ELECTROPHYSIOLOGICAL AND COGNITIVE EVALUATION OF ABSTINENT ACUTE ALCOHOLICS

D. A. Kobus

L. L. Merrill

J. A. Rogale

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NAVAL HEALTH RESEARCH CENTER
P.O. BOX 85122
SAN DIEGO, CALIFORNIA 92186-5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

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David A. Kobus
Lex L. Merrill
Jennifer A. Rogale

Naval Health Research Center
P. O. Box 85122
San Diego, California 92186-5122

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Summary

Event-related potential (ERP) component parameters were used as dependent measures in an evaluation of the functional aspects of cognition in acute alcoholics. Previous ERP studies indicated that chronic alcoholic subjects differ in unique ways from nonalcoholics in their brain electrical responses to stimuli. However, a longitudinal study has not been conducted to determine whether these differences persist. Two groups (10 alcoholics and 10 nonalcoholics) of age-matched volunteer subjects were used. The alcoholic group was diagnosed according to DSM-III-R criteria and consisted of U.S. Navy and Marine Corps enlisted men. The nonalcoholic group was composed of nine males and one female. All subjects participated in sessions one (pretreatment of the alcoholic group) and two (three months later), and seven subjects from each group completed the third session (nine months after session one). Each subject completed 300 artifact-free trials of a binaural auditory "oddball" task. The WAIS-R was administered as an additional measure of cognitive functioning. Overall, P50 amplitude, N200 amplitude and latency, and P300 amplitude and latency appeared to differ between groups over the posttreatment period. However, these differences were reduced over the nine-month posttreatment time period. A group main effect for the verbal WAIS-R subtest scaled scores was found in the first session (before treatment), but no differences were found after treatment. The initial results of this study support the idea that alcoholism has a deleterious effect upon the ERPs of human subjects. The reduced P300 amplitude, and the lack of an "oddball" effect (i.e., no difference in amplitude between rare and frequent tones) for alcoholics replicate the results of other ERP studies with alcoholics.

Background

Numerous studies have documented a difference in brain electrical activity between alcoholics and controls (Begleiter, Porjesz, & Chou, 1981; Ehlers & Shuckit, 1990; Hill, Steinhauer, Zubin, & Baughman, 1988; Patterson et al., 1989; Porjesz & Begleiter, 1983; Skerchock & Cohen, 1984; Spitzer & Newman, 1987). These studies have demonstrated that the neurophysiologically measured (e.g., computerized axial tomography [CAT], electroencephalography [EEG]) cognitive activity of alcoholics varies significantly from that of nonalcoholics. Testing with neuropsychological instruments, such as the Wechsler Adult Intelligence Scale (WAIS) and the Raven Progressive Matrices, have also shown that alcoholics are cognitively dysfunctional (Goodwin & Hill, 1975; Jones & Parsons, 1972; Parsons & Leber, 1982; Patterson, Williams, McLean, Smith, & Schaffer, 1987; Ryan & Butters, 1983). Clearly research studies have shown that alcoholism produces cognitive impairment (Grant, 1987). Although alcoholics treated by the Navy are given formal treatment and abstain from alcohol, no cognitive testing is done to ensure that they are cognitively fit to return to duty. One reason for this is the choice of an appropriate metric which could be used to assess global cognitive ability. However, past research has demonstrated the sensitivity of the event-related potential (ERP) as a tool for measuring various aspects of cognitive performance. Using ERP component parameters as a dependent measure enables the functional aspects of cognition (e.g., filtering, discrimination, memory encoding, memory retrieval, and decision making) to be observed (Donchin, Kramer, & Wickens, 1986). The performance of many Navy jobs are highly correlated with the ability to perform these covert behaviors. Therefore, the ERP seems to be a promising chronometric measure to assess operator capability.

Most electrophysiological studies of alcoholics have investigated a positive component that occurs at approximately 300 ms poststimulus (P300). P300 has been characterized as a valuable tool in the study of human information processing, and more specifically, as a reflection of memory updating (Duncan-Johnson, 1981). ERP studies that have compared alcoholics and nonalcoholics have found significantly smaller P300 amplitudes and longer latencies in alcoholics (Patterson et al., 1987; Pfefferbaum, Horvath, Roth, Clifford, & Kopell, 1980; Porjesz & Begleiter, 1985; Porjesz, Begleiter, & Sammuelly, 1982; Skerchock & Cohen, 1984). Porjesz and Begleiter (1985) have provided a review of their studies that have demonstrated that P300 was attenuated in alcoholics after two to five years of abstinence. However, their subjects were older chronic alcoholics unlike the patient population normally of concern to the Navy. Their studies used "chronic" alcoholics with a mean age of approximately 36 years who had used alcohol in excessive quantities for at least seven continuous years (Ellis & Oscar-Berman, 1989). Therefore, one plausible interpretation of their results is that chronic alcoholics may have sustained brain damage due to their heavy, long-term use of alcohol. A great deal of research effort has investigated the long-term effects of alcoholism, but little is known regarding the changes in brain activity of younger "acute" alcoholics normally found in the military setting.

Although the literature suggests that the P300 continues to be attenuated in abstinent alcoholics (Porjesz & Begleiter, 1985), a longitudinal study has not been conducted. This paper describes the initial phase of a long-term, longitudinal study to investigate whether acute alcoholic subjects demonstrate "recovery" of cognitive function with abstinence. If an electrophysiological rebound exists in abstinent alcoholics and it is correlated with cognitive performance, then the ERP technique may be a useful tool for measuring fitness for duty.

Method

Subjects

Two groups (10 alcoholics and 10 nonalcoholics) of age-matched subjects participated in the study. The alcoholics were all awaiting treatment at the Navy Alcohol Rehabilitation Center at NAS

Miramar, California. They were diagnosed according to DSM-III-R criteria and consisted of U. S. Navy enlisted men with a mean age of 25.7 years (SD=6.8) and mean education level of 11.7 years (SD=.67). Eight of the alcoholic subjects had a positive family history for alcoholism. The nonalcoholic comparison group consisted of individuals who did not have a history of alcohol or drug abuse. The group was composed of 9 males and one female (M = 28.7 years, SD=4.3) and a mean education level of 13.4 years (SD=1.95). Polich, Burns, and Bloom (1988) found no significant differences between male and female alcoholics and nonalcoholics using an auditory ERP paradigm.

Procedure

All subjects completed 300 artifact-free trials of an auditory "oddball" task. Two tones were delivered binaurally at 70 dB nHL with a constant 50 dB nHL white background noise. A 1500 Hz tone, with a 2 ms ramp and a 22 ms duration, was presented on 20% of the trials (rare tone). A 750 Hz tone, with a 2 ms ramp and a 22 ms duration, was presented on 80% of the trials (frequent tone). The WAIS-R was administered as an additional measure of cognitive functioning.

Apparatus

ERPs were amplified (x 20,000), filtered (bandwidth 1-30 Hz), averaged, and stored on a Nicolet Compact Four Electrodiagnostic System (C-4). ERPs were sampled for 100 ms prestimulus and for 800 ms poststimulus (640 Hz sampling rate). Stimuli were delivered binaurally via a Telephonics headset (TDH-39p). Grass gold cup electrodes were attached at Fz, Cz, and Pz in accordance with the International 10-20 system. All electrodes were attached with electrode paste. Linked mastoids served as reference. All impedances were below 5 kohm. Beckman biopotential electrodes were attached supra to the left and right eyes to serve as ground and to monitor eye movement. Trials with EOG amplitude greater than 100 microvolts were automatically rejected.

Results

Age and education, in number of years, were subjected to separate One-way analyses of variance. Although no significant difference between the groups were found for age, education was significantly different ($F(1,18) = 6.75$, $p<.05$). A separate Three-way (Group [2] X Site [3] X Stimuli [2]) MANOVA was calculated for each of the three sessions for the electrophysiological components of interest (P50, N100, P200, N200, and P300). Verbal, performance, and full scale IQ scores were analyzed with two-way, score by group (2), MANOVAs with education used as a covariate. No differences were found between the groups for the number of auditory targets detected. ERP components that showed a significant difference between groups in the first session data were analyzed in sessions two and three in order to test for changes over sessions (within group changes). The statistically significant results are reported below. In sessions one and two there were 10 subjects in each group and for session three there were seven. Six subjects (three from each group) were unable to continue participation due to operational commitments. The grand mean ERP waveforms for each group, each session, and targets and nontargets at Cz are shown in Figure 1. Although the alcoholic group's mean P3 target amplitude and P3 amplitude difference is smaller (for all three sessions) the overall morphology of the waveform appears to become more similar to the comparison group over sessions.

P50 Component

Session one. A Group X Stimulus interaction was found for P50 amplitude ($F(1,18) = 7.75$, $p<.05$). An examination of the Group means shows a larger Nontarget amplitude for Alcoholics while the Comparison group displayed a larger Target amplitude.

Sessions two and three. No significant results were found.

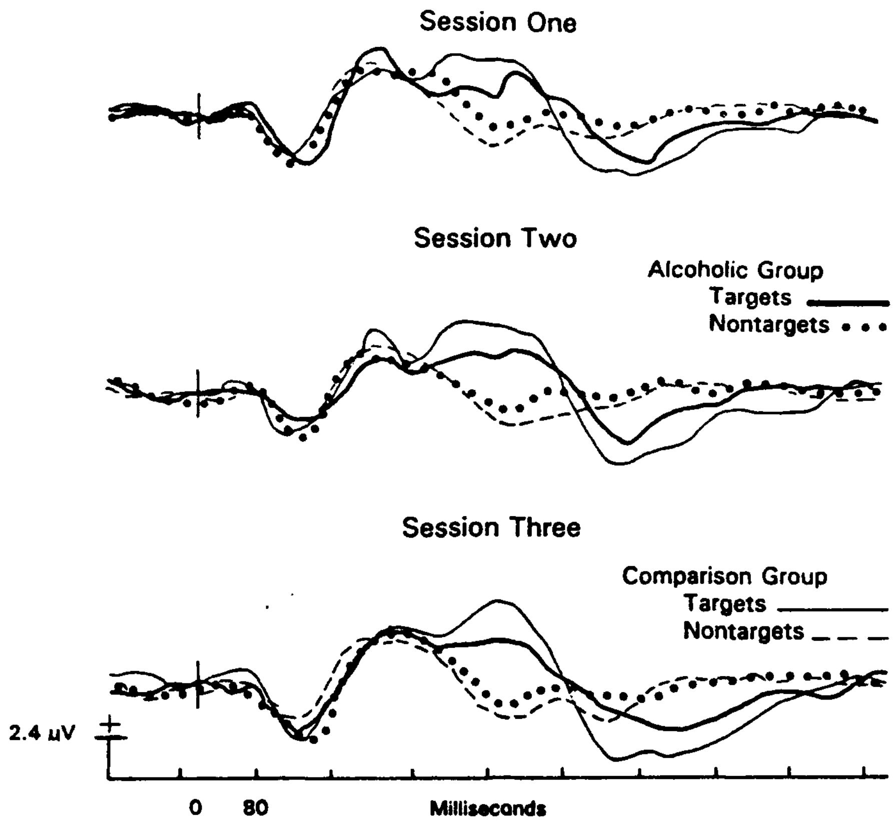

FIGURE 1. Grand Mean ERP Waveforms for Both Groups and Stimuli at Cz for each session.

N200 Amplitude

Session one. This session revealed a Group X Stimulus interaction ($F(1,18) = 5.40$, $p<.05$). Results indicate that the Alcoholic group had a similar response to Target and Nontarget stimuli. The comparison group had a larger response to Nontarget stimuli than did the Alcoholic group.

Session two. The analysis revealed a Group X Site interaction ($F(2,36) = 3.69$, $p<.05$). Alcoholics had a larger response at Fz while the Comparison group had a larger response at Cz and Pz.

Session three. No significant differences were found. The Group X Stimulus interaction found in the first session approached significance, $p = .08$.

N200 Latency

Session one. A significant Group X Stimulus interaction was found for N200 latency ($F(1,18) = 7.99$, $p<.05$). The group means show that the Alcoholics had a longer response to Target stimuli and a shorter response to Nontarget stimuli.

Session two. The Group X Stimulus interaction approached significance in this session, $p = .08$.

Session three. The Group X Stimulus interaction found in the first session was again significant in this session ($F(1,18) = 7.99$, $p<.05$). An exam ination of the means revealed the same relationship as found in session one.

P300 Amplitude

Session one. A significant interaction was found for Group X Stimulus ($F(1,18) = 4.77$, $p<.05$). The Alcoholic group had a larger Nontarget amplitude while the Comparison group had a larger Target amplitude.

Session two. The analysis revealed a similar significant Group X Stimulus interaction ($F(1,18) = 6.06$, $p<.05$) to that found in session one.

Session three. No significant differences were found.

P300 Latency

Session one. The analysis revealed a significant Group X Stimulus interaction ($F(1,18) = 5.71$, $p<.05$). The Alcoholic group had a longer response to Target stimuli and a shorter response to Nontarget stimuli.

Session two. No significant effects were found.

Session three. A significant effect of Group ($F(1,12) = 5.21$, $p<.05$) was found. The Alcoholics group had shorter latencies. The same Group X Stimulus interaction found in session one was displayed in this session. The Alcoholic group had longer Target latencies and shorter Nontarget latencies.

WAIS-R

Session one. A significant effect of groups was found for the verbal tests ($F(1,17) = 4.64$, $p<.05$). The alcoholic group displayed overall lower verbal scores.

Session two. The analysis revealed an effect that approached significance, $p<.08$.

Session three. No significant differences between groups were found.

All ERP amplitude and latency values were correlated with WAIS-R subtests, Verbal IQ, Performance IQ, and Full Scale IQ scores. Although no trends appear to dominate in the correlations, the early components (P50 and N100) comprise most of the significant correlations for the Alcoholic Group and the later components (P200, N200, and P300) comprise most of the significant correlations for the Comparison Group (see Tables 1, 2, and 3). The Information subtest score was significantly correlated with P50 amplitude in sessions one and two for the Alcoholic Group (see Tables 1 and 2).

Table 1

WAIS-R and ERP Correlations for Session One

Test	Component	Site	r
	Alcoholic Group		
Information	P50 tar amp	Cz	.78**
	N1 tar	Cz	-.81*
	P3 tar lat	Fz	.81*
Comprehension	P2 nt lat	Fz	.80*
Performance IQ	P50 nt lat	Fz	-.86*
	Comparison Group		
Digit Span	N2 nt amp	Cz	-.79*
	P3 tar amp	Cz	.82*
Picture Arrangement	N1 tar lat	Fz	-.79*
Picture Completion	N1 nt lat	Fz	-.81*
	P2 tar amp	Cz	.82*
	P2 nt amp	Pz	.78*
	P3 tar amp	Cz	.81*
	P3 tar amp	Pz	.87*
Verbal IQ	N1 tar amp	Fz	-.77*
	N2 nt amp	Cz	.82*

Note: tar = target; nt = nontarget; amp = amplitude; lat = latency. *p<.01 ** p<.001

The Performance IQ was significantly correlated with N200 latency in sessions two and three for the Comparison Group (see Tables 2 and 3).

Table 2

WAIS-R and ERP Correlations for Session Two

Test	Component	Site	r
	Alcoholic Group		
Information	P50 tar amp	Fz	-.81*
	N1 tar amp	Fz	-.92**
Similarities	P50 nt lat	Pz	.92**
Picture Completion	P50 nt amp	Pz	-.79*
Verbal IQ	N1 tar amp	Fz	-.79*
Full Scale IQ	N1 tar amp	Fz	-.89**
	Comparison Group		
Similarities	P50 nt amp	Pz	.78*
Digit Span	N1 nt amp	Fz	-.78*
Picture Completion	P50 nt amp	Fz	.77*
	P50 nt amp	Cz	.78*
Digit Symbol	N2 nt lat	Fz	.92**
	P3 tar amp	Fz	.84*
	P3 tar amp	Cz	.83*
	P3 nt lat	Cz	.91**
Block Design	P3 nt lat	Fz	.86*
Performance IQ	N2 tar lat	Fz	-.77*
	N2 nt lat	Fz	.82*
	P3 tar amp	Fz	.90**
	P3 nt lat	Fz	.72*

Note: tar = target; nt = nontarget; amp = amplitude; lat = latency. *p<.01 ** p<.001

Table 3

WAIS-R and ERP Correlations for Session Three

Test	Component	Site	r
	Alcoholic Group		
Arithmetic	P50 tar lat	Cz	-.92*
Block Design	P50 tar lat	Cz	-.93*
	N1 tar lat	Pz	-.90*
	P3 tar amp	Fz	-.91*
Performance IQ	P50 nt amp	Fz	.93*
	Comparison Group		
Similarities	N2 nt lat	Cz	-.91*
	N2 nt lat	Pz	-.88*
Arithmetic	N1 nt lat	Cz	.88*
Picture Arrangement	P50 tar lat	Pz	-.90*
	P2 tar amp	Cz	-.92*
	P2 nt amp	Cz	-.91*
	P2 tar amp	Pz	-.88*
	P2 nt amp	Pz	-.92*
Object Assembly	P2 tar amp	Pz	-.91*
Digit Symbol	N2 tar lat	Pz	-.90*
Performance IQ	N2 tar lat	Pz	-.92*

Note: tar = target; nt = nontarget; amp = amplitude; lat = latency. *$p<.01$ ** $p<.001$

Discussion

The results of this study support the notion that alcoholism has a deleterious effect upon the ERPs of human subjects. The reduced amplitude for N200 and P300 and the lack of an "oddball" effect, (i.e., no difference in amplitude between rare and frequent tones) for alcoholics replicate the results of other ERP studies using chronic alcoholics (Patterson et al., 1987; Porjesz & Begleiter, 1983; Porjesz et al., 1982). These results were found even though the subject population in the present study was concerned with acute alcoholics. It appears that the initial differences observed in the electrophysiological data were the same for acute alcoholics as shown in previous research testing chronic alcoholics. However, certain ERP component parameters (P50, N200, P300), with abstinence, may change over time in acute alcoholics. These results are very different to the past findings of Porjesz and Begleiter, 1990) who have suggested that few changes are found in alcoholics after two to five years of abstention. Although one must be cautious in the interpretation of the results with such a low study population (n=7), the results suggest that there may be a "recovery" of function in acute alcoholics postabstention.

Windle and Blane (1989) previously reported an association between verbal ability and drinking behavior in a national sample of young adult males. They found that nondrinkers had higher verbal ability (as measured by their Armed Services Vocational Aptitude Battery or "ASVAB" verbal subtests). Lower verbal ability was predictive of alcohol-related problem behavior. The WAIS-R verbal subtests differences found in this study, though significantly higher for the nonalcoholic group, were within normal limits for both groups. Although education was used as a covariate, the comparison group had significantly more years of education than the alcoholic group. These group differences may have had an impact on the verbal subtests scores. Although differences did exist between groups in the correlations of ERPs and WAIS-R scores, no significant trend was observable.

These results may provide insight for additional monitoring techniques to assess the progress of acute alcoholics and their cognitive ability prior to returning to their jobs. The present results are concerned with 3/4 of the data of the current research project. An attempt will be made to re-test all subjects (n=10) in the fourth quarter of this year.

References

Begleiter, H., Porjesz, B., & Chou, C. (1981). Auditory brainstem potentials in alcoholics. Science, 211(6), 1064-1066.

Donchin, E., Kramer, A., & Wickens, C. (1986). Application of brain event-related potentials to problems in engineering psychology. In: M. G. H. Coles, E. Donchin, and S. W. Porges (Eds.), Psychophysiology: Systems, processes and applications. New York: Guilford.

Duncan-Johnson, C. (1981). P300 latency: A new metric of information processing. Psychophysiology, 18, 207-215.

Ehlers, C., & Schuckit, M. (1990). EEG fast frequency activity in the sons of alcoholics. Biological Psychiatry, 27, 631-641.

Ellis, R., & Oscar-Berman, M. (1989). Alcoholism, aging, and functional cerebral asymmetries. Psychological Bulletin, 106, 128-147.

Goodwin, D., & Hill, S. (1975). Chronic effects of alcohol and other psychoactive drugs on intellect, learning, and memory. In: J. G. Rankin (Ed.), Alcohol, Drugs, and Brain Damage. Toronto: Addiction Research Foundation of Ontario.

Grant, Igor. (1987). Alcohol and the brain. Journal of Consulting and Clinical Psychology, 55, 310-324.

Hill, S., Steinhauer, S., Zubin, J., & Baughman, B. (1988). Event-related potentials as markers for alcoholism risk in high density families. Alcoholism: Clinical and Experimental Research, 12, 545-554.

Jones, B., & Parsons, O. (1972). Specific versus generalized deficits of abstracting ability in chronic alcoholics. Archives of General Psychiatry, 26, 380-384.

Parsons, O., & Leber, W. (1982). Alcohol, cognitive dysfunction, and brain damage. National Institute on Alcohol Abuse and Alcoholism, Alcohol and Health Monograph 2: Biomedical Processes and Consequences of Alcohol Use, (Serial No. 92-1191).

Patterson, B., Sinha, R., Williams, H., Parsons, O., Smith, L., & Schaffer, K. (1989). The relationship between neuropsychological and late component evoked potentials measures in chronic alcoholics. International Journal of Neuroscience, 49, 319-327.

Patterson, B., Williams, H., McLean, G., Smith, L., & Schaffer, K. (1987). Alcoholism: Effects on visual and auditory event-related potentials. Alcohol, 4, 265-274.

Pfefferbaum, A., Horvath, T., Roth, W., Clifford, S., & Kopell, B. (1980). Age and chronic effects of ethanol on event-related potentials. In H. Begleiter (Ed.), Biological Effects of Alcohol. New York: Plenum.

Polich, J., Burns, T. & Bloom, F. (1988). P300 and the risk for alcoholism: Family history, task difficulty, and gender. Alcoholism: Clinical and Experimental Research, 12(2), 248-254.

Porjesz, B., & Begleiter, H. (1983). Brain dysfunction and alcohol. In: B. Kissin and H. Begleiter (Eds.). The Pathogenesis of Alcoholism: Biological Factors. New York: Plenum Press.

Porjesz, B., & Begleiter, H. (1985). Human brain electrophysiology and alcoholism. In: R. Tarter and D. Van Thiel (Eds.), Alcohol and the Brain. New York: Plenum Press.

Porjesz, B., & Begleiter, H. (1990). Neuroelectric processes in individuals at risk for alcoholism. Alcohol and Alcoholism, 25, 251-256.

Porjesz, B., Begleiter, H., & Sammuelly, I. (1982). Cognitive defects in chronic alcoholics and elderly subjects assessed by evoked brain potentials. Acta Psychiatra Scand., Supplement 286, 15, 147-154.

Ryan, C., & Butters, N. (1983). Cognitive deficits in alcoholics. In: B. Kissin and H. Begleiter (Eds.). The Pathogenesis of Alcoholism, Vol 7. New York: Plenum Publishing.

Skerchock, J., & Cohen, J. (1984). Alcoholism, organicity, and event-related potentials. In: Brain and Information: Event-Related Potentials, Vol. 425. New York: New York Academy of Science.

Spitzer, J., & Newman, C. (1987). Brainstem auditory evoked potentials in newly detoxified alcoholics. Journal of Studies on Alcohol, 48, 9-13.

Windle, M., & Blane, H. (1989). Cognitive ability and drinking behavior in a national sample of young adults. Alcoholism: Clinical and Experimental Research, 13, 43-48.

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David A. Kobus, Lex L. Merrill, & Jennifer A. Rogalle

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Naval Health Research Center
P. O. Box 85122
San Diego, CA 92186-5122

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13. ABSTRACT *(Maximum 200 words)*

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