

---

# Factors Predicting the Onset of Adolescent Drinking in Families at High Risk for Developing Alcoholism

Shirley Y. Hill, Sa Shen, Lisa Lowers, and Jeannette Locke

---

**Background:** *With a longitudinal prospective design, the purpose of this study was 1) to assess, with survival analysis, the age of onset of drinking in relation to family history of alcoholism; 2) to examine the importance of selected neurobiological and psychosocial risk factors in predicting the onset to drink; and 3) to determine if the age of onset of substance dependence problems differed by risk group status.*

**Methods:** *One hundred twenty-five children and adolescents were evaluated annually (N = 638 evaluations), providing up to seven annual waves of longitudinal data. Survival analyses were performed to determine the age of onset of regular drinking and the age of onset for substance abuse/dependence. The age of onset of regular drinking outcome was modeled using familial density of alcoholism and four factors, which included neurobiological indices of development (postural sway and P300), personality characteristics, academic achievement, self-esteem, and trait anxiety.*

**Results:** *High-risk children/adolescents showed a significantly earlier age of onset of drinking and an earlier age of onset for substance abuse problems. Familial density of alcoholism predicted an earlier onset of drinking, as did having deficits in reading achievement, reduced P300 (visual and auditory), and greater postural sway for age. Higher scores on the Extraversion scale of the Junior version of the Eysenck Personality Inventory also predicted an earlier onset of drinking.*

**Conclusions:** *Familial density of alcoholism (number of alcoholic first- and second-degree relatives) is an important predictor of adolescent alcohol initiation. Evidence is presented suggesting that part of the familial/genetic variation in outcome may be due to neurobiological factors and temperament. Biol Psychiatry 2000;48:265–275 © 2000 Society of Biological Psychiatry*

**Key Words:** Adolescence, alcoholism, P300, postural sway, temperament

---

From the University of Pittsburgh School of Medicine, Department of Psychiatry, Pittsburgh, Pennsylvania.

Address reprint requests to Shirley Y. Hill, Ph.D., University of Pittsburgh School of Medicine, Department of Psychiatry, 3811 O'Hara Street, Pittsburgh PA 15213.

Received October 25, 1999; revised January 28, 2000; accepted February 3, 2000.

## Introduction

The earlier an adolescent begins regular drinking of alcohol the higher the level of misuse (Hawkins et al 1997) and alcohol dependence (Grant and Dawson 1997) and the greater the severity and persistence of problems with illicit drugs (Kandel et al 1992; Robins and Przybeck 1985). Hawkins et al (1997) recruited children between the ages of 10 and 11 and observed them for 7 years, finding greater misuse at ages 17 and 18 among those with earlier alcohol initiation. Using a large-scale population sample, Grant and Dawson (1997) showed that the age of onset of regular drinking predicted the likelihood of adult alcohol dependence. For those individuals younger than 14 years, the rate was 40%; for those age 20 and older, it was only 10%. Conversely, abstinence at age 16 was found to predict limited use at age 23 in a national representative British study, whereas regular drinking at age 16 increased the risk fourfold for heavy drinking at age 23 (Ghodsian and Power 1987).

Although numerous studies have identified factors associated with adolescent alcohol use, few studies have investigated the factors associated with problem use in adolescence (Glantz 1992). Few studies have attempted to integrate risk factors from both neurobiological and psychosocial domains. Moreover, the factors associated with the initiation of alcohol use in normal populations of adolescents may differ from those seen among adolescents who come from families with histories of alcohol or drug dependence. Children who come from families with alcoholic members are more likely to be at risk for alcohol problems (Cotton 1979). Yet, little is known about the factors that provide resilience or susceptibility to early alcohol initiation or problems. This paucity of extant literature is especially evident with respect to the neurobiological factors associated with familial/genetic risk and how this leads to individual differences in susceptibility (Nestler and Aghajanian 1997). Identification of factors that either moderate or mediate the relationship between family history and early-onset drinking might make it possible to provide intervention even before regular drinking begins. A better understanding of the neurobiological mechanisms involved in the susceptibility to addiction is

clearly needed. As noted by Koob and LeMoal (1997), this may require integration of basic neuroscience with social psychology, experimental psychology, and psychiatry. The present analysis is an attempt to identify neurobiological factors responsible for early-onset drinking in family history-positive adolescents and integrate these factors into a framework that includes known psychosocial risk factors for developing an addiction.

#### *Moderators and Mediators of Familial Risk*

**SELF-ESTEEM.** Positive self-esteem may act as a buffer against deviant behavior among adolescents and may facilitate better emotional adjustment (Schweitzer et al 1992) through reduction in anxiety (Hart 1985), depression (Beer 1987), and school absenteeism (Reid 1982). Previously an association between having lower self-esteem and a positive family history of alcoholism had been reported (Sher 1991).

**ANXIETY.** The tension-reduction theory of substance use/abuse has a long history (Conger 1956). Drive-reduction theory is used to explain how use of anxiolytic substances such as alcohol is learned through negative reinforcement (Cappell and Greeley 1987). Only modest and somewhat inconsistent relationships between trait anxiety and substance use/abuse have been found (Cox 1987; Sher 1987), however. Trait anxiety in school-age children has been studied using the children's version of the Manifest Anxiety Scale (CMAS), revised edition (Reynolds 1980; Reynolds and Richmond 1978).

**CHILD/ADOLESCENT PERSONALITY CHARACTERISTICS.** It is well known that alcoholics score higher on measures of neuroticism/emotionality than do nonalcoholics (Barnes 1979). College-age offspring of alcoholics have been evaluated using Eysenck's Neuroticism scale with both positive (Sher et al 1991) and negative (Schuckit 1983) findings. One early longitudinal study (Jones 1971) found neurotic tendencies during adolescence that appeared to be predictive of alcohol problems during adulthood in women; however, another longitudinal study of men found no relationship between neurotic tendencies during adolescence and the presence of alcohol problems in adulthood (Robins et al 1962).

Although alcoholics tend not to differ from nonalcoholic control subjects on the Extraversion scale (Barnes 1983; Cox 1979), less is known about their prealcoholic personality characteristics. The Oakland Growth Study, which provided longitudinal assessment of youth through middle age, found that males who later became alcoholic had an adolescent personality that was more sociable than adolescents who did not become alcoholic in adulthood (Jones 1968).

**FAMILY ENVIRONMENT.** Wolin and colleagues (Wolin et al 1980) have demonstrated that the disruption of family rituals by the presence of an alcoholic parent during holidays or vacations increased the risk to offspring for developing alcoholism. Prospective studies designed to determine if the quality of the family environment during childhood influences later development of alcohol and other substance use problems in offspring of alcoholics are rare. The impact of active parental alcoholism on the quality of the family environment and the distress experienced by children in the home has been documented (Moos and Billings 1982).

**ACHIEVEMENT.** Multiple studies now suggest that children of alcoholics are at risk for poorer academic achievement (Ervin et al 1984; Hegedus et al 1984a; Knop et al 1985; McGrath et al 1999); however, not all studies have found marked differences overall (Bennett et al 1988; Hill et al 1999a). A recent analysis of prospective data obtained from this laboratory suggests that achievement deficits can serve as a predictor of subsequent development of a childhood/adolescent psychiatric diagnosis (Hill et al 1999a).

**NEUROBEHAVIORAL INDICES.** A number of studies now indicate that the amplitude of the P300 component of the event-related potential (ERP) is reduced in high-risk children relative to low-risk children (Begleiter et al 1984; Berman et al 1993; Hill and Steinhauer 1993a; Hill et al 1990; Steinhauer and Hill 1993; Whipple et al 1988). Recently, follow-up data for children assessed at multiple time points through childhood and adolescence have revealed that P300 amplitude changes with age, but less so among high-risk children/adolescents. This suggests a possible delay in the development of neural circuitry responsible for P300 production (Hill et al 1999b).

Another neurobehavioral measure that has shown promise as a marker for alcoholism risk is postural sway (Hegedus et al 1984b; Hill et al 1987; Hill and Steinhauer 1993b; Lester and Carpenter 1985; Lipscomb et al 1979). Age-related changes in postural sway during childhood have been documented (Usui et al 1995). The observed differences in postural sway in association with familial risk appear to be due to a developmental delay in acquiring age-appropriate levels of balance among high-risk children who develop postural control at a slower rate than low-risk control subjects (Hill et al 2000). Thus, both P300 and postural sway appear to be neurobehavioral indices of a developmental delay in cognitive and motoric functioning among high-risk children.

**HYPOTHESES.** From an earlier analysis, it is hypothesized that the familial density of alcoholism would

predict the onset of drinking during adolescence (Hill and Yuan 1999). The goals of the present analysis were 1) to explore the mediating and moderating effects of a number of neurobiological and psychosocial variables in association with familial loading for alcoholism and 2) to model factors associated with problem use. The intent of the analyses was largely exploratory. Therefore, a large number of variables that have been implicated in the etiology of substance abuse were analyzed. A factor analysis was conducted using this set of variables to identify a smaller number of factors. Survival analyses were then performed with these factors along with familial density to predict the age of onset of regular drinking.

## Methods and Materials

### Subjects

All eligible offspring ( $N = 175$ ) between the ages of 7 and 18 years whose parents were part of a family study (Cognitive and Personality Factors Family Study) were invited to participate in a cross-sectional study that began in 1989. All children and parents who participated signed informed-consent forms before each evaluation. Two years later those children who were between the ages of 7 and 13 were targeted for yearly follow-up. Some children who participated in the cross-sectional study were not eligible to participate in the longitudinal follow-up because of their age. In these cases a younger sibling meeting the age requirement was invited to participate in the longitudinal study. The present report is based on a total of 638 evaluations involving 125 children (90% retention rate). Demographic characteristics can be seen in Table 1.

**HIGH-RISK FAMILIES.** Ascertainment of families was based on the presence of two male alcoholic brothers who met criteria for definite alcoholism by Feighner criteria (Feighner et al 1972), with one member of the pair being in inpatient treatment for alcoholism. With the treated alcoholic's consent, eligible family members (parents of the adult male alcoholic brothers, and all living siblings) were asked to participate. An in-person, structured interview (Diagnostic Interview Schedule) was performed blindly for all living and available parents, grandparents, aunts, and uncles of the children by M.A.-level interviewers who had achieved 90% reliability with the trainer before beginning assessments. A second unstructured interview was performed by an M.A.- or Ph.D.-level psychologist to arrive at a "best estimate" consensus diagnosis, as described by Weissman et al (1987). For those relatives not assessed by a face-to-face interview (less than 40%), a minimum of two family history reports was used to arrive at an appropriate family history diagnosis. (This study typically obtains a family history report for all known relatives, even when that relative has been diagnosed in person, providing validity estimates for the family history data.) Families were not included if recurrent major depression, bipolar disorder, a primary substance use disorder other than alcohol dependence, or schizophrenia disorders were present in either the proband pair of adult alcoholic brothers or

Table 1. Demographic Characteristics and Distribution of Assessments

| Sample characteristics                                 | High risk <sup>a</sup> | Low risk    |
|--|------------------------|-------------|
| Age at entry (mean years $\pm$ SD)                     | 9.85 (2.1)             | 9.90 (2.0)  |
| Age at last follow-up (mean years $\pm$ SD)            | 16.19 (1.4)            | 16.11 (2.0) |
| % of children in upper two SES categories <sup>b</sup> | 47.2                   | 62.7        |
| Cumulative number of assessments <sup>c</sup>          |                        |             |
| Baseline   | 74                     | 51          |
| Retest 1   | 146                    | 102         |
| Retest 2   | 216                    | 147         |
| Retest 3   | 280                    | 188         |
| Retest 4   | 329                    | 224         |
| Retest 5   | 362                    | 248         |
| Retest 6   | 379                    | 259         |

<sup>a</sup>16.2% of children had an alcoholic mother, 64.9% had an alcoholic father, and 24.3% with neither parent alcoholic had an average of 3.1 first- and second-degree relatives who were alcoholic.

<sup>b</sup>The socioeconomic status (SES; Hollingshead 1975) of the high- and low-risk children was determined from an average score of both parents. No differences were found [ $\chi^2(1) = 2.90, p = .09$ ] when the highest levels (professional/technical) were contrasted with the lowest (skilled and semiskilled).

<sup>c</sup>Children entered the study over a 3-year period (1989–1991). Therefore, some children have not completed the fourth, fifth, or sixth retest evaluations. The average number of evaluations completed by 1998 was 5.1.

their first-degree relatives. (Alcohol dependence must have been diagnosed as occurring at least 1 year before other drug dependence [e.g., opioid dependence, cocaine dependence] was present.)

The high-risk group consisted of 74 children and adolescents (38 male and 36 female) from high-density (an average of 4.0 first- and second-degree relatives who were alcoholic), multigenerational alcoholism families (Table 1). Alcoholism tended to segregate within these families in a pattern consistent with a major genetic effect (Yuan et al 1986).

**LOW-RISK CONTROL SUBJECTS.** Community control subjects were identified through an index case who responded to a newspaper advertisement. Families were chosen on the basis of having the same structural characteristics as the high-risk families (at least two adult brothers). Family members were interviewed using the same diagnostic procedures used for the high-risk families. Each potential control family was screened for the presence of alcohol or drug dependence using the family history report of the index case. Presence of a definite diagnosis of alcoholism by Feighner criteria or alcohol or drug dependence by DSM-III in the index case or his first-degree relatives disqualified a potential control family. Low-risk families were included if all first- and second-degree relatives of the index case were free of alcohol and drug dependence. The study design, which included obtaining family history and direct interviews of family members from both sides of the family, assured that the control children/adolescents came from bilineal low-risk-for-alcoholism pedigrees. Fifty-one low-risk children/adolescents (28 male and 23 female) were available for follow-up.

### Adolescent Alcohol Use—K-SADS and AAIS Determinations

The onset of regular drinking was determined by utilizing both self-report data (Adolescent Alcohol Involvement Scale [AAIS];

Mayer and Filstead 1979]) and a clinician-administered child psychiatric interview (Schedule for Affective Disorders and Schizophrenia for School-Aged Children [K-SADS], present and lifetime) administered to both the child and the parent. Data were obtained at each evaluation with these two instruments, enabling us to determine when regular drinking began and problem use/dependence occurred. Where the two instruments were discrepant, the earliest date was used.

Every child classified as a drinker was drinking one to two times a month; if drinking was as infrequent as one to two times a year, supporting evidence was required indicating that alcohol was used in sufficient quantities to have a pharmacologic effect (reported drinking two or more drinks per occasion; reported a lifetime history of ever having been high, drunk, passed out, or ill as result of drinking; or experienced memory loss [blackout]) as determined by the AAIS. This ensured that those children who had only taken a sip of an alcoholic drink would not be considered drinkers. Among the 60 subjects who drank regularly, 47 reported drinking to the point of being drunk, with some passing out or having a blackout (impaired memory for events occurring during a drinking period). The remaining 13 drank to the point of feeling mildly ("loose, easy feeling") to moderately ("moderately high") intoxicated. Among the subjects who had begun to drink, the mean quantity per occasion was 3.5 drinks (median = 3.0 drinks).

### *Assessment of Prenatal Ethanol Exposure*

All mothers provided a retrospective report concerning their drinking during pregnancy. Though retrospective reports are not ideal, Erhardt et al (1988) have shown that reports of concurrent drinking during pregnancy correlated significantly ( $r = .67$ ) with 5-year retrospective recall. Most mothers, including the alcoholic women, decreased their intake by the second and third trimesters. For the 11 alcoholic mothers who drank during pregnancy, an average of 205 drinks was consumed during the pregnancy; however, only three of these alcoholic mothers drank more than two drinks per month after the first trimester. Less alcohol was consumed by the nonalcoholic mothers who drank during pregnancy (high and low risk): an average of 42 drinks, with the largest quantity consumed during the first trimester. The remainder (71%) reported no drinking during pregnancy.

### *Testing Multivariate Models of Outcome*

The primary variable of interest was familial loading for alcoholism and its impact on the age of onset of regular drinking in offspring. The goal was to model variables hypothesized to influence the onset of drinking and the onset of problem use of alcohol and drugs, based on work from this laboratory (Hill and Yuan 1999) and others. Measures of two personality dimensions, Extraversion and Neuroticism, from the Junior Eysenck Personality Inventory (JEPI; Eysenck 1963) were utilized, along with the child's anxiety (CMAS; Reynolds and Richmond 1978) and self-esteem (Coopersmith Self-Esteem Inventory [SEI; Ahmed et al 1985]) and an estimate of the child's family cohesion based on scores from the Cohesion scale (Family Environment Scale, Child's version [CVFES; Pino et al 1984]). Additionally, aca-

ademic achievement, measured by the Wide Range Achievement Test (WRAT), was tested in the model. The neurobiological variables assessed included postural sway and the amplitude of the P300 component of the ERP.

**ACHIEVEMENT TEST SCORES.** All children were administered an age-appropriate form of the WRAT (WRAT-R or WRAT-III) by a trained M.A.-level clinician at each annual evaluation. An academic-deficit score based on the difference between the current academic grade and the grade-equivalent scores from the spelling, reading, and math sections of the WRAT was determined.

**ASSESSMENT OF BODY SWAY.** Postural sway was evaluated by an experimenter blind to the risk status of the child using a total of six trials (three eyes-open trials and three eyes-closed trials) in each of two procedures: a Lipscomb stance (Hill et al 1987; Hill and Steinhauer 1993b; Lipscomb et al 1979) and a right monopodal stance in which the right foot remained raised while the child stood on his or her left foot (Hill and Steinhauer 1993b). In the Lipscomb stance children stood with feet side to side. In the monopodal position the child was asked to keep one leg dangling freely (no hooking of the elevated leg against the rigid one to improve balance). For the eyes-closed condition, children were blindfolded so that no visual input was available to improve balance. The children were asked to stand without shoes in the middle of a movement platform (Kistler [Winterthur, Switzerland] Model 9281B) and to keep their arms folded across the chest. A 30-sec intertrial interval and a 1-min interval between tasks were provided in which the child was allowed to get off the platform. The output data of amplifiers at each corner of the movement platform reflected changes in pressure at varying points on the platform and were digitized and stored at 18 Hz. Scores obtained from the eyes-closed condition were modeled in the present analysis.

**ERP ASSESSMENTS.** Each child performed an auditory (choice reaction time) task and a visual ERP task with electrodes placed at frontal, vertex, parietal, and occipital locations (Fz, Cz, Pz, Oz, P3, and P4). Auditory ERPs were elicited with "high" (1500 Hz) and "low" pitched (800 Hz) tones, presented every 3 sec (70-dBA intensity; 40-msec duration) in a modified oddball paradigm as previously described (Hill et al 1990, 1995; Steinhauer and Hill 1993). The visual task consisted of presenting brief (0.33 msec) target or nontarget stimuli. The target condition consisted of a stick figure "head" with a nose and only one ear. The subject responded to the position of the ear with a button press as described previously (Hill and Steinhauer 1993a).

### *Statistical Analysis*

The statistical analysis was aimed at answering three questions. First, would the high-risk children show decreased survival time with respect to initiation of regular drinking? Second, would the child/adolescent's levels of anxiety, self-esteem, personality characteristics, academic achievement, neurobehavioral functioning, and familial loading for alcoholism (the number of both first and second-degree relatives who were affected) predict

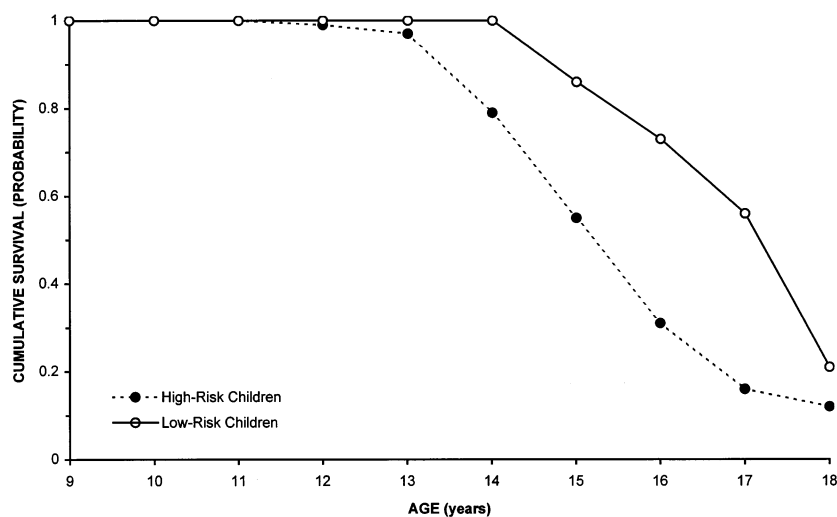


Figure 1. The Kaplan–Meier estimates of the survival curves for age of onset of regular drinking for children/adolescents from high- and low-risk families. Risk status significantly affected the survival time [Tarone–Ware  $\chi^2(1) = 16.30$ ,  $p < .0001$ ]. High-risk children began regular drinking at an earlier age.

onset of drinking? Third, would any of the variables found to predict survival be found to mediate or moderate the familial density for alcoholism effect?

For the first question, standard survival-analysis methods were used to derive the age-specific risk and the cumulative risk of initiation of drinking over an observation period of up to 10 years in some children (mean  $\pm$  SD = 5.5  $\pm$  2.0 years). Using the terminology of survival analysis, we treated the age of initiation of drinking as the survival time and the child as “right censored” with a survival time of his or her current age if he or she was free of drinking at the time of the most recent interview. To estimate the overall survival curve, we used the nonparametric product-limit estimate from the BMDP 1L software package (Benedetti et al 1988; Kaplan and Meier 1958). The survival analysis was repeated using the age at which alcohol or drug abuse/dependence was diagnosed, using information obtained from the K-SADS interview with the child and parent (interviewed separately) and from the self-report instrument used (AAIS).

Using the Cox proportional hazards stepwise regression model (BMDP 2L [Hopkins 1988]), we modeled the relationship between incidence rate of initiation of drinking and a set of explanatory variables (predictors were all time dependent with the exception of familial density, which was time independent) to answer the second question. The predictor value was chosen from among the repeated measures obtained at each annual assessment and was based on the child’s age at the point of nonsurvival (initiation of drinking). Because prenatal drinking was not found to be a predictor of either outcome, it was dropped from further analyses.

To answer the third question, a series of regression analyses were performed, modeled after suggestions of Baron and Kenny (1986). These analyses would determine if the significant factors found in the survival analysis were moderators or mediators of the familial density effect upon the earlier age of onset of drinking seen in children/adolescents from the high-risk families. Baron and Kenny discuss mediators as those variables having overriding importance in describing the relationship between a predictor variable and a criterion variable so that the mediating

variable may weaken or entirely account for the relationship between a predictor variable and a criterion. In contrast, moderators are capable of reducing or enhancing the impact of the predictor on the criterion.

## Results

### *Determination of the Role of Family Type on Survival Time for Age of Onset of Regular Drinking*

The lifetime cumulative Kaplan–Meier estimates of the survival curves for high- and low-risk children for age of onset of regular drinking are shown in Figure 1. Survival curves for the onset of regular drinking for children from high- and low-risk families revealed significant differences by risk group status [Tarone–Ware  $\chi^2(1) = 16.30$ ,  $p < .0001$ ] and a hazard ratio of 2.86 ( $p = .001$ ). The age of onset of regular drinking was 15.2  $\pm$  1.2 years old (mean  $\pm$  SD) for high-risk children and 16.5  $\pm$  1.2 years old for low-risk children. (Data for 45% of the high-risk and 63% of the low-risk children were right censored.) The cumulative survival for not engaging in regular drinking by the age of 16 was 0.31  $\pm$  0.07 (mean  $\pm$  SE) for the high-risk children and 0.73  $\pm$  0.08 for the low-risk children.

### *Determination of the Role of Family Type on Survival Time for Alcohol and Drug Abuse/Dependence*

A total of 20 children/adolescents met DSM-III criteria for alcohol abuse/dependence ( $n = 16$ ) or drug abuse/dependence ( $n = 4$ ). Survival curves for high- and low-risk children for the substance abuse/dependence outcome are shown in Figure 2. Significantly more high-risk children/adolescents met criteria for alcohol or drug abuse/dependence [ $\chi^2(1) = 4.26$ ,  $p = .04$ ]. Consequences of drinking

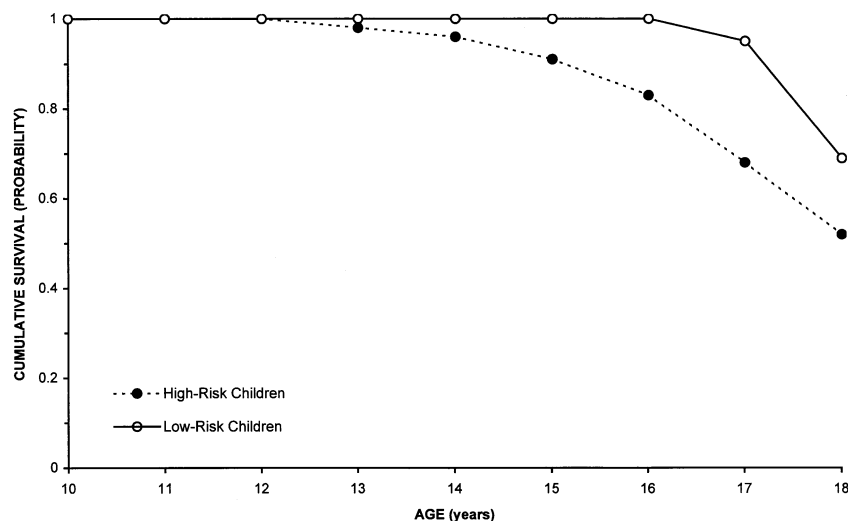


Figure 2. The Kaplan–Meier estimates of the survival curves for age of first diagnosis of alcohol or drug abuse/dependence. The curves show that the high-risk children became abusers of alcohol or alcohol dependent at a significantly earlier age than the low-risk children [Tarone–Ware  $\chi^2(1) = 6.71, p = .0095$ ].

were greater among the high-risk group, with 29.7% of the high-risk youth reporting having been drunk or ill, had a blackout, or passed out from drinking, in contrast to 19.6% of the low-risk youth. Because the study is ongoing, some individuals who currently would not meet criteria for substance abuse/dependence can be expected to convert to affected status at a later time. Accordingly, the small number of individuals currently meeting criteria for abuse/dependence could not be used to model the factors influencing the substance abuse/dependence outcome.

#### *Establishing the Relative Contribution of Selected Predictors on Outcome*

A factor analysis was performed by extracting factors using principal components analyses and included orthogonal rotation of factors having eigenvalues greater than one. Although the variables could be grouped by inspection, a factor analysis was performed to reduce the number of available variables to a manageable size to increase the power to detect significant predictors of the onset of regular drinking. Factors were sorted according to the sum of squared loadings for each factor. Statistical results revealed that these variables could be classified into four factors. Factor I was composed of five predictors (CVFES Cohesion, Extraversion, and Neuroticism scales; CMAS and SEI scores). Factor II included three achievement test scores (math, reading, and spelling). Factor III consisted of the postural sway assessments (total amount of sway observed in the Lipscomb and right monopodal stances under the eyes-closed condition). Factor IV contained the ERP measurements (auditory and visual P300 amplitude). Predictors of the age of onset of regular drinking were determined in separate analyses of males, females, and all children within each of the four factors identified in the factor analysis. Thus, 12 separate survival analyses were conducted using the familial loading

variable and the predictor variables. Significant results from these analyses may be seen in Table 2. Additional tests were conducted to determine which variables were mediators and which were moderators (Table 3).

#### *The Contribution of Predictors to the Age of Onset of Regular Drinking*

**ROLE OF FACTOR I.** The familial density variable, the five Factor I variables, and their interactions were used to model the initiation of regular drinking outcome. With all six variables entered, scores on the JEPI Extraversion scale were found to have a significant main effect on the age at which adolescents began regular drinking. Further testing of boys and girls separately indicated that the finding was restricted to boys (Table 2). Using the suggestions of Baron and Kenny (1986) for determining if one variable can substitute for another (mediation) or is a moderator of a significant variable, we tested the importance of Extraversion in predicting the onset of drinking by comparing Models 1–4 (Table 3). Familial density of alcoholism was a significant predictor of the age of onset of regular drinking in boys [Model 1;  $\chi^2(1) = 4.45, p = .03$ ]. Also, Extraversion scores predicted the onset of drinking in boys [Model 2;  $\chi^2(1) = 8.92, p = .004$ ]. Additionally, familial density predicted their Extraversion scores [Model 3;  $F(1,64) = 5.25, p = .03$ ]. When the significant relationship between familial density and age of onset of regular drinking was tested along with Extraversion (Model 2 vs. Model 4), the influence of the familial density variable was eliminated [ $\chi^2(1) = 1.06, p = .3$ ]. Results of these comparisons indicate that Extraversion is a mediator of the familial risk for alcoholism effect that results in high-risk boys beginning to drink earlier than low-risk boys. Extraversion did not appear to mediate or moderate the familial density effect on onset of

Table 2. Survival Analysis

| Predictors   | Significant effects                       | $\chi^2$ | df | <i>p</i>         |
|--|---|----------|----|------------------|
| Age of onset of regular drinking for all children    |   |          |    |                  |
| Factor 1   | Extraversion × Familial Density           | 14.84    | 1  | <.0001           |
|  | Extraversion                              | 5.04     | 1  | .03 <sup>a</sup> |
| Factor 2   | Familial Density                          | 14.60    | 1  | <.0001           |
|  | Reading × Familial Density                | 5.97     | 1  | .02 <sup>a</sup> |
| Factor 3   | Sway (right monopodal) × Familial Density | 17.04    | 1  | <.0001           |
| Factor 4   | Auditory P300 × Familial Density          | 16.45    | 1  | <.0001           |
| Age of onset of regular drinking for male children   |   |          |    |                  |
| Factor 1   | Extraversion                              | 11.93    | 1  | .001             |
| Factor 2   | Reading × Familial Density                | 8.00     | 1  | .01 <sup>a</sup> |
| Factor 3   | Sway (right monopodal) × Familial Density | 6.81     | 1  | .01 <sup>a</sup> |
| Factor 4   | Visual P300 × Familial Density            | 4.52     | 1  | .03 <sup>a</sup> |
| Age of onset of regular drinking for female children |   |          |    |                  |
| Factor 1   | Extraversion × Familial Density           | 13.39    | 1  | .0003            |
| Factor 2   | Familial Density                          | 12.86    | 1  | .0003            |
| Factor 3   | Sway (right monopodal) × Familial Density | 13.35    | 1  | .0003            |
| Factor 4   | Auditory P300 × Familial Density          | 13.84    | 1  | .0002            |

<sup>a</sup>Bonferroni correction for the number of survival analyses performed would indicate nonsignificance for these variables.

drinking in girls, however. (The familial density variable remained significant when tested jointly with Extraversion and the interaction of Extraversion and familial density was not significant when only these two variables were modeled.)

**ROLE OF FACTOR II.** Three WRAT achievement test scores (math, reading, and spelling), familial density, and their interactions were used to model the initiation of regular drinking outcome for all children and separately by gender. Although familial density was found to interact with reading achievement scores (Table 2), reading achievement did not meet criteria as a moderating or mediating variable of the familial density effect on onset of regular drinking.

Table 3. Regression Analyses for Male Subjects

| Model | Dependent variable | Independent variable    | Log likelihood |
|-------|--------------------|-------------------------|----------------|
| 1     | Onset of drinking  | Familial Density        | -83.30         |
| 2     | Onset of drinking  | Extraversion            | -79.34         |
| 3     | Extraversion       | Familial Density        |                |
| 4     | Onset of drinking  | Extraversion            | -78.81         |
|       |                    | Familial Density        |                |
| 5     | Onset of drinking  | Sway                    | -82.52         |
|       |                    | Familial Density        |                |
| 6     | Onset of drinking  | Sway                    | -80.53         |
|       |                    | Familial Density        |                |
|       |                    | Sway × Familial Density |                |

A mediation effect was found for Extraversion—Model 1 [ $\chi^2(1) = 4.45, p = .03$ ], Model 2 [ $\chi^2(1) = 8.29, p = .004$ ], Model 3 [ $F(1,64) = 5.25, p = .03$ ], and Model 2 vs. Model 4 [ $\chi^2(1) = 1.06, p = ns$ ]. A significant moderation effect was seen for Sway (right monopodal)—Model 5 vs. Model 6 [ $\chi^2(1) = 3.98, p = .046$ ].

**ROLE OF FACTOR III.** Familial loading for alcoholism and postural sway (amounts of sway observed in the Lipscomb and right monopodal stances under the eyes-closed condition), along with their interactions with familial loading, were tested. Right monopodal sway and familial density were found to have an interactive effect in predicting the age of onset of regular drinking (Table 2). A series of regression analyses were used to determine if the sway variable was moderating the effects of the familial density variable. A significant interaction was found for boys [ $\chi^2(1) = 3.98, p = .046$ ; Models 5 and 6, Table 3], indicating that sway was a moderator of familial density in predicting age of onset of regular drinking in boys. To further illustrate, boys were divided into two groups based on a median split of the total body sway for the entire sample. For those with scores above the median, the number of relatives affected with alcoholism had a significant effect on the age of onset of regular drinking [ $\chi^2(1) = 5.00, p = .03$ ]. Also, comparing children with high and low amounts of sway within the high- or low-risk groups revealed an earlier onset of drinking for high-risk children with higher amounts of sway in contrast to those with lower amounts of sway ( $15.5 \pm 0.78$  vs.  $16.0 \pm 1.55$ ). Low-risk children with lower and higher amounts of sway showed the same age of onset (16.0 years), however.

**ROLE OF FACTOR IV.** The familial density variable, P300 amplitude (auditory or visual procedure), and the interaction between P300 amplitude and the familial loading were modeled. The interaction between familial density for alcoholism and auditory P300 amplitude was

found to be significant when all children were considered, as it was for girls (Table 2). For boys, visual P300 amplitude was significantly associated with familial loading (Table 2); however, when only the familial density variable and either one of the P300 amplitudes were tested for boys, girls, and all children in the Cox model, none of the interaction effects were significant. Thus, neither the visual nor the auditory P300 amplitude met the necessary conditions for being a moderator or mediator of the familial density effect on the onset of drinking during adolescence.

## Discussion

Although the follow-up has not been completed and the maximum number of substance abuse/dependence cases has not been detected, it is clear that high-risk children/adolescents have an earlier onset of regular drinking and earlier development of substance abuse/dependence than do control subjects. An intriguing finding was that Extraversion was an independent predictor of onset of regular drinking in male offspring, mediating the effect of the familial history of alcoholism variable on this outcome. These results support the results of an early longitudinal follow-up (Oakland Growth Study) in which the preadolescent personality of males who later became alcoholic was characterized by their being more outgoing and sociable than their cohorts (Jones 1968).

There has been speculation that the factors associated with the onset of regular drinking may be different than those associated with the likelihood of having alcohol problems (Newcomb and Bentler 1989; Stice et al 1998). Because the present results are based on data from a longitudinal study that is ongoing, not all participants have moved through the window of risk for substance abuse/dependence. Therefore, it was not possible to model the factors predicting substance abuse/dependence due to the small number of available cases for modeling this outcome; however, it is clear that high-risk children begin to drink earlier and to develop substance abuse/dependence earlier. High-risk children also appear to have a greater likelihood of experiencing an internalizing disorder (e.g., depression, anxiety) or an externalizing disorder (e.g., conduct disorder, attention-deficit/hyperactivity disorder; Hill et al 1999a; Hill and Muka 1996).

Our analysis has identified four variables that predict earlier onset of drinking during adolescence (extraversion, postural sway, P300 amplitude, and reading achievement). The findings for Extraversion confirm an earlier report from this laboratory based on a shorter follow-up (Hill et al 1999c). Postural sway and P300 amplitude are of interest because of the recognition that high-risk children may exhibit developmental delays in acquiring appropriate

levels of postural control or P300 amplitude for their age. P300 is of interest because of its association with high risk for alcoholism status in children (Hill et al 1999b; Hill and Steinhauer 1993a). Also, there is evidence that P300 has a familial genetic basis (Eischen and Polich 1994; Hill et al 1999c; Steinhauer et al 1986, 1987; Surwillo 1980; van Beijsterveldt 1996). It is somewhat surprising that P300 amplitude did not moderate or mediate the familial risk effect on early-onset drinking in view of the frequently noted reduction in P300 seen in high-risk children (Begleiter et al 1984; Berman et al 1993; Hill and Steinhauer 1993a; Hill et al 1990); however, different variables than those that predict substance dependence may predict onset of drinking. Two studies have followed children who have been assessed for P300 at one point in time and have had outcome determined at a later point (Berman et al 1993; Hill et al 1995). Both studies found lower P300 amplitude predicted substance dependence after 4-year (Berman et al 1993) and 8-year (Hill et al 1995) follow-up. Thus, P300 amplitude may be a better predictor of substance-related problems than it is a predictor of the initiation of drinking during adolescence.

Reading achievement was modeled along with other achievement measures because high-risk children have been reported to display academic achievement deficits in some studies (McGrath et al 1999) though not all (Hill et al 1999a). Also, a recent analysis from this laboratory has indicated that academic achievement deficits predict the onset of subsequent psychopathology (Hill et al 1999a). Our analysis was designed to determine if adolescents with lesser academic achievement would show earlier onset of drinking. Although none of the achievement scores predicted the onset of drinking, it is currently unknown whether this variable might predict substance abuse/dependence onset.

It is interesting to note that postural sway was found to moderate the familial density effect on the onset of regular drinking in males. Recently, high-risk children have been found to show a developmental delay in developing control of postural sway (Hill et al 2000). Our results indicate that these high-risk children with a greater familial density of alcoholism have a higher risk for early alcohol initiation. The significant moderating effects of impaired postural control suggest that having a higher familial density of alcoholism may be related to delays in maturation of neural circuitry involved in standing steadiness (e.g., cerebellum, basal ganglia). Specific brain pathways for the positive reinforcing effects of drugs have been described (Harlan and Garcia 1999; Koob and Bloom 1988; Wise and Rompre 1989) and include portions of the basal ganglia. The mesocorticolimbic dopamine system appears to be important for the acute effects of cocaine, amphetamine, and nicotine (Koob and Bloom 1988).



Moreover, ethanol interacts with multiple neurotransmitter systems, all of which are in the mesocorticolimbic dopamine system and its connections to the nucleus accumbens and amygdala (Engel et al 1992). Further work is needed to determine if brain areas responsible for postural control, such as basal ganglia, may be altered in individuals at high risk for developing alcohol or other substance dependence. Alterations in the cerebellar vermis has been identified in schizophrenia and bipolar illness (Helmkamp et al 1999) as it frequently has been in alcoholism (Allen et al 1979). The long-term neuropathologic effects of alcohol use associated with alcoholism preclude identification of cerebellar alterations that might precede the addictive process, however.

Our results appear to support a number of studies showing that familial risk for alcoholism, as defined by the presence of parental alcoholism, is a predictor of alcohol use and alcohol problems in adolescents (Chassin et al 1991, 1993; Sher et al 1991). We used a quantitative estimate of familial loading for alcoholism (number of first- and second-degree relatives affected) to model the familial effect. This approach may provide greater precision in estimating the degree of familial loading for alcohol dependence; however, exposure to an alcoholic parent or older sibling may provide secondary effects that can influence onset of drinking. One previous study addressing this issue did not find that living with an alcoholic parent had an effect on adolescent risk for increased frequency or quantity of drinking (Bahr et al 1995).

It must be noted that the high-risk methodology cannot elucidate the relative role of genetic and environmental factors in the etiology of adolescent drinking in the absence of either an adoption methodology or extensive genotyping where clear and known genetic markers are available. Also, because the familial loading was much greater than that seen in the general population by study design, it would also suggest that youngsters from these families might have greater access to alcohol through older siblings or parents. Additionally, these individuals might provide role models for excessive drinking. Further follow-up of this cohort will enable us to determine if the predictors modeled in this analysis will predict problems with alcohol in young adulthood as well.

---

This research is supported by grants from the National Institute on Alcohol Abuse and Alcoholism (Nos. AA05909 and AA08082).

The authors thank S. Gronlund, K. Walsh, and C. Konicky for their excellent technical assistance, and T. Smith and D. Muka for recruiting subjects and assisting in clinical evaluations. They also thank S. Steinhauer, Ph.D., for his continued support and collaboration. Also, our research group is indebted to the families who participated and the treatment centers who have allowed us to recruit families from among their patient population.

---

## References

- Ahmed SMS, Valliant PM, Swindle D (1985): Psychometric properties of Coopersmith Self-Esteem Inventory. *Percept Mot Skills* 61:1235–1241.
- Allen JH, Martin JT, McLain LW (1979): Computed tomography in cerebellar atrophic processes. *Radiology* 130:379–382.
- Bahr SJ, Marcos AC, Maughan SL (1995): Family, educational and peer influences on the alcohol use of female and male adolescents. *J Stud Alcohol* 56:457–469.
- Barnes GE (1979): The alcoholic personality: A reanalysis of the literature. *J Stud Alcohol* 40:571–633.
- Barnes GE (1983): Clinical and personality characteristics. In: Kissin B, Begleiter H, editors. *The Pathogenesis of Alcoholism: Psychosocial Factors*, Vol 6. New York: Plenum Press, 113–196.
- Baron RM, Kenny DA (1986): The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 51:1173–1182.
- Beer J (1987): Depression and self-esteem of teachers. *Psychol Rep* 60:1097–1098.
- Begleiter H, Porjesz B, Bihari B, Kissin B (1984): Event-related brain potentials in boys at risk for alcoholism. *Science* 225:1493–1496.
- Benedetti J, Yuen K, Young L (1988): Life table and survival functions. In: Dixon WJ, editor. *BMDP Statistical Software Manual*, Vol 2. Berkeley: University of California Press, 689–718.
- Bennett LA, Wolin SJ, Reiss D (1988): Cognitive, behavioral and emotional problems among school-age children of alcoholic parents. *Am J Psychiatry* 145:185–190.
- Berman SM, Whipple SC, Fitch RJ, Noble EP (1993): P3 in young boys as a predictor of adolescent substance abuse. *Alcohol* 10:69–76.
- Cappell H, Greeley J (1987): Alcohol and tension reduction: An update on research and theory. In: Blane HT, Leonard KE, editors. *Psychological Theories of Drinking and Alcoholism*. New York: Guilford, 15–54.
- Chassin L, Pillow DR, Curran PJ, Molina BSG, Barrera M (1993): Relation of parental alcoholism to early adolescent substance use: A test of three mediating mechanisms. *J Abnorm Psychol* 102:3–19.
- Chassin L, Rogosch F, Barrera M (1991): Substance use and symptomatology among adolescent children of alcoholics. *J Abnorm Psychol* 100:449–463.
- Conger JJ (1956): Alcoholism: Theory, problem and challenge. II. Reinforcement theory and the dynamics of alcoholism. *Q J Stud Alcohol* 17:296–305.
- Cotton N (1979): The familial incidence of alcoholism: A review. *J Stud Alcohol* 40:9–116.
- Cox WM (1979): The alcoholic personality: A review of the evidence. In: Major BA, editor. *Progress in Experimental Personality Research*, Vol 9. San Diego, CA: Academic Press, 89–148.
- Cox WM (1987): Personality theory and research. In: Blane HT, Leonard KE, editors. *Psychological Theories of Drinking and Alcoholism*. New York: Guilford, 55–89.
- Eischen SE, Polich J (1994): P300 from families. *Electroencephalogr Clin Neurophysiol* 92:369–372.

- Engel JA, Enerback C, Fahlke C, Hulthe P, Hard E, Johannessen K, et al (1992): Serotonergic and dopaminergic involvement in ethanol intake. In: Naranjo CA, Sellers EM, editors. *Novel Pharmacological Interventions for Alcoholism*. New York: Springer, 68–82.
- Ernhardt CB, Morrow-Tlucak M, Sokol RJ, Martier S (1988): Underreporting of alcohol use in pregnancy. *Alcohol Clin Exp Res* 12:506–511.
- Ervin CS, Little RE, Streissguth AP, Beck DE (1984): Alcoholic fathering and its relation to child's intellectual development: A pilot investigation. *Alcohol Clin Exp Res* 8:362–365.
- Eysenck SBG (1963): *Manual for the Junior Eysenck Personality Inventory*. San Diego: Educational and Industrial Testing Service.
- Feighner JP, Robins E, Guze SB, Woodruff RA Jr, Winokur G, Munoz R (1972): Diagnostic criteria for use in psychiatric research. *Arch Gen Psychiatry* 26:57–63.
- Ghodsian M, Power C (1987): Alcohol consumption between the ages of 16 and 23 in Britain: A longitudinal study. *Br J Addict* 82:175–180.
- Glantz MA (1992): Developmental psychopathology model of drug abuse vulnerability. In: Glantz M, Pickens R, editors. *Vulnerability to Drug Abuse*. Washington, DC: American Psychological Association, 389–418.
- Grant BF, Dawson DA (1997): Age at onset of alcohol use and its association with DSM-IV alcohol abuse and dependence: Results from the National Longitudinal Alcohol Epidemiologic Survey. *J Subst Abuse* 9:103–110.
- Harlan RE, Garcia MM (1999): Brain regions and drug addiction. *Science* 248:1124–1125.
- Hart JG (1985): LAWSEQ: Its relation to other measures of self-esteem and academic ability. *Br J Educ Psychol* 55:167–169.
- Hawkins JD, Graham JW, Maguin E, Abbott R, Hill KG, Catalano RF (1997): Exploring the effects of age of alcohol use initiation and psychosocial risk factors on subsequent alcohol misuse. *J Stud Alcohol* 58:280–290.
- Hegedus AM, Alterman AI, Tarter RE (1984a): Learning achievement in sons of alcoholics. *Alcohol Clin Exp Res* 8:330–333.
- Hegedus AM, Tarter RE, Hill SY, Jacob T, Winsten NE (1984b): Static ataxia: A possible marker for alcoholism. *Alcohol Clin Exp Res* 8:580–582.
- Helmkamp CE, Bigelow LB, Paltan-Ortiz JD, Torrey EF, Kleinman JE, Herman MM (1999): Evaluation of superior vermal Purkinje cell placement in mental illness. *Biol Psychiatry* 45:1370–1375.
- Hill SY, Armstrong J, Steinhauer SR, Baughman T, Zubin J (1987): Static ataxia as a psychobiological marker for alcoholism. *Alcohol Clin Exp Res* 4:345–348.
- Hill SY, Locke J, Lowers L, Connolly J (1999a): Psychopathology and achievement in children at high risk for developing alcoholism. *J Am Acad Child Adolesc Psychiatry* 38:883–891.
- Hill SY, Muka DH (1996): Childhood psychopathology in children from families of alcoholic female probands. *J Am Acad Child Adolesc Psychiatry* 35:725–733.
- Hill SY, Shen S, Locke J, Lowers L, Steinhauer S, Konicky C (2000): Developmental changes in postural sway in children at high and low risk for developing alcohol-related disorders. *Biol Psychiatry* 47:501–511.
- Hill SY, Shen S, Locke J, Steinhauer SR, Konicky C, Lowers L, Connolly J (1999b): Developmental delay in P300 production in children at high risk for developing alcohol-related disorders. *Biol Psychiatry* 46:970–981.
- Hill SY, Steinhauer SR (1993a): Assessment of prepubertal and postpubertal boys and girls at risk for developing alcoholism with P300 from a visual discrimination task. *J Stud Alcohol* 54:350–358.
- Hill SY, Steinhauer SR (1993b): Postural sway in children from pedigrees exhibiting a high density of alcoholism. *Biol Psychiatry* 33:313–325.
- Hill SY, Steinhauer SR, Lowers L, Locke J (1995): Eight year longitudinal follow-up of P300 and clinical outcome in children from high-risk for alcoholism families. *Biol Psychiatry* 37:823–827.
- Hill SY, Steinhauer SR, Park J, Zubin J (1990): Event-related potential characteristics in children of alcoholics from high density families. *Alcohol Clin Exp Res* 14:6–16.
- Hill SY, Yuan H (1999): Familial density of alcoholism and onset of adolescent drinking. *J Stud Alcohol* 60:7–17.
- Hill SY, Yuan H, Locke J (1999c): Path analysis of P300 amplitude of individuals from families at high and low risk for developing alcoholism. *Biol Psychiatry* 45:346–359.
- Hollingshead AB (1975): Four factor index of social status. Unpublished manuscript.
- Hopkins A (1988): Survival analysis with covariates—Cox models. In: Dixon WJ, editor. *BMDP Statistical Software Manual*, Vol 2. Berkeley: University of California Press, 719–743.
- Jones MC (1968): Personality correlates and antecedents of drinking patterns in adult males. *J Consult Clin Psychol* 32:2–12.
- Jones MC (1971): Personality antecedents and correlates of drinking patterns in women. *J Consult Clin Psychol* 36:61–69.
- Kandel DB, Yamaguchi K, Chen K (1992): Stages of progression in drug involvement from adolescence to adulthood: Further evidence for the gateway theory. *J Stud Alcohol* 53:447–457.
- Kaplan EL, Meier P (1958): Nonparametric estimation from incomplete observations. *J Am Stat Assoc* 53:457–481.
- Knop J, Teasdale TW, Schulsinger F, Goodwin DW (1985): A prospective study of young men at high risk for alcoholism: School behavior and achievement. *J Stud Alcohol* 273–278.
- Koob GF, Bloom FE (1988): Cellular and molecular mechanisms of drug dependence. *Science* 242:715–723.
- Koob GF, LeMoal M (1997): Drug abuse: Hedonic homeostatic dysregulation. *Science* 278:52–58.
- Lester D, Carpenter JA (1985): Static ataxia in adolescents and their parentage. *Alcohol Clin Exp Res* 9:212.
- Lipscomb TR, Carpenter JA, Nathen PE (1979): Static ataxia: A predictor of alcoholism? *Br J Addict* 74:289–294.
- Mayer J, Filstead WJ (1979): The adolescent alcohol involvement scale: An instrument for measuring adolescent use and misuse of alcohol. *Curr Alcohol* 7:169–181.
- McGrath CE, Watson AL, Chassin L (1999): Academic achieve-

- ment in adolescent children of alcoholics. *J Stud Alcohol* 60:18–26.
- Moos RH, Billings AG (1982): Children of alcoholics during the recovery process: Alcoholic and matched control families. *Addict Behav* 7:155–163.
- Nestler EJ, Aghajanian GK (1997): Molecular and cellular basis of addiction. *Science* 278:58–62.
- Newcomb MD, Bentler PM (1989): Substance use and abuse among children and teenagers. *Am Psychol* 44:242–248.
- Pino CJ, Simons N, Slawinowski MJ (1984): *Manual for the Children's Version of the Familial Environment Scale (CVFES)*. East Aurora, NY: Slosson Educational Publications.
- Reid K (1982): The self-concept and persistent school absenteeism. *Br J Educ Psychol* 52:179–187.
- Reynolds CR (1980): Concurrent validity of what I think and feel: The revised children's manifest anxiety scale. *J Consult Clin Psychol* 48:774–775.
- Reynolds CR, Richmond BO (1978): What I think and feel: A revised measure of children's manifest anxiety. *J Abnorm Child Psychol* 6:271–280.
- Robins LN, Bates W, O'Neal P (1962): Adult drinking patterns of former problem children. In: Pittman D, Snyder CR, editors. *Society, Culture, and Drinking Patterns*. New York: Wiley, 395–412.
- Robins LN, Przybeck TR (1985): Age of onset of drug use as a factor in drug and other disorders. In: Jones CL, Battjes RJ, editors. *Etiology of Drug Abuse: Implications for Prevention*, NIDA Research Monograph No 56, DHHS Publication No ADM 85-1335. Washington, DC: US Government Printing Office, 178–192.
- Schuckit MA (1983): Extroversion and neuroticism in young men at higher or lower risk for alcoholism. *Am J Psychiatry* 140:1223–1224.
- Schweitzer RD, Seth-Smith M, Callan V (1992): The relationship between self-esteem and psychological adjustment in young adolescents. *J Adolescence* 15:83–97.
- Sher KJ (1987): Stress response dampening. In: Blane HT, Leonard KE, editors. *Psychological Theories of Drinking and Alcoholism*. New York: Guilford, 227–271.
- Sher KJ (1991): *Children of Alcoholics: A Critical Appraisal of Theory and Research*. Chicago: University of Chicago Press.
- Sher KJ, Walitzer KS, Wood PK, Brent EE (1991): Characteristics of children of alcoholics: Putative risk factors, substance use and abuse, and psychopathology. *J Abnorm Psychol* 100:427–448.
- Steinhauer SR, Hill SY (1993): Auditory event-related potentials in children at high risk for alcoholism. *J Stud Alcohol* 54:408–421.
- Steinhauer SR, Hill SY, Zubin J (1986): Event-related potential similarity in adult siblings. *Psychophysiology* 23:464.
- Steinhauer SR, Hill SY, Zubin J (1987): Event-related potentials in alcoholics and their first-degree relatives. *Alcohol* 4:307–314.
- Stice E, Barerra M Jr, Chassin L (1998): Prospective differential prediction of adolescent alcohol use and problem use: Examining the mechanisms of effect. *J Abnorm Psychol* 107:616–628.
- Surwillo WW (1980): Cortical evoked potentials in monozygotic twins and unrelated subjects: Comparisons of exogenous and endogenous components. *Behav Genet* 10:201–209.
- Usui N, Maekawa K, Hirasawa Y (1995): Development of the upright postural sway of children. *Dev Med Child Neurol* 37:985–996.
- van Beijsterveldt T (1996): *The Genetics of Electrophysiological Indices of Brain Activity: An EEG Study in Adolescent Twins*. Amsterdam: University of Amsterdam, Department of Psychology.
- Weissman MM, Gammon GD, John K, Merikangas KR, Warner V, Prusoff BA, et al (1987): Children of depressed parents: Increased psychopathology and early onset of major depression. *Arch Gen Psychiatry* 44:847–853.
- Whipple S, Parker ES, Noble EP (1988): An atypical neurocognitive profile in alcoholic fathers and their sons. *J Stud Alcohol* 49:240–244.
- Wise RA, Rompre PP (1989): Brain dopamine and reward. *Annu Rev Psychol* 40:191–225.
- Wolin S, Bennett L, Noonan D, Teitelbaum M (1980): Disrupted familial rituals. *J Stud Alcohol* 41:199–214.
- Yuan H, Marazita M, Hill SY (1986): Segregation analysis of alcoholism in high density families: A replication. *Am J Med Genet Neuropsychiatr Genet* 67:71–76.