Evoked Brain Potential Differentiation Between Geriatric Subjects and Chronic Alcoholics with Brain Dysfunction

B. Porjesz and H. Begleiter

Downstate Medical Center, Department of Psychiatry, Brooklyn, New York 11203

It has been hypothesized that alcoholism accelerates the aging process, as similarities in cognitive dysfunction between young alcoholics and old people have been reported (e.g., abstraction and adaptive abilities) (4,5,7,8,20). Although alcoholics may exhibit similar behavioral deficits to old people (e.g., perseverative tendencies), these behavioral deficits may well reflect the endpoints of different complex neurophysiological processes.

For the past several years, we have systematically examined electrophysiological aberrations in various patient populations with the use of event-related potentials (ERPs) (1,2,12,13). These ERP techniques require the subject to be actively engaged in a task, usually an information-processing task. In the present study, we investigated the P3 or P300 component of the ERP in alcoholics and elderly people. A P300 wave can only be elicited under rather specific conditions relating to stimulus significance; namely, task relevance, unpredictability, and infrequency (17–19).

We were interested in investigating the ability of these subjects to differentiate between relevant and irrelevant inputs and their ability to probability-match stimuli in terms of their frequency of occurrence. Therefore, we designed a visuospatial P300 task that both groups of subjects would find somewhat difficult, as it required them to change sets; stimuli that were relevant in one block were no longer relevant in another block.

METHODS

Subjects

Three groups of education-matched, right-handed male subjects were studied: 30 alcoholics, 10 geriatrics, and 30 controls. All subjects (Ss) were otherwise healthy and medication-free for a minimum of 3 weeks. The alcoholics (mean age 36) had been drinking an average of 10 years and had been abstinent from alcohol a minimum of 1 month. The geriatric subjects were elderly people who...
were all over 65 years of age (mean age 72). They ranged from nondrinkers to occasional "social drinkers," and none had ever had a drinking problem. The control group consisted of young males who were age-matched to the alcoholic group (mean age 34). Their drinking histories were similar to those of the geriatric group.

Procedure

The subject sat in a sound-attenuated room with his head resting on a chin rest so that he was looking directly at the center of a computer-generated display located 50 cm from his eyes. All stimuli were presented in the center of the screen at a random rate of every 2 to 5 sec. The stimuli consisted of two regular geometric shapes (square and triangle) and irregular geometric forms, all equated for size and intensity.

The subject's task was to press a button only to the target stimulus which was either a square or triangle. When the square was the target (T), the triangle was the nontarget (NT), and vice-versa, so that ERPs could be obtained to the same stimulus when it served as a T or NT. The T stimuli occurred rarely (8.3%), as did the novel stimuli (irregular shapes), whereas the NTs made up the remaining 83.3% of the stimuli. Each novel (N) stimulus was presented only once. The T and NT stimuli were alternated every other block, with a tone indicating the beginning of a new block; the subject had to keep track of which stimulus was T and which was NT.

Monopolar recordings were obtained from midline occipital (O2), parietal (Pz), central (Cz), and frontal (Fz) scalp locations in accordance with the 10–20 International System, using the linked ears as reference and the nasion as ground; vertical eye leads recorded electrooculograms (EOG). The ERPs were amplified by Grass amplifiers (bandwidth 0.3–60 Hz) and were sampled by a PDP 11/40 computer for a 500-msec epoch (200 points/sec).

In order to do the data analysis on an equal number of ERPs in each stimulus category, ERPs were averaged to all the novels (N) together, targets (T) together, and only the nontargets immediately preceding the target stimuli. These stimuli were named preceding nontargets (PNT) and are labeled as such in all figures. Results from peak-to-peak amplitude and latency measures of N2–P3 recorded at Pz only will be reported here; the other results will be reported elsewhere.

RESULTS

A two-way analysis of variance with repeated measures on one factor was performed (21).

As indicated in Fig. 1, the amplitude of N2–P3 was found to be significantly smaller in the alcoholic subjects to the T stimuli only, both in comparison with the control group (p < 0.001) and the geriatric group (p < 0.02). No significant amplitude difference existed between groups for PNT and N stimuli. The
amplitude of N2–P3 was not statistically different between old people and normal controls.

The amplitude of N2–P3 differed significantly across the three classes of stimuli in both the control and the geriatric groups (Fig. 1); it was largest for T, next largest for N, and smallest for PNT ($p < 0.001$, controls; $p < 0.02$, geriatrics). As indicated in Fig. 1, this was not the case for the alcoholic group who maintained the same low-level P3 amplitude regardless of task.

As Fig. 2 indicates, P3 amplitude was significantly larger when the same stimulus served as T or NT in the control group ($p < 0.001$) and the geriatric group ($p < 0.005$). There was no significant difference in P3 amplitude between T and NT in the alcoholic group.

The difference in waveform (P3 amplitude) to T or NT stimuli in the control group is illustrated in Fig. 3. As Fig. 3 indicates, the P3 component was significantly larger to the T than the NT. In addition, there is a latency shift in P3 that occurs significantly earlier when the stimulus is a NT than when it is a T in both the control and geriatric groups ($p < 0.001$, control; $p < 0.001$, geriatric); the difference in P3 latency between T and NT in the alcoholic group was negligible.

In contrast to the control group, the alcoholic grand mean waveform did not differ significantly in any respect between T and NT stimuli (Fig. 4). The magnitude of the P3 component to T stimuli was significantly depressed in alcoholics in comparison to controls (Fig. 3).

As is indicated in Fig. 5, P3 occurred significantly later in the geriatric group than in each of the other two groups ($p < 0.001$) for all stimulus categories. On the other hand, the latency of P3 fell within the normal range for the chronic alcoholics.
FIG. 2. Mean VERP amplitude N2–P3 to target (solid bars) and nontarget (hatched bars) stimuli for the three groups of subjects: control, alcoholic, and geriatric. Each division on the ordinate is equal to 1.5 μV. See Fig. 1 for SDs.

FIG. 3. Grand mean ERP waveforms recorded at Pz to the target stimulus (solid line) and nontarget stimulus (dashed line) in the control group. Each division on the ordinate is equal to 2 μV.
FIG. 4. Grand mean ERP waveforms recorded at Pz to the target stimulus (solid line) and nontarget stimulus (dashed line) in the alcoholic group. Each division on the ordinate is equal to 2 μV.

FIG. 5. Mean latency of P3 to the target (T), nontarget (PNT), and novel (N) stimuli in the control, alcoholic, and geriatric groups of subjects. Standard deviations are as follows: T (41.11, 42.35, 36.6), PNT (30.13, 40.39, 43.39), N (47.05, 39.74, 54.18), for the control, alcoholic, and geriatric groups, respectively, for each stimulus category.

The latency of N2 also occurred significantly later in the geriatric group than in the other two groups (p < 0.001 for T and N; p < 0.02, PNT), whereas latencies of N2 were virtually identical between the alcoholic and the control group.

DISCUSSION

The results of this study indicate that the P3 component was significantly reduced in chronic alcoholics. This component is of normal amplitude in elderly subjects but occurs significantly later. Thus, it appears that although ERPs in
both groups differ from those of young healthy controls, the nature of their aberration is different.

The finding that P3 amplitudes are similar in old people and normal controls indicates that old people are able to probability-match as well as young people. The P3 amplitude was significantly larger and later to target than nontarget stimuli in both the control group and elderly group. This indicates that old people are able to respond to relevant target stimuli and attenuate responding to irrelevant stimuli. On the other hand, the alcoholics maintained the same low amplitude and identical latencies of P3 to both target and nontarget stimuli regardless of stimulus relevance. Thus, they seem to be unable to respond differentially to relevant and irrelevant inputs. This seems to indicate a deficit in "sensory filtering" in chronic alcoholics and an inability to utilize available information.

As P3 latency reflects the amount of time necessary to make a decision, the significantly longer P3 latency in the elderly group suggests that old people are slower in deciding whether a stimulus is target. The P3 latencies have been found to correlate with reaction time latencies (11,14,16), and both of these seem to increase with age (3). Our finding that P3 occurs later in old people without concomitant amplitude decrements has been reported in several different laboratories (6,9,15). In one normative P3 study (10), the rate of delay in latency with age was found to be 0.7 msec/year for P2, 0.8 msec/year for N2, and as high as 1.8 msec/year for P3.

It seems, therefore, that both the alcoholic and elderly groups manifest electrophysiological brain dysfunction. However, although both groups resembled each other behaviorally, they were quite different from each other electrophysiologically. The major ERP aberrations in the alcoholic group were (a) the lack of differentiation between their responses to relevant and irrelevant inputs, and (b) the low voltages of their event-related brain activity. Although the major electrophysiological aberration in the alcoholic subjects is one of voltage, the major electrophysiological dysfunction in the geriatric subjects is one of latency. The alcoholics manifest impaired "sensory-filtering" and probability-matching processes (responding identically to infrequent relevant and frequent irrelevant inputs), whereas the geriatric subjects differentiate between relevant and irrelevant inputs. The geriatric subjects, on the other hand, exhibit impaired stimulus evaluative mechanisms with regard to speed of evaluation, requiring a longer period of time to determine the relevance of a stimulus.

Thus, on the basis of this information-processing event-related-potential experiment, it was concluded that although ERPs in both alcoholic and geriatric subjects differ from those of young, healthy controls, the nature of brain dysfunction is different. Despite behavioral similarities between alcohol-related deficits and those of the aging process, the underlying neurophysiological aberrations are quite different in the two groups and suggest caution in the postulation of a common neuropathological mechanism.
ACKNOWLEDGMENTS

We would like to thank Lynda Herskovits for her invaluable assistance in all aspects of the study. We would also like to thank Dr. Joel Solomon, Dr. Israel Samuely, Sharon Schurtz, and Maureen Meehan for their most helpful recruiting and screening of patients. This study was supported by Grant R01 AA02686.

REFERENCES

