The Effects of Maternal Alcohol Consumption and Cigarette Smoking during Pregnancy on Acoustic Cry Analysis

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During the last trimester of pregnancy, 127 primiparous Irish mothers were interviewed to ascertain their history of alcohol and tobacco use. Confounding effects due to other drugs were not a factor in this sample. Mothers consumed an average of .21 ounces absolute alcohol (AA) per day, with 62% classified as moderate drinkers, 10.6% as heavy drinkers, and 26% as nondrinkers. Neurobehavioral status was measured using acoustic characteristics of the infant's cry, collected on the third day of life. Multiple regression analysis showed that more ounces AA per day was related to more dysphonation and higher first formant, while more cigarette smoking was related to higher pitch, higher second formant, and more variability in the second formant. Analysis of variance comparisons of these 3 alcohol groups demonstrated significant cry effects on infants of heavy drinking mothers

It has been well documented that alcohol consumed during pregnancy crosses the placenta and can alter fetal brain development (Poskitt, 1984; Sokol, Miller, & Reed, 1980; Streissguth, Sampson, Barr, Bookstein, & Carmichael Olson, 1994; West, 1986). The teratogenic properties of alcohol have been described through clinical studies of children with the Fetal Alcohol Syndrome (FAS) (e.g., Carmichael Olson, 1994; Jones & Smith, 1973; Streissguth, Clarren, & Jones, 1985). However, FAS may represent only the most severe outcome on a continuum of adverse effects which may include more subtle effects on fetal development and newborn behavior (Barrison & Wright, 1984; Carmichael Olson, 1994; Coles, Smith, Lancaster, & Falek, 1987; Coles & Platzman, 1993). While there is little doubt that the consumption of large amounts of alcohol during pregnancy imposes a risk for the fetus, less is known about the effects of more moderate levels of drinking on birth outcome and on the

neurobehavioral integrity of the newborn (Smith, Lancaster, Moss-Wells, Coles, & Falek, 1987).

In studies of prenatal exposure to alcohol and newborn behavior, alcohol consumption has been measured as the average ounces of absolute alcohol per day (ounce AA/day) as described by Cahalan, Cisin, and Crossley (1969). Newborn behavior in these studies has been measured using the Brazelton scale (Brazelton & Nugent, 1995). Streissguth, Martin, and Barr (1983) found that newborn infants exposed to moderate amounts of alcohol (.27 ounce AA/day or about one-half of a drink per day) during pregnancy were less well able to habituate to aversive stimuli, as measured by the Brazelton scale. Jacobson, Fein, Jacobson, Schwartz, and Dowler (1984) studied a group of predominantly middle-class mothers whose alcohol consumption averaged .25 ounce AA per day and found that this level of alcohol exposure was related to lower levels of arousal in the infants, reflected in the low range of state scores on the Brazelton Scale.

In the Ottawa Prenatal Prospective Study, Fried and Makin (1986) studied a sample of 700 middle-class mothers who consumed 0.25 ounce AA per day during pregnancy and found that their infants showed signs of increased irritability on the Brazelton Scale. Higher levels of prenatal exposure to alcohol were studied in a small sample of lower SES high-risk mothers and their infants by Coles et al. (1987), They reported that infants whose mothers continued drinking through pregnancy (a mean of 13.34 ounce AA/week) showed more deviant reflexes on the Brazelton Scale at 14 days than infants whose mothers did not. At 30 days, these infants still had more deviant reflexes and poorer autonomic regulation on the Brazelton Scale than infants whose mothers abstained from alcohol.

Although these studies have shown statistically reliable effects of moderate amounts of prenatal exposure to alcohol on newborn behavior, the magnitude of these effects is relatively small and subtle. In their study of moderate alcohol consumption during pregnancy, Fried and Makin (1986) pointed out that on the Brazelton scale the effects of alcohol are smaller than the effects of either Marijuana or cigarettes. Although Richardson, Day, and Taylor (1989) found that second-trimester alcohol use was a significant predictor of orientation scores on the Brazelton scale, alcohol accounted for only 1% of the variance. Ernhart, Wolf, Linn, Kennard, and Filopovich (1985) found no relation between Brazelton scores and an average daily consumption of 0.20 ounce AA/day during pregnancy.

Despite the subtlety of the effects reported, longitudinal studies suggest that there are long-term developmental consequences of prenatal exposure to alcohol. In the Seattle Study of Alcohol and Pregnancy, Streissguth, Barr, Sampson, Darby, and Martin (1989) reported that the consumption of more than 1.5 ounce AA/day during pregnancy was related to an average IQ decrement of almost five points in children of 4 years of age, even after controlling for maternal and paternal education, race, prenatal nutrition, aspirin and antibiotics, gender, birth order, mother-child interaction, and preschool attendance. O'Connor, Sigman, and Kasari (1993), in their retrospective study of the effects of maternal alcohol use and cognitive development, reported results that replicate these findings. They found that the mean MDI scores of 1-year-old infants, whose mothers reported drinking two or fewer drinks per occasion during pregnancy (with an AA score of greater than. 10), were 15 points lower than the average IQ of infants whose mothers were classified as nondrinkers. In addition, Streissguth et al. (1984) found that maternal alcohol use during pregnancy was related to increased attentional errors and longer reaction time in 4-year-old children.

In the Seattle Study of Alcohol and Pregnancy 7-year follow-up, IQ scores remained significantly related to prenatal alcohol use while the alcohol-related attentional deficits observed

at 4 years continued to be significant (Streissguth et al., 1990). On achievement tests, arithmetic achievement was most strongly related to prenatal alcohol consumption (Streissguth et al., 1990). Fried, O'Connell, and Watkinson (1992) also found that alcohol exposure resulted in lower levels of impulsive responding on a CPT task at 6 years.

One methodological problem in this area that has been widely acknowledged is the difficulty of controlling for possible confounding variables. These include the use of other harmful substances as well as differences in factors such as prenatal care and nutrition that could also affect newborn behavior (Coles & Platzman, 1993; Streissguth et al., 1994; Zuckerman & Hingson, 1986). The present study, a prospective longitudinal study of first-time working-class mothers and their infants, was conducted in a setting where none of the mothers in the sample used recreational and addictive substances during or before pregnancy, other than alcohol and smoking. This setting provided the opportunity to control for confounding variables including demographic factors and the *use* of substances other than alcohol or cigarette smoking in our efforts to establish a direct relation between prenatal-exposure to alcohol and the neurobebavioral integrity of the newborn infant.

We also examined the effects of smoking during pregnancy, and we report the use of cigarette smoking when effects due to alcohol are controlled. Smoking use during.pregnancy has been related to low birthweight (Abel, 1980), reduced fetal growth (Fried & O'Connell, 1987), and increased risk of perinatal mortality (Naeye, 1978). On the Brazelton scale, cigarette smoking during pregnancy has been related to poorer habituation to auditory stimuli (Fried & Makin, 1986; Richardson et al., 1989), to increased tremulousness and poorer autonomic regula- lion (Fried & Makin, 1986; Picone et d., 1982), and to poorer auditory orientation (Picone et al., 1982).

As with the effects of alcohol, the magnitude of smoking effects in, these studies is small and subtle, but there is some evidence of longer term developmental consequences of cigarette smoking during pregnancy. In a follow-up study by Fried and Watkinson (1990) prenatal exposure to smoking was related to cognitive scores at 3 years of age. In their 4-year follow-up, they found that even when they controlled for the effects of the home environment, maternal smoking during pregnancy was related to: cognitive, vocabulary, and language measures (Fried .& Watkinson, 1990). Streissguth et al. (1984) reported that 4-year-old: children whose mothers smoked heavily during pregnancy had more attentional errors on a series of vigilance: outcome measures even when a variety of potentially confounding variables were accounted for. However, they found. no relation between nicotine and attentional problems at 7 years. Neither was there a relation between nicotine *and* IQ at 4 *or* 7 years, once alcohol and other, relevant environmental factors were adjusted for.

In the present study; the neurobehavioral integrity of the infant *was* measured using acoustical cry analysis. Acoustic characteristics of the infant's cry are controlled, in part by central nervous system input (Lester, 1984) and are, correlated with various medical risk factors, including prematurity, low birthweight, intrauterine growth retardation, and obstetrical complications (Lester, 1976, 1984, 1981; Lester & Zeskind, 1979; Rapizrdi, Vohr, Cashore, Peucker, & Lester, 1989) and with later developmental outcome in preterm infants (Lester, 1984; Lester et al., 1989). More recently, acoustic cry characteristics have been studied in relation to prenatal substance abuse. Lester arid Dreher (1989) used a cross-cultural approach to control for demographic factors and the use of other harmful substances in a study of prenatal exposure to marijuana in Jamaica. The cries of infants whose mothers smoked marijuana during pregnancy showed different acoustic characteristics than the cries of infants of nonsmoking mothers. In a study of newborns with prenatal exposure to cocaine

(Lester et al, 1991) acoustic cry characteristics were used to differentiate excitable versus depressed neurobehavioral syndromes. Our primary interest in the present study was to determine the effects of maternal prenatal alcohol consumption on newborn cry characteristics. As part of this effort, we also studied the effects of maternal cigarette smoking on newborn cry.

Method

The sample consisted of 127 primiparous mothers interviewed during the seventh month of pregnancy at the antenatal clinic at the National Maternity Hospital in Dublin. Fifty-four percent of the mothers were single, the rest were married. The average age of the mothers was 22, with 13% below, $_1$8 years of age. The mothers were classified as working class based on educational and occupational levels according to MacGreill's adaptation of the Hollingshead method of SES classification (MacGreill, 1977.). The average educational level of the sample was 3 years of secondary school. All mothers received prenatal care with an average *of* 9.34 prenatal visits (SD = 5.29).

Alcohol and nicotine levels were based on maternal report from an interview conducted with the mother during the seventh month of pregnancy. The interview was designed to collect normative data on the transition to parenthood in this Dublin sample,
so that the questions on smoking and alcohol behaviour were embedded in an hour-long interview which covered many aspects of the mother's attitudes to pregnancy and parenthood. To minimize the possibility of underreporting, the interview was administered by a research assistant who was trained to elicit the information in a non-judgmental manner. Moreover, the items were presented in a way that provided opportunities for the interviewer and respondent to clarify or qualify any ambiguities ^{in} the recording or interpretation of the responses. The confidentiality of the mother's responses was also emphasized.

To reduce the possible confounding effects of other drugs on newborn behaviour, 12 women from the original sample of 139, who reported using substances other than alcohol and nicotine at any time in their lives, were excluded from the study, resulting in a final sample size of 127 subjects.

The 127 infants were all born by vaginal delivery at term (gestational age ranged from 38 to 41 weeks) with birthweights above 2,500 grams. Exclusion criteria were gestational age below 38 weeks, birthweight below 2,500 grams, Apgars lower than 8 at 1 min and 9 at 5 min, and any congenital anomalies. The Obstetrical Complications Scale (Littman & Parmelee, 1978) was scored from the medical records (M = 118, SD = 23).

The cries of these 127 infants were tape-recorded on the third day postpartum during a standard physical examination of the newborn. The infant was in a supine position with the microphone held 15 cm from the infant's mouth and the technician was unaware of the mother's history of substance use.

The first 30-sec cry that occurred during the exam was tape-recorded. A specially designed tone box was used to place a 3,300 hertz tone on the tape to mark the onset of the cry. For infants who required more than one stimulus, the tone marked the final stimulus applied to elicit the cry. The cries were analyzed using a computer-based infant cry analysis system described in detail elsewhere (Lester et al., 1991). The analysis is completely computerized; no coders are involved.

A total of 11 summary cry variables were computed. With the exception of the number of cries, the summary variables were based on the average of the first two utterances. The summary cry variables are described in Table 1.

Alcohol consumption during *pregnancy.*—We quantified the volume of alcohol consumption using the method developed by Cahalan, Cisin, and Crossley (1969), with two standard alcoholic drinks (i.e., two 12-ounce beers, two 5-ounce glasses of wine, or two drinks containing 1.5

ounce of distilled spirits) being considered to be equivalent to 1 ounce of absolute alcohol. We computed daily alcohol use by multiplying the usual number of drinking occasions per day by the amount of alcohol usually consumed per occasion in terms of absolute ounces. Table 2 shows that the average consumption for this sample, prior to pregnancy recognition, was .72 ounce AA (SD = .76, range 0-5.13), and during pregnancy was .21 ounce AA (SD = .32, range 0-1.87), which is the equivalent of slightly less than one-half of one drink per day. Mothers drank an average of 2.98 drinks per drinking occasion (SD = 1.82, range 0-9.0) before pregnancy recognition and 1.57 drinks per occasion during pregnancy (SD = 1.42, range 0-9.0).

Thirteen percent of the mothers in this working class Dublin sample (n=17) reported that they never drank alcohol at all. When mothers who drank alcohol were asked about their drinking patterns before they knew they were pregnant, 57% reported

TABLE 1

SUMMARY CRY VARIABLES

Number of cries.—Number of expiratory cry phonations that occurred during the 30-sec recording.
Duration - Average length in milliseconds of the cry utterance.
Amplitude.—Average energy in decibels of the cry utterance.
Dysphonation.—Average percent of the cry utterance with turbulence (noise) or aperiodic sound.
Fundamental frequence (f0).—Average median frequency in hertz of vocal fold vibration or what is commonly known as voice pitch.
Fundamental frequency variability.—Average interquartile range of fundamental frequency.
Hyperphonation —Average percent of the cry utterance in which fundamental frequency exceeds 1,000 hertz.
Formant frequencies (two variables, FI *and* F2).—Average median frequencies in hertz of the resonance frequencies that occur as a result of the filtering of the vocal tract following generation of the sound by the vocal cords
Formant variability —Average interquartile range of F1 and F2 (also 2 variables)

that they drank once or twice a week, and 53% said they consumed between three to five drinks on these occasions. When they became pregnant, a further 12% abstained from alcohol, while the number of occasions when mothers drank was reduced. Moreover, the number of drinks they consumed on these occasions was also reduced. While 53% of mothers consumed between three and five drinks when drinking before pregnancy, only 20% drank that amount on each occasion during pregnancy. Of the mothers who continued to drink during pregnancy, most consumed either one or two drinks on any occasion and these occasions become fewer when mothers realized they were pregnant. Of the total sample, 4.8% (n = 6) had four or more drinks per occasion. Most mothers who drank during pregnancy consumed beer only (62%), while 14% drank wine only, and 12% drank spirits only. The remaining 12% consumed a combination of beer, wine, or spirits.

T A B L E 2
Alcohol and Cigarette-Smoking Discriptive Statistics

	Mean	SD	Min	Max
Average ounces of absolute alcohol/day:				
Prior to pregancy recognition	.72	.76	0	5.13
During pregnancy gnancy	.21	.32	0	1.87
Average drinks per occasion:				
Prior to pregnancy	2.98	1.84	0	9.0
During pregnancy	1.57	1.42	0	9.0

Number of cigarettes/day*:*	*Amount*	*Percentage*
Prior to pregnancy recognition	40-60	1.5
	20-40	19.5
	10-20	31.0
	<10	16.5
	0	31.5
During pregnancy	40-60	0
	20-40	7.9
	10-20	22.8
	<10	29.9
	0	39.4

.*Cigarette consumption*.—Cigarette consumption rates are also presented in Table 2. Heavy cigarette use (20-40 cigarettes/day) occurred in 7.9% of the sample during pregnancy, while 27.8% could be called moderate smokers (10-20 cigarettes/day). Thirty percent of the mothers smoked fewer than 10 cigarettes a day and were called light smokers. Among the mothers who smoked, there was a decrease in the number of cigarettes smoked when they realized they were pregnant. Heavy smoking decreased from 21% before pregnancy to 7.9% during pregnancy, while the number of nonsmokers increased from 31.5% before pregnancy to 39A% during pregnancy. More specifically, the number of moderate smokers decreased from 31% before pregnancy to 22.8% during, and the percentage of light smokers went from 16.5% to 30%. The number of cigarettes smoked each day during pregnancy was retained for the examination of the effects of smoking on cry characteristics.

Results

There were no significant correlations between demographic variables and alcohol and cigarette use. There was a correlation between alcohol (ounce AA/day) and smoking (number of cigarettes per/day), $r = .24$, $p < .005$.

Two types of statistical analyses were conducted. Hierarchical multiple regression was used to examine the effects of maternal alcohol and tobacco use during pregnancy on cry- characteristics after controlling for medical factors. ANOVAs were then used to determine whether observed alcohol effects were due to the highest levels of alcohol consumption.

The regression analysis was conducted using four variables: two medical variables (number of prenatal visits and the OCS score), average dosage of absolute alcohol (ounce AA/day) and the number of cigarettes per day. Number of prenatal visits and OCS (Obstetric Complications Scale) scores were selected because these were the only variables in the data set with sufficient variabilit[y] to justify inclusion in the regressions. The selection criteria for inclusion in the study resulted in a healthy sample with little variability in medical factors that: interact with the effects of alcohol and smoking on infant cry. The regressions were conducted twice: first, the two medical factors were entered followed by alcohol then cigarette use; second, the two medical factors were entered followed by cigarette then alcohol use. The two sets of regressions were carried out for each of the 11 cry variables.

Effects of alcohol or smoking were found on five of the 11 cry variables. The same effects were observed regardless of the order of entry of alcohol and smoking. There were no effects in either set of regressions for number of prenatal visits or OCS score. In the results below, alcohol was entered before smoking as this was the initial hypothesis tested.

Effects of alcohol were found on two cry variables. More ounces AA/day was related to cries with more dysphonation, $F(4, 123) = 7.55$, $p < .005$, and a higher first formant, $F(4, 123) = 4.16$, $p < .04$. There were no significant effects for cigarette smoking on these variables.

Effects of cigarette smoking were found on three cry variables. More cigarette smoking per day was related to cries with a higher fundamental frequency or pitch, $F(4, 123) – 5.74$, $p < .01$, a higher second formant, $F(4, 123) = 7.37$, $p < .005$, and more variability in the second formant, $F(4, 123) = 4.58$, $p < 03$. There were no significant effects for alcohol on these variables.

For the ANOVAs, the infants were divided into three groups based on average ounce AA/day of prenatal alcohol exposure: (1) no alcohol group, mothers with average ounce AA/day = 0; (2) moderate use group, defined as .01–.49 average ounce AA/day; (3) heavy use group, defined as .50–.99 average ounce AA/day. Twenty-six percent of the sample (n = 33) were included in the no alcohol group, 66.6% (n = 77) were included in the moderate use group, and 10.6% (n = 13) were included in the heavy use group. The no alcohol group comprised 33 mothers (26.8%) with average ounce AA/day = 0. There were 77 mothers (62.6%) in the moderate use (.01–.49 average ounce AA/day) group and 13 mothers (10.6%) in the heavy use (.50–.99 average ounce AA/day). A one-way ANOVA was computed across the no, moderate, and hea[v]y alcohol use groups for the 11 cry variables.

For the two cry variables on which significant alcohol effects were found in the regression analysis, the ANOVA comparisons of the three groups were significant for the first formant, $F(2, 120) = 6.10$, $p < .003$, but not for dysphonation. The Duncan Multiple Range Test showed that the mean first formant of the cry was significantly higher ($p < .05$) in infants whose mothers were heavy drinkers (M = 1,404 hertz) than in infants of mothers who were moderate drinkers (M = 1.126 hertz) or mothers who did not drink during pregnanc[y] (M = 1,103 hertz). Although the effects were not significant for dysphonation, the means were in the expected direction (30% dysphonation in the heavy use group, 20% in the moderate use group, and 16% in the no use group). There were no significant differences among the three groups on any of the other cry variables.

Intercorrelations were computed among the 11 acoustic cry variables. Of the 111 correlations computed, 27 were statistically significant ($p < .05$). However, the correlations were generally of low magnitude; in only five of the significant correlations was $r > .29$.

Discussion

The evidence presented here strongly suggests that moderate levels of maternal alcohol consumption during pregnancy affect the acoustic characteristics of the newborn Cry. In other studies, comparable levels of maternal alcohol consumption have been found to affect performance on the Brazelton scale (Coles et al., 1987; Fried. & Makin, 1986; Jacobson et al., 1984, Streissguth et al., 1983). Since we were able to control for medical, demographic factors and the use of other substances, it seems reasonable to conclude that the increased dysphonation and a higher first formant in the cry were due to the direct effects of prenatal exposure to alcohol on the nervous system. These differences would be perceived as more noise or turbulence and higher resonance frequencies in the cries of infants with prenatal alcohol exposure. When the infants were divided into three groups representing no, moderate, and heavy alcohol use, the results showed that the higher first formant effects were due primarily to the heavier drinkers whereas the increased dysphonation did not differ between the heavy and moderate use groups, suggesting a possible dose response relation for the dysphonation variable. The alcohol findings in this study provide further evidence for the functional effects of prenatal alcohol exposure in the absence of dysmorphic features, that is physical features, associated with FAS.

Cigarette effects, were also observed in this study, despite the fact that most. mothers in this study were not heavy smokers. Both the fundamental frequency and the mean and variability of the second formant of the cry were increased with increased cigarette smoking. These effects would be perceived as higher pitched cries with a higher and more variable upper register associated with increased cigarette use. As with, the alcohol findings the smoking effects appear to be independent of medical and demographic factors., Although relatively little work has been done on prenatal smoking as compared with alcohol and other drugs, our findings do support previous studies in documenting neurobehavioral effects of cigarette smoking during pregnancy (Fried & Makin, 1986 Jacobson et al., 1984; Picone et al., 1982). Also, there is an interesting parallel between the, alcohol and smoking effects in. this study in that smoking effects were also observed independent of any physical effects on the newborn. Cigarette smoking has been related to physical alterations such as low birthweight and reduced fetal growth (Fried & O'Connell, 1987; Naeye, 1978). Therefore, functional. effects of cigarette use were also observed in the absence of morphologic changes.

It is also interesting that in the regression analysis the results were unaffected by the order of entry of alcohol: and cigarette use. This suggests that the effects of alcohol and cigarette use are independent and that there may be different, nervous system disturbances for alcohol than cigarettes, as Streissguth and her colleagues argue (Streissguth et al., 1994). We know that crying is activated by the hypothalamic-limbic system and controlled by rnidbrain and brain stem regions (Lester et al, 1989), that ethanol, for example, affects hypothalamic function, and smoking is a stimulant that affects the parasympathetic system (Jaffe and Jarvik, 1978). The acoustic cry characteristics that were affected by alcohol and smoking in this study are controlled by dynamic adjustments in the larynx and vocal tract and interaction With the respiratory system, primarily mediated by brain stem activity (Lester, 1984; Lester & Boukydis, 1991). These acoustic features include characteristics related to respiratory (dysphonation), laryngeal (fundamental frequency), and vocal tract (first and second formant) function. In other studies, these acoustic cry characteristics have been affected by prenatal exposure to marijuana and cocaine (Lester et al., 1991; Lester & Dreher, 1989). It is reasonable that alcohol and. smoking can affect different aspects of the cry control system that result in alterations in these acoustic characteristics.

The descriptive data presented here reveal a moderate level of alcohol consumption during pregnancy in this sample of Dublin primiparous working-class mothers (.21 ounce AA/day),

while a small subgroup of mothers (10.6%) were classified as heavy drinkers (consuming more than .50 ounce AA/day). In other studies of prenatal alcohol exposure and neonatal behaviour, classification of moderate maternal alcohol consumption levels ranges from .20 to 1.9 ounce AA/ day (e.g., Ernhart et al., 1985; Fried & Watkinson, 1990; Fried, Watkinson, Dillon, & Dulberg, 1987; Jacobson et A., 1984; O'Connor, Sigman, & Kasari, 1993; Richardson et al., 1989;. Streissguth et al., 1983). Mothers in the present study averaged at the lower end of this range (.21 ounce. AA/day) and consumed less alcohol than respondents from more general population groups in England and Wales (Wilson; 1980; Wright, Harrison, & Waterson, 1983), Scotland (Plant, 1984), France (Kaminsky, Rumeau-Rouquette, & Schwartz, 1978). It should be pointed out that the average ounce AA/day scores: reported here describe, the sample as a whole, both drinkers and abstainers, so that the mean scores may mask the contribution of heavy drinking or binge drinking to the results. Of the 13 mothers (10.6% of the sample) classified in the heavy drinking category, six reported drinking more than .85 ounce AA/day and taking, an average of four drinks per occasion, with one mother taking nine drinks.

The possibility of underreporting in self-report studies of alcohol use must also be analysed, as Ernhart and Streissguth and their colleagues argue (Ernhart, Morrow-Tlucack, Sokol, & Martier, 1988; Streissguth et al., 1994). In this study, every effort was made to reduce the possibility of underreporting by conducting the interviews during pregnancy and relying on current and short-term recall reports, and by ensuring that the interviews were conducted in a non-judgmental manner by a trained interviewer. There is also a possibility that underreporting may not be as likely in this sample of mothers because of the social nature of alcoholic drinking in Irish society. Drinking alcohol is seen as a social event that usually takes place in public settings in the company of friends, rather than an event that takes place at home in isolation. As such it may not carry the kind of social stigma that may lead to underreporting in some studies. Since it has also been suggested that there may be a greater degree of underreporting by heavier drinkers, it should be pointed out that of the 10.6% of the sample who were classified as heavy drinkers, less than half of this group (4.8% of the total sample) fall at the extreme of this category (i.e., drinking at an average level of >.85 ounce AA/day). O'Connor and Daly (1985), in their study of the drinking behaviour of a random sample of Irish drinkers, classified 1.2% of Irish females as heavy drinkers, which supports the notion that the figures reported here may not be underestimates.

In contrast to studies conducted in North America (cf. Jacobson et al., 1984; Kuzma & Kissinger, 1981), we found no relation between alcohol or smoking consumption rates and demographic variables, including SES, family income level, and maternal education. Furthermore, while young age and marital status have been found to be related to bad health habits in pregnancy (Zuckerman et al., 1983), in our sample there was no relation between maternal age, marital status, prenatal care, and smoking or drinking during pregnancy. These findings underscore the importance of examining the cultural context of alcohol and cigarette use during pregnancy and suggest that risk indicators in one setting may not be applicable in other cultures or social settings.

The results from this study support the conclusion that newborn infants show functional disturbances in the nervous system due to the consumption of moderate levels of alcohol and moderate cigarette use during pregnancy. There are subtle but nonetheless significant neonatal neurobehavioral correlates of these levels of prenatal exposure to alcohol and smoking. This study also provides further evidence that acoustic analysis of the infant's cry is a sensitive indicator of the effects of licit and illicit substances during pregnancy on the neurobehavioral organization of the infant.

In work with preterm infants, variations in the acoustic characteristics of the cry have been related to longer term developmental outcome (Lester, 1987; Lester et al., 1989), and evidence is building suggesting that alcohol and smoking consumption during pregnancy at levels comparable to those reported here may have long-term sequelae, as Coles and Platzman (1993), Fried and Watkinson

(1990) and Streissguth et al. (1994) have demonstrated. Therefore, it is possible that even though the effects observed in this study were subtle, they may have direct long-term consequences. An alternative hypothesis, and one that fits with our understanding of biological risk factors and developmental outcome (Sameroff & Chandler, 1975), is that alcohol and smoking may have indirect effects on the development of the child. In this model, prenatal alcohol and smoking behaviour may affect the neurobehavioral organization of the infant, which in turn affects mother-infant interaction as O'Connor et al. (1993) have hypothesized. It is this interaction, shaped by residual effects of alcohol and smoking, well after the infant has "recovered" from the toxic effects of these substances, that will determine later child outcome.

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