Assessment of Prepubertal and Postpubertal Boys and Girls at Risk for Developing Alcoholism with P300 from a Visual Discrimination Task*

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ABSTRACT. A total of 86 children (45 male) between the ages of 8-18 who were from families that were either at high- or low-risk for developing alcoholism were evaluated in a visual event-related potential paradigm. The children responded to two target conditions (hard and easy) and a blank condition by pressing an appropriate button. P300 amplitude was reduced in prepubescent boys who were at high-risk for developing alcoholism. Reaction time data for type of target indicated that, while latency was longer for the hard condition compared to the easy one, no significant differences by risk status were found. Performance accuracy did not differ by group status. These behavioral findings suggest that P300 amplitude is an electrophysiological marker of alcoholism risk in young boys. (J. Stud. Alcohol 54: 350–358, 1993)

THERE IS considerable evidence that risk for becoming alcoholic tends to be familial (Cotton, 1979; Hill et al., 1977, 1987). Demonstration that a characteristic or trait is familial does not prove that it is genetic. Obviously, risk for alcoholism can be increased by association with persons who drink heavily. It may be assumed that individuals from high-risk families have both higher genetic loading and greater exposure to individuals who drink excessively. Therefore, finding markers of alcoholism risk that are minimally affected by exposure to an alcoholic parent, sibling or other family member could prove useful in understanding the relative contribution of genetic factors to alcoholism vulnerability. Moreover, these markers could be utilized in prevention efforts by providing a screen for alcoholism vulnerability.

Since 1982 when Elmasian et al., comparing young adult subjects with a family history of alcoholism (FHP) with those without such history (FHN), found reduced amplitude of the P300 component of the event-related potential (ERP) among the FHP subjects, there have been a number of efforts designed to determine if these particular electrical brain potentials are associated with alcoholism risk. The event-related potential is of interest for two reasons. First, ERPs are associated with particular sensory and cognitive aspects of information processing. Second, the ERP waveform appears to be under genetic control (Bock, 1976; Polich and Burns, 1987; Surwillo, 1980).

The first attempts to replicate the Elmasian finding, using the same subject population and an auditory paradigm but without placebo manipulation, were unsuccessful (Neville and Schmidt, 1985). Polich and Bloom (1987, 1988) and Polich et al. (1988a), contrasting two family history groups of young men and utilizing an auditory paradigm, found no differences between family history groups either with respect to P300 latency or amplitude. Schuckit et al. (1988) also failed to find family history differences in P300 amplitude or latency except when ethanol was administered. Here, the results were only for P300 latency and involved the speed with which FHP subjects returned to baseline (FHP subjects returned to baseline more quickly than did FHN subjects).

Steinhauer et al. (1987) and Hill et al. (1988), using an auditory paradigm, also failed to find differences in P300 amplitude in high- and low-risk young men, though differences in latency were noted. When the same paradigm was used with minor children, mixed results were obtained (Hill et al., 1990). Whereas high-risk children displayed decreased amplitude in two stimulus probability conditions (.67 and 1.00), they did not show a decrease in the .33 probability condition. In that paradigm the .33 condition represents those situations in which a target is infrequent and is preceded by a nontarget, whereas .67 represents one nontarget following another nontarget. In the 1.00 probability condition a nontarget followed a target stimulus. This 1.00 condition was termed the "certainty" condition, because the subjects knew the next
stimulus had to be a nontarget since they had been instructed that one target never followed another target.

The results for P300 using visual tasks have also been explored with generally more consistent results. Three types of tasks have been employed. One involved a head orientation task with two levels of discrimination difficulty (Begleiter et al., 1984; O'Connor et al., 1987). A second involved matching forms that varied on three dimensions (color, shape and number) using a modification of the Continuous Performance Test (CPT) after Rosvold et al. (1956), which required subjects to count the number of times two consecutive stimuli matched on all three dimensions (Whipple et al., 1988). The third visual task that has been used with high-risk individuals employed a discrimination task in which subjects were asked to discern two intensities of light and silently count the number of times the dim light appeared (Polich et al., 1988b).

To date, only the Begleiter et al. (1984) and Whipple et al. (1988) investigations have utilized prepubescent boys. This strategy has the advantage of removing the unwanted effects of either acute or chronic alcohol use upon brain functioning, both of which appear to be associated with changes in ERP characteristics inasmuch as chronic alcoholics have repeatedly been shown to exhibit ERP changes relative to nonalcoholics (Parsons et al., 1990; Patterson et al., 1987). The present investigation was conducted with minor children so that these extraneous factors might be removed. Secondly, because age and gender distributions of the various samples utilized in previous studies may have contributed to the inconsistencies of the reported findings, a larger sample size was employed making it possible to control statistically for these important variables. Finally, the visual task employed was intended as replication of the paradigm used by Begleiter et al. (1984), one of two visual paradigms (Begleiter et al., 1984; Whipple et al., 1988) that resulted in impressive differences between high- and low-risk prepubescent children.

Method

Subjects

A total of 86 children participated in the study. The children were drawn from two groups: high risk and low risk. The high-risk group had an exceptionally high family history of alcoholism and consisted of 45 children (23 male). The low-risk group had no first- or second-degree relatives with diagnosed alcoholism and consisted of 22 male and 19 female children.

The high-risk families were part of a larger family study of alcoholism (the Cognitive and Personality Factors Family Study—CPFFS) that includes multiple extended pedigrees with multigenerational alcoholism, largely uncontaminated by other psychopathology (all first-degree relatives were required to be free of DSM-III [Axis I] disorders). These high-risk families had been ascertained through a proband set comprised of a pair of alcoholic brothers. The presence of alcoholism or other psychopathology was determined for these brothers and their first-degree relatives through face-to-face interviews (Diagnostic Interview Schedule [DIS]), allowing for DSM-III (Spitzer, 1982) and Feighner (Feighner et al., 1972) criteria to be applied.

The low-risk families who were also part of the larger study included multiple members of pedigrees selected for absence of psychopathology. These families were selected from among volunteers who responded to advertisements in local newspapers soliciting participation in research. Families qualified for participation by having both multiple siblings and at least one parent available for personal interview, as well as absence of psychopathology, including alcoholism, upon direct interview (DIS). In order to ensure that the structural characteristics of the two family types were similar, the families were selected through a pair of male siblings. All available siblings and parents were interviewed to confirm the absence of psychopathology in the designated sibling pair and their first-degree relatives.

All available children between the ages of 8-18 who were the offspring of the proband brothers (high or low risk) or were their siblings were included in the study. Multiple children from the same nuclear family, where available, were included (nine high-risk families and 14 low-risk families had two children, and one high-risk family had three children). Extensive clinical information based on direct interview of family members was available for each parent. One parent was a member of the high-risk CPFFS pedigrees; the other parent was one who married into the target pedigree. Similar assessment methods were used for low-risk family members.

However, due to the design of the larger study from which the sample was drawn, less control could be exerted over the clinical characteristics of the parent “marrying in” to the target (high- and low-risk) CPFFS families. Therefore, occasionally it was the case that some children from high-risk families may have had the potential for familial psychopathology other than alcoholism, though this was minimal. (In fact, this usually served to increase the alcoholism risk of the child because parents marrying into our high-risk target families often were themselves from alcoholic families. Their family history data were not included in assessment of risk because of the greater reliability of family interview data of which the target family data were comprised.) In the case of children from low-risk families, parents who represented either the proband set or their siblings were free of all Axis I psychopathology including alcoholism, as were their first-degree relatives. However, the parent “marrying in” might have alcoholism or other psychopathology present. In order to ensure that a truly low-risk sample might be studied, cases of this type were excluded from the present analysis.
These high-density families represent a form of alcoholism that appears to be mediated by a major gene (Aston and Hill, 1990). Of the 45 high-risk children included in this study, 30 came from a family with at least one alcoholic parent. Furthermore, among the relatives for whom reliable diagnostic information was available, it is noted that 8 grandmothers and 27 grandfathers were alcoholic. Of the 121 maternal and paternal uncles available for assessment, 99 were alcoholic. Among the 40 aunts, 10 were alcoholic. Thus, each child had an average of 3.7 alcoholic relatives. (Calculations were based on the high-risk CPFFS pedigrees only.) Therefore, even those children who did not live with an alcoholic parent had a very high lifetime risk for developing alcoholism.

The children were well matched on age. Additionally, an attempt was made to match the children for socioeconomic status of their parents. The mean (±SD) age was 10.87 ± 3.0 for high-risk males and 11.45 ± 3.6 for high-risk females. Mean age for control males was calculated to be 10.77 ± 2.7 while the females averaged 12.05 ± 3.3. The socioeconomic status (SES) of the two groups was determined by employing Hollingshead's Four Factor Index of Social Status (Hollingshead, 1975). This instrument combines the education and job title of each parent into a summary score which can then be grouped into five levels: V, professional; IV, semiprofessional/technical; III, skilled; II, semiskilled; and I, unskilled. Comparing the high- and low-risk groups reveals a somewhat higher socioeconomic status of the low-risk children. For the high-risk children 38.2% were from homes where the parents were in the top two categories, professional or semiprofessional/technical, while 63.0% of the low-risk children were from families in these two categories. A chi-square analysis did reveal differences among the two groups when children from levels I, II and III and those from levels IV and V were grouped in a 2 × 2 analysis \( \chi^2 = 3.68, 1 \text{ df}, p < .055 \). The lower SES of the families of high-risk children may not be surprising in view of the tendency for alcoholism to result in a downward drift in socioeconomic status. Nevertheless, with 38.2% of the families representing professional and semiprofessional socioeconomic status, the high-risk children came from relatively high-functioning families.

**Procedure**

The task employed in this study was a visual event-related potential task after the procedure of Begleiter et al. (1984). An Atari 130 computer executed a basic program to present the stimuli at 33 msec duration with intertrial interval varying randomly between 2.25 and 4 sec. The subjects were seated in a darkened, sound-attenuated testing room. Stimuli were displayed on a Magnavox RGB Monitor 80, placed 132 cm from the subject, subtending a visual angle of 3.8°. The monitor was set to the default green mode, resembling the oscilloscope display used by Begleiter et al. (1984). Five stimuli were randomly presented. One view, the nontarget stimulus, was a simple circle to which the subject was instructed not to respond (blank condition). There were four possible aerial views of target stimuli, a representation of a head with a nose and only one ear. The subject was instructed to press the button that corresponded to the depicted ear. The easy conditions occurred when the nose was oriented upward and the ear (right or left) was on the same side as the button depressed. In the hard conditions, the nose was oriented downward and the subject was required to spatially rotate the head in order to respond correctly. Thus, in the hard condition, the ear was depicted on the opposite side of the head as the button was pressed.

A standard set of instructions was read to each child. If additional clarification was needed, directions were amplified by the experimenter. The child was first shown a picture of each of the stimuli and asked to make the correct response to each head (target) stimulus. Next, each stimulus was presented on the video monitor at a slow pace using a long exposure duration (3,200 msec). Once the child was performing correctly (usually less than 10 trials), the visual display duration was decreased to the 33 msec exposure time of the main experiment for several additional practice trials. (The children were encouraged to respond quickly, but more importantly, to respond accurately.) Two blocks of 120 trials were presented to the subjects. Of the 240 total trials, 160 were blank (nontargets), 40 were easy condition targets (20 right, 20 left) and 40 were hard condition targets (20 right, 20 left).

Event-related potentials were recorded using Ag/AgCl electrodes placed over the midline frontal, vertex, parietal and occipital (Fz, Cz, Pz, Oz) locations, and left and right parietal (P3, P4) locations, referred to linked ears, with forehead ground. Ocular artifacts were monitored from an electrode placed beneath the left eye, referred to linked ears. Electrophysiological data were amplified by 20k (10k for the eye channel) using a Grass Model 12 Neurodata system, set to a bandpass of .01 to 30 Hz. A Digital Equipment Corp. PDP-11/23 lab computer (slaved to coincide with the video output of the Atari) sampled each trial for a 1,200 msec epoch, at 8 msec intervals, beginning with a 200 msec prestimulus baseline. All data were stored on magnetic media. The subject's response, reaction time and correctness of the response were automatically encoded into the data file. Eye artifacts (blinks or eye movements) greater than approximately 50 μV were identified online. Offline, all correctly performed, artifact-free trials were averaged according to condition (hard, easy, blank).

ERP components N100, P200, N250 and P300 were identified offline using a peak detection program, although the present discussion focuses primarily on P300 component. The program searched for maximum positivity of
P300 at Pz in an initial window beginning at 256 msec (or the peak of N250, if later) and extending to 416 msec. Augmented by the analog plots of all ERP data, peak identification was verified visually by at least two experimenters who extended the search window up to 700 msec when necessary. Latency at Pz and peak-to-baseline amplitudes for each electrode were automatically stored in ASCII files. Behavioral and ERP data were analyzed utilizing ANOVA (BMDS2V). The Greenhouse-Geisser correction for nonhomogeneity of variance was applied where appropriate. For post hoc comparisons, the Newman-Keuls test (alpha = .05) was employed.

Results

Behavioral measures

Reaction time data were analyzed using an ANOVA to determine differences between group (high and low risk), gender, age and condition (hard versus easy). Reaction time data for each target type are presented by group and gender in Table 1. A significant condition effect was found as a result of longer latencies being associated with the more difficult condition (\( F = 130.57, 1/78 \) df, \( p < .0001 \)). There was also a significant decrease in reaction time for older children compared to younger children (\( F = 42.81, 1/78 \) df, \( p < .0001 \)). Of particular relevance to the ERP findings is the fact that there were no significant differences in reaction times between the high- and low-risk groups or between males and females.

Performance was also analyzed in terms of hit rates for the combined target conditions and false alarm rates for the blank condition (see Table 1). Hit rates ranged from .70 to .91 for the eight age by gender groups. Older children showed an improvement in hit rates compared to younger children (\( F = 4.34, 1/78 \) df, \( p = .041 \)). Also, an interaction between age and gender was seen for hit rates due to a greater change in hit rates occurring with age for females than for males (\( F = 4.49, 1/78 \) df, \( p = .037 \)). There were no significant differences in false alarm rates among the groups. Thus, the behavioral data (performance and reaction time) indicate a high degree of similarity between the high- and low-risk children.

Event-related potentials

Overall analysis—Amplitude of P300. Amplitude data for the P300 component were subjected to an ANOVA in which the main effects and interactions of five factors—group (high risk and low risk), gender, age, condition and electrode (six sites)—were evaluated. Significant main effects were seen for condition (\( F = 129.14, 2/153 \) df, \( p < .0001 \)). Post hoc tests (alpha = .05) indicated that blanks elicited significantly smaller P300s than did targets at all electrodes except Fz, while hard and easy targets did not differ significantly at any electrode.

Differences were seen across electrode location (\( F = 133.37, 3/219 \) df, \( p < .0001 \)). Topographically, P300 was significantly larger at Pz and smaller at Fz than at all other sites (Cz, P3, P4, Oz amplitudes did not differ significantly). At each electrode, differences between hard and easy conditions (averaged across all subjects) were less than 1 μV. Normalized amplitudes (with Pz set at 100%) were 7.2%, 57.6%, 100% and 63%, respectively, for midline locations Fz, Cz, Pz and Oz, and 53% and 61%, respectively, for P3 and P4. A similar distribution was observed for P300 in the blank condition, although reduced to approximately 60% of the hard and easy amplitudes.

There was a significant interaction of Group × Gender (\( F = 5.69, 1/78 \) df, \( p = .02 \)). While the control males had larger amplitudes than the control females, high-risk males had lower amplitudes than high-risk females. There was an Age × Electrode interaction (\( F = 5.90, 3/219 \) df, \( p = .0009 \)) indicative of larger differences in age over more anterior electrode locations (Fz and Cz) than at

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<thead>
<tr>
<th>Table 1. P300 reaction time, hit rate and false alarm rate (mean ± SD)</th>
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<tr>
<td><strong>Reaction time (msec)</strong></td>
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<tr>
<td><strong>High-risk</strong></td>
</tr>
<tr>
<td>Prepubertal</td>
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<tr>
<td>Male (n = 17)</td>
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<td>Female (n = 15)</td>
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<tr>
<td>Postpubertal</td>
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<tr>
<td>Male (n = 6)</td>
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<td>Female (n = 7)</td>
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<tr>
<td><strong>Low-risk</strong></td>
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<tr>
<td>Prepubertal</td>
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<tr>
<td>Male (n = 17)</td>
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<td>Female (n = 11)</td>
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<tr>
<td>Postpubertal</td>
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<td>Male (n = 5)</td>
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<td>Female (n = 8)</td>
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conditions, as compared to the blank stimulus, at the Pz electrode than at other sites.

There were three 3-way interactions and one 4-way interaction, all of which involved differences in electrode location, but not group (high or low risk). These were omitted from the present discussion.

The P300 component was significantly larger at the midline parietal electrode (Pz) than at other sites across all groups and conditions. The average ERP waveforms from all electrodes are plotted by group in Figure 1. Subsequent analyses of P300 are limited to Pz. Limiting the analysis to Pz (Group × Age × Gender × Condition) resulted in significant interactions between age and gender ($F = 4.48, 1/78$ df, $p = .038$) and age and condition ($F = 6.71, 2/148$ df, $p = .002$). (See Table 2.) Additionally, a trend ($p = .06$) for a Group × Gender interaction was observed. This was due to high-risk males having lower P300 amplitudes than their low-risk counterparts, whereas the high-risk females tended to have higher amplitudes than did the low-risk females (see Figure 2).

The amplitude of the visual P300 observed in these children is somewhat larger than that seen using auditory paradigms (Hill et al., 1990). However, the values obtained (25-40 μV) are well within the range observed by other investigators who have studied young children (Courchesne et al., 1984; Holcomb et al., 1985; Johnson, 1989; Lincoln et al., 1985). Although these investigations have focused on children with other problems (e.g., attention deficit disorder, autism), the control children that have been included in these studies allow for comparison with the present sample. Comparison of the amplitudes obtained from control children in the present study with those from children included in these other investigations shows remarkably similar amplitudes (26-38 μV). Thus, the reduction in amplitude in high-risk boys relative to control boys cannot be interpreted as being a result of artifactually high amplitudes among control boys.

Because developmental effects were suggested by results of the analyses performed using two age groups,

### Table 2. P300 amplitude and latency (mean ± SD)

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<tr>
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<th>Amplitude (μV)</th>
<th>Latency (msec)</th>
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<tbody>
<tr>
<td></td>
<td>Hard</td>
<td>Easy</td>
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<tr>
<td><strong>High-risk</strong></td>
<td></td>
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<tr>
<td>Prepubertal</td>
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<tr>
<td>Male (n = 17)</td>
<td>29.94 ± 8.7</td>
<td>30.90 ± 9.1</td>
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<tr>
<td>Female (n = 15)</td>
<td>37.11 ± 12.1</td>
<td>40.75 ± 18.3</td>
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<tr>
<td>Postpubertal</td>
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<tr>
<td>Male (n = 6)</td>
<td>33.84 ± 6.3</td>
<td>35.70 ± 11.0</td>
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<tr>
<td>Female (n = 7)</td>
<td>32.03 ± 13.2</td>
<td>28.35 ± 8.8</td>
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<tr>
<td><strong>Low-risk</strong></td>
<td></td>
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<tr>
<td>Prepubertal</td>
<td></td>
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<tr>
<td>Male (n = 17)</td>
<td>38.11 ± 9.0</td>
<td>36.25 ± 12.1</td>
</tr>
<tr>
<td>Female (n = 11)</td>
<td>34.71 ± 7.4</td>
<td>33.64 ± 7.3</td>
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<tr>
<td>Postpubertal</td>
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<tr>
<td>Male (n = 5)</td>
<td>38.40 ± 7.9</td>
<td>32.57 ± 9.6</td>
</tr>
<tr>
<td>Female (n = 8)</td>
<td>25.55 ± 7.8</td>
<td>24.63 ± 9.7</td>
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several analyses were repeated using age as a covariate rather than as a grouping factor. Thus, an analysis of covariance was performed to control for the effects of age on P300 (Group × Gender × Condition). While age was not a significant covariant in this analysis, controlling for age allowed the Group × Gender interaction to become manifest at Pz (F = 6.22, 1/81 df, p = .015). Given the Group × Gender interaction, the data were next analyzed separately for males and females.

**Analysis by gender.** Data were analyzed separately for the male and female groups. For males, significant differences were seen for the high- versus the low-risk groups, with larger amplitudes being observed for the low-risk children (F = 4.14, 1/43 df, p = .048). Utilizing age as a covariate had no effect on this finding. Differences between high- and low-risk groups were not significant for the females, however. Differences among conditions were significant for both males (F = 148.60, 2/84 df, p < .0001) and females (F = 99.37, 2/66 df, p < .0001).

**Analysis by gender and age group.** Further analyses were employed to compare these data to those of Begleiter et al. (1984), who tested only males aged 7 to 13. Using our data for younger males only (aged 8 to 12), a significant group difference was still found (F = 4.49, 1/32 df, p = .042), which was not affected by covarying age. In contrast, there were no significant group differences for prepubertal and postpubertal female subjects or for post-
High-Risk Males
Low-Risk Males
High-Risk Females
Low-Risk Females

PREPUBERTAL
(8-12)
POSTPUBERTAL
(13-18)

FIGURE 3. Mean P300 amplitude at Pz (± 1 SE) averaged across hard and easy conditions as a function of gender, age and high- or low-risk status

pubertal boys. (See Figure 3 in which the average amplitudes of the hard and easy conditions are displayed by age group, risk status and gender.)

Distribution of amplitude by age and gender. To explore further the gender difference found by parametric analyses, each child from the high-risk families was classified with respect to his/her deviation from the mean of the controls. The purpose of this classification was not to evaluate statistically the differences between groups, as nonparametric analyses would have lesser power, but to determine how frequently these aberrations occurred. Inspection of the amplitudes revealed that 20% of the girls and 35.3% of the boys 12 years old and under showed decreased P300 amplitude > 1 standard deviation below the mean. In comparison, 10.7% of controls (9.1% for girls and 11.8% for boys) showed a deviation this large. It is of interest to note that when the other end of the distribution is inspected other gender differences become apparent. Whereas 31.8% of the high-risk girls showed an elevation in amplitude, none of the high-risk boys showed an elevation. For controls, 10.5% of the girls and 9.1% of the boys exceeded 1 standard deviation.

Latency of P300. The observed mean latency for P300 was 499 msec (Table 2 provides a breakdown of latencies by condition and subject group). Latency data for P300 at Pz were subjected to the same four-way analysis of variance as was used to evaluate the amplitude data. No significant differences in latency were observed as a function of age (F = 73.80, 1/78 df, p < .0001) (postpubescent children had shorter latencies). In addition, there was a main effect of condition (F = 36.45, 2/137 df, p < .0001). The hard and easy conditions had similar P300 latencies which were each significantly longer than for the blank condition. A significant interaction between age and condition was also noted (F = 5.92, 2/137 df, p = .005).

Earlier ERP components—Amplitude. Amplitude findings for earlier components are summarized briefly. N100, P200 and N250 all showed significantly larger distributions over anterior than over posterior electrodes (all p’s < .0001). Subsequent analyses focused on activity at the Cz electrode. N100 showed only a significant effect of age (F = 21.16, 1/78 df, p < .0001), with younger children having greater negativity than older children. P200 at vertex was different only for condition (F = 30.49, 2/149 df, p < .0001), with the hard and easy conditions more positive than blanks. N200 showed both an effect of age (F = 20.09, 1/78 df, p < .0001), with young children having greater negativity, and condition (F = 7.09, 2/130 df, p = .0023), with the blank condition less positive than the two target conditions.

Earlier ERP components—Latency. The N100, P200 and N250 components were associated with observed mean latencies of 126, 243 and 320 msec, respectively. For N250 there was a significantly earlier peak for older (301 msec) than younger (340 msec) children (age: F = 22.05, 1/78 df, p < .0001). The other latency findings for these components must be regarded with some question because they fell within a range of only one or two sampling points (i.e., data were digitized only every 8 msec). Findings in this category for N100 include a difference in latency for high-risk (122 msec) compared to low-risk (131 msec) children (F = 4.70, 1/78 df, p = .033) and a Group × Age interaction (F = 6.29, 1/78 df, p = .014). Similarly, for P200, there was a condition effect (F = 5.05, 2/147 df, p = .009) over a range of 8 msec and a Gender × Age × Condition interaction (F = 3.19, 2/147 df, p = .047) over an 18 msec range. For N250, there was a Gender × Condition interaction (F = 5.29, 2/147 df, p = .007).

Discussion

The high-risk children employed in this study have an exceptionally high lifetime risk for developing alcoholism. The high-density pedigrees from which these children were drawn exhibit numerous cases of alcoholism within the parental generation and include multigenerational occurrence. Because of the design of the larger study of which these children are a subsample the low-risk children have a very low risk for developing alcoholism. At least one parent and his or her first-degree relatives had been screened for absence of other psychiatric disorders. As a result, these control children have a lower risk for developing other psychiatric disorders as well.

Comparison of the electrophysiological and behavioral performance of these two groups of children revealed
clear and significant differences in electrophysiological characteristics. Whereas the high-risk children on the whole did not display reduced P300 amplitude, when the ages of the subjects were covaried out clear gender by group differences were apparent. This was due to the fact that the high-risk boys, on the whole, had smaller P300 amplitudes than did their low-risk counterparts. Among the high-risk girls, fewer showed a reduction in amplitude than did the boys, resulting in no statistically significant difference. However, more girls than boys showed increases in amplitude (> 1 SD above mean).

It is concluded that P300 amplitude reduction may be considered a risk marker for alcoholism, but only in males at the present time. Possibly even larger samples might resolve this intriguing gender difference. Relatively large samples are required to find evidence for P300 being a marker because not all children from high-risk families should be considered as carrying any given marker. Although the lifetime risk for the group of boys, as a whole, is quite large, on a case by case basis one would expect that by age 30 only one-third would be alcoholic (Aston and Hill, 1990). It may not be surprising, therefore, that only one-third of the boys exhibit reduction in P300 amplitude.

Only two other studies have examined the P300 component of the visual ERP in prepubertal boys from families at risk for developing alcoholism (Begleiter et al., 1984; Whipple et al., 1988). Both of these studies have shown significant differences in P300 amplitude between their high- and low-risk children. Other studies that have contrasted family history positive and family history negative individuals using a visual ERP paradigm have employed prepubescent boys (O'Connor et al., 1987; Polich et al., 1988b) with inconsistent findings. Similarly, studies of young men that have compared high- and low-risk groups utilizing a variety of auditory ERP paradigms also have produced inconsistent results (Elmasian et al., 1982; Hill et al., 1988; Neville and Schmidt, 1985; Polich and Bloom, 1987, 1988; Polich et al., 1988a).

The relatively more straightforward nature of the present findings may have occurred because younger aged subjects (8-18) were included, so that the possibly confounding effects of cumulative alcohol or drug use, or other life experiences (e.g., head injury), did not mask our ability to detect group differences. Also, the particular task administered taps a neuropsychological capacity that may be associated with vulnerability for developing alcoholism. Clearly, the task employed drew heavily on visuospatial abilities. There have been numerous reports indicating that alcoholics have more difficulty with these types of tasks than they do with language functions (Goodwin and Hill, 1975). However, these difficulties had originally been considered to be the consequence of long years of heavy drinking. Inasmuch as the task employed in the present study was intended to replicate that used by Begleiter and colleagues in as much detail as possible, the two investigations were similar with regard to the loading for visuospatial functioning. Whipple et al. (1988) similarly used a modification of the CPT task, a task that requires visuospatial coordination and problem solving. In fact, these authors note that the reduction in P300 amplitude observed among the children they studied was correlated with their performance on certain visuospatial tasks and not with memory functioning.

The significance of the findings from the current study is that assessment of both prepubertal and postpubertal male and female children enabled us to identify the parameters that appear to be critical in reliably distinguishing high- and low-risk children. The visuospatial functioning of high-risk children would appear to be deficient. However, this is manifest only in prepubescent boys, inasmuch as it was not seen in girls or in postpubescent boys. Serendipitously, those studies with the strongest findings (Begleiter et al., 1984; Whipple et al., 1988) have employed prepubescent boys. It remains to be determined why these differences are apparent in prepubescent boys but are not seen in postpubescent boys.

Regardless of risk status or gender, increasing age was associated with increased P300 amplitude and decreased P300 latency, which is consistent with the developmental ERP literature (Bashore, 1990). Moreover, there were no topographical differences between risk groups, as also reported by Begleiter et al. (1984).

A comparison of electrophysiological and behavioral data provides several intriguing interpretations. In both the present study and that of Begleiter et al. (1984) there were no differences in P300 latency between risk groups or in reaction times. However, in both studies the reaction times to hard targets were longer than those to easy targets. The lack of a P300 difference in both amplitude and latency between hard and easy tasks in the present study suggests that the longer reaction times for hard targets is associated with a stage of response selection that follows stimulus evaluation as indexed by the late positive complex of the ERP, which includes P300. Further, it is noted that, whereas the high-risk group of Begleiter et al. (1984) performed less accurately than did low-risk children, there were no differences in accuracy for these groups in the present study. Thus, the present findings cannot be attributed to deficits in performance among the high-risk children.

In summary, the present findings provide the strongest evidence obtained to date for P300 amplitude reduction being a risk marker for alcoholism in prepubescent boys. First, performance was equal in the risk groups (accuracy and reaction time). Second, the high-risk children were not disadvantaged by low socioeconomic background. Approximately 40% of the parents of the high-risk children came from the two highest Hollingshead socioeconomic levels. Third, these children were from high-risk families that had been screened for absence of other psychopathol-
ology so that any differences in electrophysiological functioning might be considered a marker for alcoholism risk per se, rather than a marker for proneness to psychopathology in general. Moreover, these families were selected from families exhibiting an exceptionally high density of alcoholism allowing for maximal familial loading. This latter fact may have also contributed to the strength of our findings.

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