp. I) Contrasts composite ("com") and individual subject VEPs of the 1st SIGHT (solid line) and SIZE (dotted line) conditions. Time constant = 0.12 sec. Trace onset 50 msec pre-stimulus; extends 950 msec post-stimulus. Baseline drawn through average of 50 msec pre-stimulus EEG. Subject LD: most representative of changes seen in composite VEPs. Subject TG: least representative. The number of trials in each average is indicated at the right of the figure. The thin vertical line indicates stimulus onset.
- Fig. 2: (Exp. II) Contrasts composite ("com") and individual subject VEPs of the 1st SIGHT (solid line) and SIZE (dotted line) conditions. Time constant = 8.0 sec. Trace onset 2050 msec pre-stimulus; extends 2150 msec post-stimulus. Baseline indication, number of trials per average, and stimulus onset indicated as in Fig. 1.

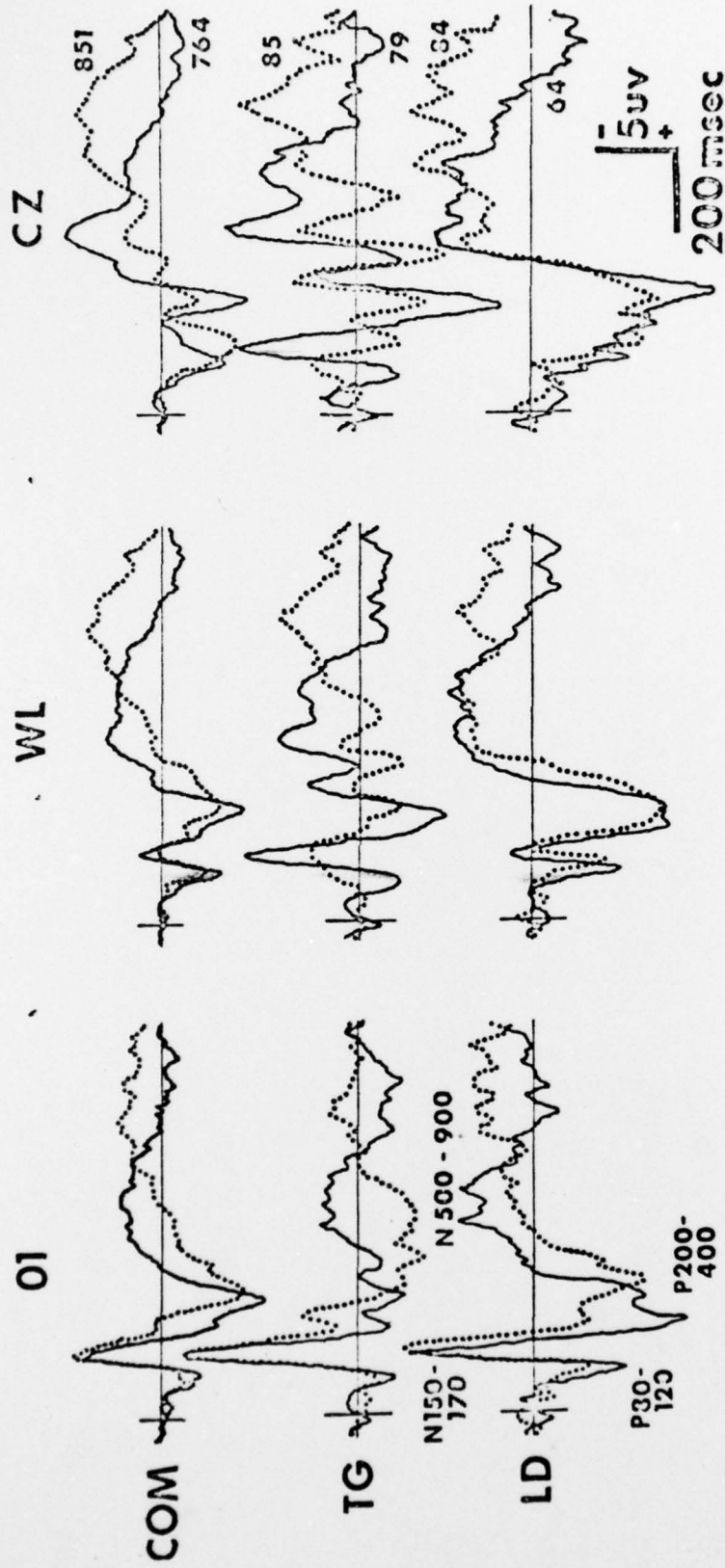


Fig 2

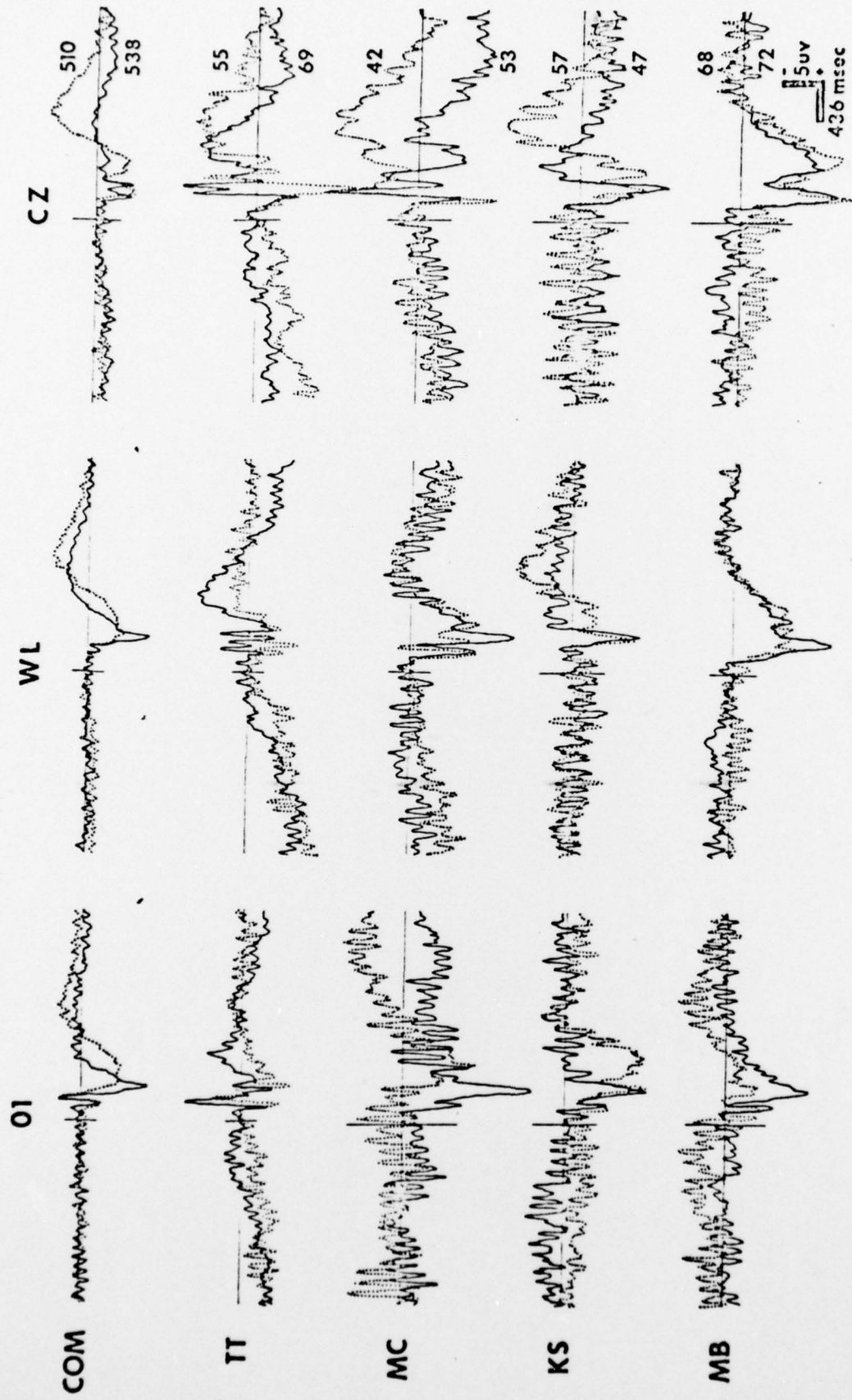
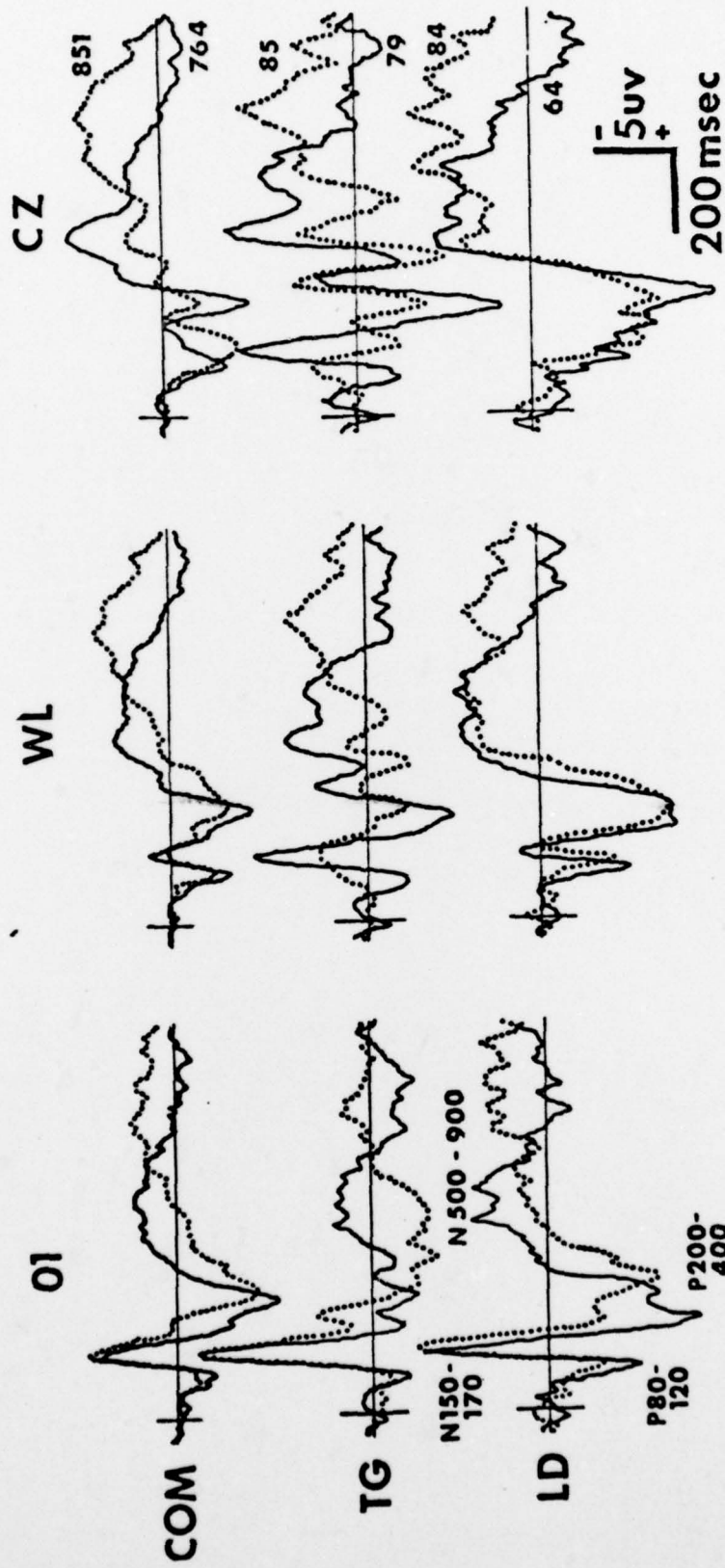
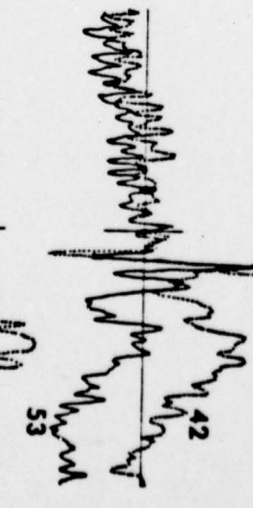


Fig. 2.








UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 75-29	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Visual Evoked Potential Change During Information Processing: Correlate of Cognition or Reactive Change		5. TYPE OF REPORT & PERIOD COVERED Interim
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David M. SEALES		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Health Research Center San Diego, CA 92152		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS MR000.01.01-6010
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research & Development Command Bethesda, MD 20014		12. REPORT DATE April 1975
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Bureau of Medicine & Surgery Department of the Navy Washington, DC 20372		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) VEP    Lateralization of function Cognition                                        Task complexity Cortical arousal                                Information processing Expectancy		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) 1. Two experiments investigated a change in the late positive activity (200 to 550 msec) of the visual evoked potential (VEP). This P2-effect, maximal at the occiput, appeared related to cognitive aspects of information processing. Results did not support an interpretation of the P2-effect in cognitive terms (Experiment I) but rather in terms of shifts in cortical arousal and in expectancy (Experiment II). (2)  (continued on reverse side)		

DD FORM 1473 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-014-6601

UNCLASSIFIED  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. Abstract (continued)

2. In both studies, subjects viewed letter-pair stimuli, e.g., HH or bD, responding when they saw a stimulus (SIGHT task), or when they determined whether the two letters were the same or different in either size or name (SIZE and NAME tasks). EEG was recorded from vertex and from homologous bilateral occipital and parietal sites.
3. Reaction times increased from the SIGHT to the SIZE to the NAME task, objectifying the increase in task complexity.
4. The P2-effect occurred with the increase in task complexity from the SIGHT to the SIZE task, but did not increase further in the NAME task or show asymmetry in relation to lateralized processing. In Experiment II, slow wave shifts were observed during and surrounding the trials of Experiment 1. These slow waves revealed subject-specific ranges of cortical arousal. The P2-effect appeared to result primarily from continued or noncontinued expectancy following stimulus reception.
5. This work demonstrates the difficulty involved in controlling for and evaluating the effects of shifts in cortical arousal and in expectancy during cognitive information processing. The results are relevant to the question of CNV-P300 dissociability, and support alternate explanations of previously reported VEP changes. X

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)