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PSYCHOBIOLOGICAL MEASURES AS PREDICTORS OF SONAR OPERATOR PERFO--ETC(U)
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PSYCHOBIOLOGICAL MEASURES AS PREDICTORS OF SONAR OPERATOR PERFORMANCE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the application of a relatively new technology, the visual event related brain potential (VERP) method of brain wave analysis, as a possible means of improving the prediction of performance of sonar operators.

The subjects, 26 trainees at the Fleet Antisubmarine Warfare (ASW) School, were assigned to a HIGH or LOW group based on their performance of a sonar simulator task. Eight channels of VERP data were recorded for each subject from scalp contact

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electrodes, and microvolt root mean square amplitude measures were computed for the wave forms at each of the eight electrode sites. To assess relationships between the brain's right hemisphere (RH) and left hemisphere (LH), asymmetry measures were computed by subtracting the LH amplitude value from the RH value for each of the homologous sites. Results of discriminate analysis performed to discriminate the HIGH and LOW groups showed smaller VERP amplitudes for the HIGH group than for the LOW group. Also, hemispheric asymmetry was greater for the LOW than the HIGH group, especially in the occipital (visual processing) area of the head. Aptitude tests used by the Navy in selecting recruits for sonar training showed no differences between the two performance groups.

FOREWORD

This research and development was conducted within Independent Exploratory Development Work Unit ZF66-512-001-03.01 (Evaluation of Psychobiological Methods for Enhancing Learning and Performance of Naval Personnel) under the sponsorship of the Director of Navy Laboratories. Psychobiology represents a new and relatively untried approach to research in the personnel and training area.

This is the fourth in a series of reports describing recent advances in using psychobiological methods for improving personnel assessment and enhancing personnel training and performance. The first demonstrated that brain wave measures, such as the visual event related potential (VERP), were useful in predicting the success of Navy remedial reading trainees (Lewis, Rimland, & Callaway, 1976); the second, that relationships existed between VERP measures and Navy paper-and-pencil aptitude tests (Lewis, Rimland, & Callaway, 1977); and the third, that VERPS could be used to differentiate pilots and radar intercept officers (Lewis & Rimland, 1979). The research described herein was conducted to determine whether VERPs could be used in predicting the performance of sonar operators.

Appreciation is expressed to LT Peter Young, formerly of NAVPERSRANDCEN, and the staff and members of the Fleet Antisubmarine Warfare School, San Diego for their assistance and cooperation.

DONALD F. PARKER
Commanding Officer

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INTRODUCTION

Problem

The operator of today's sophisticated sonar equipment must perform difficult and demanding mental operations requiring quick processing of visual and auditory information and the visualization of moving objects in three-dimensional space. Although conventional paper and pencil aptitude tests are reasonably effective in predicting academic performance in sonar school, they are not effective in identifying, from a pool of applicants, those who are most likely to perform successfully as a sonar operator.

Background

In 1975, in response to this and other refractory problems in personnel selection, classification, utilization, and training, the Navy Personnel Research and Development Center established the Applied Psychobiology Project. This project is concerned with investigating the use of advanced psychobiological methods as possible means of improving the accuracy of prediction of human performance in high technology jobs. Recent advances in the understanding of brain function, coupled with progress in such fields as computer science, electronics, and neurophysiology, have suggested the possibility that brain wave measures may provide a tool for assessing heretofore unidentified individual differences in aptitudes.

One area that may be promising for personnel research is visual event related brain potential (VERP) analysis. VERPs, which are also referred to as visual evoked potentials (VEPs), are minute electrical signals derived by computer analysis of the brain's response to sensory stimulation. It is widely recognized that the brain's left hemisphere (LH) (usually dominant in right-handed people) tends to support the functions required by academic school-type learning, while the right hemisphere (RH) (usually nondominant in right-handed people) tends to support simultaneous, judgmental, spatial functions (Dimond & Beaumont, 1974; Kinsbourne, 1978). Since the latter types of functions seem highly relevant to certain kinds of jobs, it seems plausible that measures designed to tap RH functioning might prove useful in predicting performance in those jobs.

Three previous studies have been conducted under the Applied Psychobiology Project to relate psychobiological measures, such as the VERP, to performance. The first (Lewis, Rimland, & Callaway, 1976) demonstrated that VERP measures were useful in predicting the success of a group of Navy trainees undergoing remedial reading; the second (Lewis, Rimland, & Callaway, 1977), that relationships existed between VERPs and certain paper and pencil aptitude tests used by the Navy; and the third (Lewis & Rimland, 1979), that VERPs could be used to differentiate Navy pilots and radar intercept officers.

Objective

The objective of this study was to determine if VERP measures could be used to predict, or to improve the prediction of, performance of sonar operators.

METHOD

Subjects

In the original research design, plans had been made to test 125 trainees at the Navy Antisubmarine Warfare (ASW) School, Navy Training Center (NTC), San Diego. Data had been obtained for only 26 trainees, however, when testing was terminated because of circumstances beyond the control of the investigators.

Performance Measures

Performance measures consisted of instructor and peer ratings, ASW school laboratory practical test scores on four subjects and the ASW classroom grade, and five Navy aptitude test scores.

1. Instructor and Peer Ratings. The following four questions were used to obtain instructors and peer ratings of trainees' performance as a sonar operator, a member of the sonar team, a troubleshooter, and a sonar technician.

a. Your ship is transiting a combat zone during wartime. There is a high probability of enemy submarine attack. Whom would you want operating the sonar?

b. Your ship is engaged in a peacetime Fleet exercise. Whom could you count on to work best as a member of your sonar team?

c. Your ship is transiting a combat zone in wartime. There is a high probability of enemy submarine attack, and your sonar gear is down. Who would be able to troubleshoot the gear and get it back on line fastest?

d. Who in your class worked hardest toward becoming a good sonar technician?

Respondents were asked to study the questions and then rate each trainee on the tasks described. Responses were made on a four-point scale, where 1 = "best" and 4 = "worst."

2. ASW School Test Scores and Grade. Laboratory practical test scores were obtained for the following subjects:

a. Electronic test equipment operation.
b. Aural identification of sonar contacts.
c. Visual identification of sonar contacts.
d. Sonar simulator performance.

The trainees' ASW classroom grade was also obtained.

3. Navy Aptitude Test Scores. Study participants entered the Navy in 1976, when scores obtained on the Navy's Basic Test Battery (BTB) were used for selection and initial assignment of recruits to "A" schools and on-job training.[1] Those selected for ASW school had to have above average grades on the following BTB subtests: General Classification Test (GCT), Arithmetic Reasoning Inventory (ARI), Mechanical Aptitude Test (MECH), and Electronics Technician Selection Test (ETST). Thus, scores on these tests were available for subjects, plus their score on the Armed Forces Qualification Test (AFQT). (Scores obtained by GCT, ARI, and MECH subtests were summed together and converted to an AFQT score.)

[1] In January 1976, the Armed Services Vocational Aptitude Battery (ASVAB) replaced the Navy Basic Test Battery (BTB) for use in selecting and assigning recruits.

Table 1

Correlation Matrix for Performance Measures

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Instructor Rating—Sonar Operator	—																	
2. Instructor Rating—Sonar Team Member	.98**	—																
3. Instructor Rating—Troubleshooter	.28	.30	—															
4. Instructor Rating—Sonar Technician	.76**	.80**	.31	—														
5. Peer Rating—Sonar Operator	.66**	.68**	.17	.46**	—													
6. Peer Rating—Sonar Team Member	.55**	.55**	.19	.38*	.92**	—												
7. Peer Rating—Troubleshooter	.46**	.45**	.10	.24	.80**	.70**	—											
8. Peer Rating—Sonar Technician	-.06	-.06	-.14	.12	.30	.34*	.17	—										
9. Test Score—Elect. Test Equip. Oper.	.55**	.53**	.25	.62**	-.12	-.18	-.26	-.24	—									
10. Test Score—Aural Ident. Sonar Cont.	-.24	-.19	.14	-.08	-.38*	-.36*	-.29	-.35*	.12	—								
11. Test Score—Visual Ident. Sonar Cont.	.40*	.42*	.24	.51**	-.12	-.16	-.21	-.07	.69**	.03	—							
12. Test Score—Sonar Sim. Perf.	-.74**	-.76**	-.22	-.64**	-.60**	-.43*	-.40*	.09	-.37*	.33*	-.33*	—						
13. Test Score—ASW Classroom	-.39*	-.39*	-.30	-.29	-.47**	-.39*	-.68**	.14	.02	-.14	.18	.35*	—					
14. GCT Score	-.14	-.10	.03	.10	-.04	-.08	-.16	.17	.20	.43*	.16	-.02	.02	—				
15. ARI Score	-.01	.00	.13	.07	.05	-.05	.01	.12	.14	.48**	.15	-.02	-.02	.84**	—			
16. MECH Score	-.13	-.11	.13	.12	-.06	-.08	-.18	.19	.20	.43**	-.04	.04	.00	.82**	.76**	—		
17. ETST Score	-.01	.04	.13	.15	.18	.17	.04	.08	.01	.24	-.01	-.10	-.32	.66**	.46**	.57**	—	
18. AFQT Score	-.05	.01	-.11	.12	-.19	-.25	-.35*	.01	.23	.04	.38*	.06	.47**	.37*	.31	.37*	.26	—

*$p < .05$.
**$p < .01$.

The correlation matrix for the performance measures is provided in Table 1. As shown, there was generally fair agreement between and within the instructor ratings, peer ratings, and laboratory practical grades. Little relationship was found between the aptitude test scores and the other measures. The aptitude scores were, however, highly correlated with each other.

For the purposes of subsequent statistical analysis, it was desirable to select one measure as a single overall index of ASW trainee performance. An examination of Table 1 showed that the sonar simulation performance measure (No. 12) was most highly and consistently correlated with the others. Accordingly, trainees who scored 82 and above on this measure (N = 14) were assigned to the HIGH performance group; and those who scored 81 and below (N = 12), to the LOW performance group. Descriptive statistics for the two groups are presented in Table 2.

Table 2

Descriptive Statistics for HIGH and LOW Performance Groups

	HIGH (N = 14)		LOW (N = 12)	
Item	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Aptitude Test Scores				
GCT	60.46	6.91	60.33	5.60
ARI	57.23	6.47	57.92	6.37
MECH	54.54	6.98	52.00	6.62
ETST	64.91	4.28	63.25	2.73
AFQT	73.71	13.05	72.33	12.07
Test Scores on ASW Laboratory Practicals:				
Elect. Test Equip. Oper.	89.25	8.51	86.08	9.39
Aural Ident. of Sonar Contacts	89.36	9.25	88.92	11.07
Visual Ident. of Sonar Contacts	77.17	17.84	73.42	17.45
Sonar Simulator Performance	87.57	4.31	74.92	7.79
ASW Classroom Grade	75.43	4.88	72.75	5.71
Age	20.54	2.25	19.22	.82

Instrumentation

The instrumentation used in this study was similar to that described in previous studies (Lewis, Rimland, & Callaway, 1976, 1977; Lewis & Rimland, 1979). It was based on a Data General NOVA 2/10 central processing unit (CPU), hardware multiply and divide, and direct memory access with a floppy disk unit (Advanced Electronics Design, Model 2500). The CPU, the floppy disk unit, the EEG amplifier with filter circuitry, and the alphanumeric oscilloscope monitor (Tektronix Model 603) were mounted in a single cabinet 30 inches high, 24 inches deep, and 22 inches wide (76 x 61 x 56 cm). The entire unit weighed about 180 pounds (82 kg). Peripheral to the cabinet were the small solid-state keyboard, a fluorescent tube and power supply for the visual stimulus, and the small EEG multiplex and preamplifier unit. The latter unit multiplexed, preamplified (about 200X), and optically isolated the EEG signals. At the computer, the signals were demultiplexed and further amplified for a total gain of about 20,000X. Amplifier frequency response was flat to about 150 Hz. The eight filters were passive resistor-capacitor circuits with a frequency rolloff of about 3 db per octave. Three time constants (.1, 1, and 10 seconds) were available for the high-pass filters and corresponded to approximately 2.0, .2, and .02 Hz. Two low-pass filter options (30 and 100 Hz) were available.

Procedure

After the subjects had been briefed on the research procedures and purposes and had signed voluntary consent forms, they were prepared for recording. After a technician had cleansed subject's hair and scalp at the electrode sites with an alcohol-impregnated cotton swab, a Lycra (elastic cloth) helmet was placed on subject's head. Electrodes were placed in contact with the scalp over homologous sites in the frontal (F3 and F4), central (C3 and C4), parietal (P3 and P4), and occipital (01 and 02) regions of the left and right hemispheres (Jasper, 1958). The location of the electrodes is shown in Figure 1.

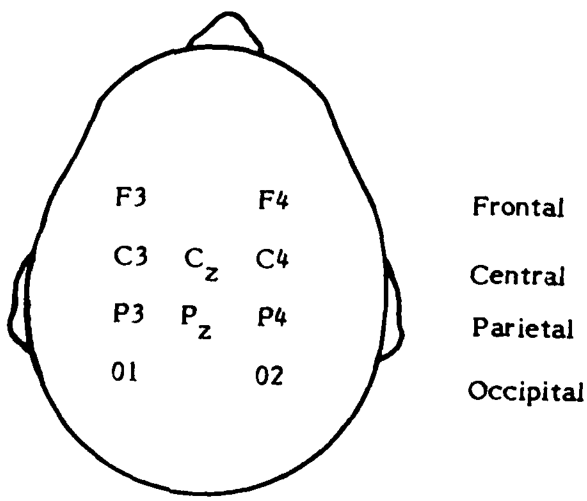

Figure 1. Electrode site montage.

The electrodes, which were held in place by lucite bushings secured to the helmet, were of the standard EEG recording type (Beckman miniature, 11 mm). They were attached to a clear plastic extension tube (38mm), which was filled with electrolytic solution. A small sponge soaked with electrolyte held the solution in the tube and made contact with electrode paste on the scalp. The extension tube minimized slow potential drift, which otherwise would have been picked up at the recording site.

After all electrodes were in place and the impedance was checked (< 5KΩ), the subject was instructed to observe his real-time EEG activity on the oscilloscope display. He was instructed to move his jaws, eyebrows, etc., so that he could observe how muscle artifact may contaminate the VERP data. He was then seated in a darkened room in alignment with the visual stimulus and given a hand-held "time-out" switch that permitted him to suspend all stimulus presentation and analysis operations. He was instructed to press the switch to reject muscle artifact when he had to move, cough, etc.

The visual stimulus consisted of a commercial fluorescent tube (GE Model F8T5-CWUSA) with a custom-built power supply that was triggered by a computer-generated pulse. The stimulus duration was approximately 2 msec, flashed aperiodically with a mean inter-flash interval of about 1.5 seconds. The target was a homogeneous white rectangle (approximately 7" x 15", 18 x 38 cm), placed at a 1-meter viewing distance from the subject. Luminance of the target was approximately 3 foot-Lamberts (Gamma Scientific telephotometer system, model 2009K).

The experimental session lasted for about 10 minutes, and was divided into two phases--A and B. During this time, eight channels of VERP data--one for each electrode site--were acquired simultaneously. Each channel was referred to vertex (i.e., the top of the head--C_z in Figure 1), while the subject ground was on the midline in the parietal region (P_z). In phase A, the subject observed computer-generated aperiodic flashes in two series of 50 flashes each, while microvolt root mean square (μVrms) amplitude data were obtained from each of the eight channels. Band pass was between approximately 2.0 and 30 Hz. Waveforms and amplitude (μVrms) values were recorded separately for the first and second 50 flashes and displayed on the monitor scope. The first 50 flashes were designated by number 1; and the second 50, by number 2 (e.g., frontal 1, frontal 2). Data obtained during this phase were also used to compute measures of asymmetry and variance (see p. 7).

In phase B, procedures similar to those used by Ertl and Schafer (1969) were used to obtain latency values; that is, delays in milliseconds between the stimulus and the resulting brain wave activity. Rather than the computer-generated aperiodic flashes used in phase A, the flash was triggered by the subject's own EEG activity (self-stimulation). Band pass was between approximately .2 and 30 Hz. The subject's EEG activity between frontal (F4) and parietal (P4) right hemisphere sites was monitored by computer. When the EEG activity passed through the base line (zero-cross), with a positive slope, the light flashed and the resultant VERP was recorded. The reliability of the VERP latency measures was increased by taking into account the background EEG activity.

All software subroutines used in VERP testing and analyses were on floppy disk and each could be accessed by a single keyboard command. These subroutines included (1) impedance monitoring and calibration, under computer control, of all eight channels, (2) real-time display of the eight channels of EEG activity, (3) subject identification entry, and (4) acquisition and analysis of eight channels of VERP data. Polaroid photographic records of the CRT display of VERP data were made following each 100-flash presentation.

VERP Measures Obtained

VERP data obtained were analyzed to produce the following measures:

1. Amplitude (Phase A)--The average power at each of the electrode sites was measured in microvolt root mean square (μVrms). At each electrode site, VERPs were averaged separately for the first and second 50 flashes. The X-axis (time = 500 msec) for each VERP used 250 address (time point) locations in the computer. During the averaging, voltages at a particular address for each VERP were obtained. The mean voltage was then determined for the entire VERP. The deviations from this mean value at each time point were squared, the average of the squared deviation was obtained, and the square root of the average was determined. The value obtained represented the standard deviation of the VERP and thus provided, in effect, an approximation of the square root of the average power in microvolt root mean square (μVrms). The μVrms measure has been found to be correlated with the VERP component measures more commonly used. The standard deviation was used instead of the variance to keep the units in microvolts instead of watts (Callaway, 1975, p. 150). An average power value was determined for each of the two sets of 50-flash VERPs. Figure 2 provides an example of amplitude data obtained.

2. Asymmetry (Phase A)--An index of the difference in the evoked voltages (μVrms) measured from homologous sites on the scalp. The asymmetry values were computed by subtracting the LH amplitude values from the RH amplitude values (R-L). The more dissimilar the hemispheres in the amplitude of response, the higher the asymmetry values. Four asymmetry values were obtained, since VERPs were measured at each of the four pairs of LH and RH sites--frontal, central, parietal, occipital.

3. Variance (Phase A)--A measure of the overall trial-to-trial variability of VERPs. At each light flash, all 8 VERPs are summed to provide a single VERP. Then, for each of the 250 time points, a sum and sum of squares are computed so that, at the end of 100 flashes, 250 standard deviations can be computed. These are averaged to provide the final measure. Figure 3 provides an example of variance waveforms.

4. Latency (Phase B)--The time delay (msec) from the onset of the stimulus to a designated feature of the VERP waveform. In this study, VERP latency was determined from the onset of the visual stimulus to the first, second, and third positive slope zero-crosses (i.e., approximately 100, 200, and 300 msec, respectively), to be referred to as L1, L2, L3. Zero-cross was defined as the point where the waveform passed through base line (zero voltage) in the positive direction. Figure 4 provides an example of latency waveforms.

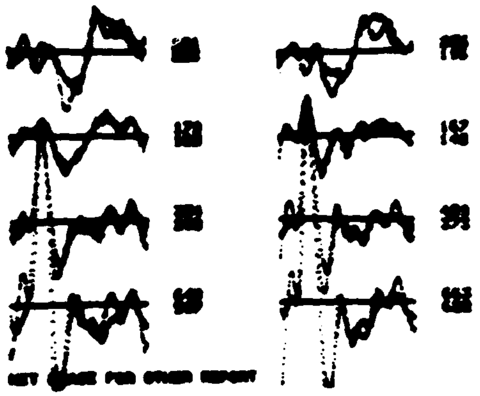

Figure 2.

Amplitude data showing left and right hemisphere VERPs in the left and right columns, respectively. The locations are frontal, central, parietal, and occipital, reading from top to bottom. The upper number at each site represents the μVrms value for the first 50 flashes; and the lower number, the second 50 flashes. The waveforms for each 50 flash series are superimposed on the same baseline.

Figure 3.

Variance waveforms, displaying composite amplitude variability of all eight recording sites for 100 flashes. Numerical values at bottom represent minimum, mean, and maximum standard error measures, respectively.

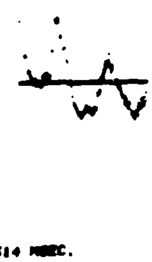

Figure 4.

Latency VERP waveform recorded between right hemisphere frontal and parietal sites, for 100 flashes. The first, second, and third zero-cross latency values (msec) are displayed under the waveform.

RESULTS

VERP Amplitude, Variance, and Latency

Table 3 presents the means and standard deviations (SDs) of the measures of VERP amplitude, variance, and latency obtained for the HIGH and LOW performance groups. As shown, the HIGH group showed smaller VERP amplitudes than did the LOW group on all 16 comparisons. There are no consistent between-group relationships for the measures of VERP variance or latency.

To estimate the extent to which VERP measures might be used to differentiate members of the two groups, all 20 of the amplitude, variance, and latency values were entered in a stepwise discriminate analysis (Dixon, 1973). Results are provided in Table 4, which indicates that the two groups can best be discriminated by measures of amplitudes. These results must be interpreted with caution, however, since the small size of the sample precluded cross-validation, as was done in previous studies (Lewis et al., 1976, 1977).

VERP Asymmetry

Table 5 provides asymmetry measures (i.e., RH amplitude minus LH amplitude at each of the four regions) for the two groups. In computing these measures, data for the six left-handed subjects (four from the HIGH group and two from the LOW) were deleted, because hemisphericity tends to be mixed or indeterminate in left-handed individuals. The major finding in this analysis is the large and significant asymmetry difference between the two groups at the occipital region. This difference is primarily due to the negative readings obtained for the LOW group members. All ten of the LOW subjects showed negative occipital asymmetry, compared to only two of the HIGH subjects.

The asymmetry SDs for all four regions for the HIGH group are similar. Those for the LOW group, however, increase strongly and consistently from the frontal through the central and parietal to the occipital region. The means and SDs of asymmetry values for the two groups are shown graphically in Figure 5.

Table 3

VERP Amplitude, Variance, and Latency Measures for the HIGH and LOW Performance Groups

Measure	HIGH (N = 14)		LOW (N = 12)	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Amplitude (μ Vrms)				
Left Hemisphere:				
• Frontal 1	1.59	.69	1.89	.55
• Frontal 2	1.35	.45	1.54	.36
• Central 1	1.06	.47	1.30	.51
• Central 2	.87	.33	1.18	.47
• Parietal 1	1.86	.63	2.00	.68
• Parietal 2	1.57	.51	2.05	.59
• Occipital 1[a]	3.55	1.29	4.32	1.73
• Occipital 2[a]	3.41	1.26	4.82	1.70
Right Hemisphere:				
• Frontal 1	1.55	.60	1.80	.50
• Frontal 2	1.40	.57	1.49	.35
• Central 1	1.25	.53	1.29	.35
• Central 2[a]	1.03	.35	1.30	.44
• Parietal 1	1.76	.77	2.13	.90
• Parietal 2	1.73	.53	2.23	.85
• Occipital 1	3.53	1.41	3.85	1.37
• Occipital 2	3.45	1.22	4.48	1.44
Variance (μ Vrms)	6.13	1.58	6.55	1.27
Latency (Msec)				
L1	98.75	9.15	100.64	7.12
L2	214.64	20.24	212.33	11.61
L3	325.50	24.03	326.64	18.76

[a]Variate selected by discriminant analysis, Table 4.

Table 4

Discriminant Analysis Summary

Step	Variate	F	Percent Correctly Classified[a] High (N = 14)	Low (N = 12)	Total (N = 26)	Chi-Square
1.	Occipital 2 LH AMPL	5.87*	64 (9)	58 (7)	62 (16)	2.40
2.	Occipital 1 LH AMPL	2.08	79 (11)	75 (9)	77 (20)	9.77**
3.	Central 2 RH AMPL	2.00	86 (12)	83 (10)	85 (22)	15.33**

[a]The top entry in each cell is the percentage correctly classified; and the lower entry, in parentheses, the number of subjects.

*$p < .02$.
**$p < .01$.

Table 5

VERP Asymmetry (R-L) Measures for the HIGH and LOW Performance Groups

	HIGH (N = 10)		LOW (N = 10)		(HIGH vs. LOW)
Region	$\bar{X}$	S.D.	$\bar{X}$	S.D.	t (df = 18)
Frontal (R-L)	-.07	.30	.03	.32	-.67
Central (R-L)	.25	.26	.13	.41	.76
Parietal (R-L)	.17	.25	.15	.62	.08
Occipital (R-L)	.18	.35	-.52	.75	2.70*

Note. Left-handed subjects deleted.

*$p < .02$.

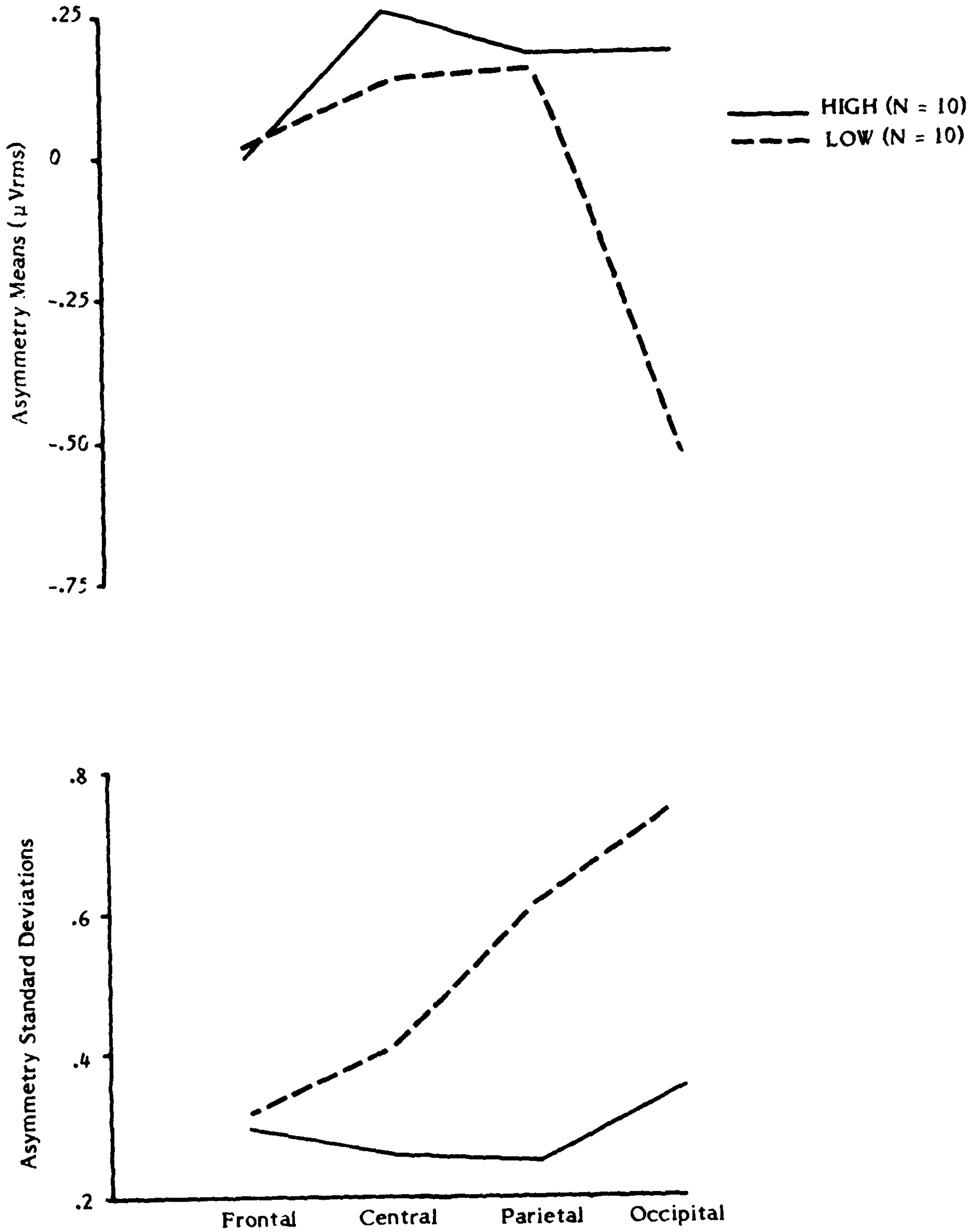

Figure 5. Asymmetry mean and standard deviation values for the HIGH and LOW groups. Left-handed subjects deleted.

DISCUSSION AND CONCLUSIONS

This study must be considered a preliminary, exploratory investigation, which is part of a larger effort directed toward developing and evaluating new methods for enhancing the selection and performance of sonar operators and other intensively selected and trained personnel. Some of its limitations are listed below:

1. The number of subjects was too small for cross-validation.

2. The visual stimulus for generating the VERPs was simply a flashing white light. Recently developed hardware and software will permit the use of more meaningful visual, auditory, and bimodal stimuli in subsequent studies.

3. Trainees' performance on the simulator was measured by subjective ratings by senior sonar instructors. More accurate objective performance and simulator-derived proficiency measures have been developed for future use.

Despite these rather severe limitations, several interesting VERP relationships emerged within the present sample of sonar trainees. These relationships are consistent with those found in previous studies with other populations (Lewis et al., 1976, 1977), even though there were important differences in the criteria, stimulation, and testing conditions. For example, there appears to be a consistent positive relationship between ability and small left hemisphere (LH) VERP amplitude. Lewis et al. (1977), when comparing HIGH and LOW aptitude recruits as measured by the AFQT, found that six of the eight LH amplitudes (all but occipital 1 and 2) were smaller for the HIGH ability subjects than for the LOW ability subjects. In the present study (Table 4), all eight LH amplitudes and all eight RH amplitudes were smaller for the HIGH performers than the LOW performers.

These findings are also consistent with other research showing the right hemisphere to be heavily involved in tasks relating to the individual's orientation in three-dimensional space. The findings of large differences between the HIGH and LOW groups in the occipital area is thus of special interest, because of the occipital area's strong role in visual perception. The operational tests used in sonar student selection showed no differences between the HIGH and LOW groups.

This study suggests that it may be feasible to use psychobiological (VERP) recordings from sonar trainees as a means of improving the methods used for the selection of sonar operators.

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