

The Effects of Alcohol in Breast Milk on Infant Behavioral State and Mother–Infant Feeding Interactions

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The short-term impact of infant exposure to alcohol in breast milk on mother–infant interactions and infant arousal was examined. Fourteen mother–infant dyads were tested on 2 occasions that consisted of an alcohol administration and a nonalcohol condition. Mother–infant interactions during feeding were videotaped and coded for dyadic reciprocity, maternal noncontingency, and dyadic conflict. Infants were observed for 1 hr after receiving either plain breast milk or breast milk containing alcohol. Behavioral state, startles, and tremors were recorded every 30 sec. Mother–infant interactions were characterized by higher noncontingency and dyadic conflict in the alcohol condition. After drinking breast milk containing alcohol, infants changed behavioral state more often, startled more, and spent less time in quiet sleep and more time in quiet alert and crying states. These findings suggest

that exposure to breast milk containing alcohol may not have a sedating effect, as commonly believed.

An estimated two thirds of American women drink alcohol during their childbearing years (National Institute on Drug Abuse, 1988). Consequently, numerous researchers have studied the impact of exposure to alcohol on infant outcomes. Fetal effects associated with prenatal exposure to alcohol are particularly well documented and include fetal alcohol syndrome (Jones & Smith, 1973), growth retardation (e.g., Little, 1977; Smith, Coles, Lancaster, Fernhoff, & Falek, 1986), disturbances in neurobehavioral functioning and regulation (e.g., Coles, Smith, Fernhoff, & Falek, 1985; Streissguth, Barr, Martin, & Hermann, 1980), cognitive deficits (e.g., Streissguth, Barr, Sampson, Darby, & Martin, 1989) and attention deficits (e.g., Streissguth et al., 1986).

In contrast to the extensive literature addressing the association between prenatal alcohol exposure and infant development, there is considerably less research examining the effects of alcohol exposure during lactation on infant behavioral development. Although some studies suggest that alcohol exposure via breast milk may alter infant feeding (Mennella, 1997; Mennella & Beauchamp, 1993) and sleeping patterns in the short term (Mennella & Beauchamp, 1991; Mennella & Gerrish, 1998), mothers are still frequently advised to drink alcohol during breastfeeding by physicians, lactation specialists, or nurses (Lawton, 1985; Mennella, 1997). Although many of these reports are anecdotal in nature, a survey of women in Vancouver, British Columbia, at 1 month postpartum found that 45% of women who were given medical advice about drinking while breastfeeding were told that drinking alcoholic beverages was desirable, and an additional 42% were told that drinking in moderation was acceptable (Davidson, 1981). This medical advice is probably based on the belief that the hops in beer increase the production of breast milk. Medical lore also recommends that nursing mothers, especially those with colicky infants, consume moderate amounts of alcohol before an evening feeding to alleviate fussiness during the evening (Adams & Davidson, 1987; Lawrence, 1989). However, there is little research evidence indicating that low doses of ethanol in the breast milk may alleviate crying or have a sedating effect on the infant. This lack of research evidence is a significant concern given that approximately 64% of infants in the United States are breast-fed and about 29% are breast-fed until at least 6 months of age (Hill, 2000).

The lack of attention to this area of research is particularly surprising because within 1 hr of consuming an alcoholic beverage, alcohol diffuses into human milk, reaching concentrations equal to or slightly higher than the levels of ethanol in maternal blood (Lawton, 1985). In addition, infants younger than 3 months of age metabolize alcohol at a rate approximately half that of an adult due to immature liver functioning (Abel, 1984; Idanpaan-Heikkila & Jouppila, 1972), which may increase the duration of exposure to alcohol for the infant. Consequently, breast-fed

infants are exposed to the alcohol consumed by their mother at a time when the central nervous system (CNS) is developing at a rapid rate and is particularly vulnerable to environmental insult (Vorhees, 1986).

In an effort to examine the immediate effects of lactational exposure to alcohol on infant behavior, Mennella and Gerrish (1998) conducted an alcohol administration study with thirteen 6- to 26-week-old breast-feeding infants. Infants were fed breast milk with small amounts of alcohol (32 mg in 100 ml of milk) on one testing occasion and plain breast milk 1 week later. Their sleep and activity levels were then observed for 3 hr following feeding. Contrary to expectations, infants who drank the milk with alcohol had shorter periods of sleep and spent significantly less time in active sleep during the second half of the testing session. These results were contrary to popular expectations regarding the sedative effects of alcohol in breast milk and were attributed to the possible stimulatory effects of low doses of ethanol.

However, the ages of the infants in this study ranged from 6 to 26 weeks. Modulation of behavioral state is vastly different for 26-week-old infants compared to those at 6 weeks of age. Indeed, studies have demonstrated that there is a significant developmental shift in sleep states at about 8 weeks of age. In addition, mothers were permitted to feed their infants on demand during the 3.5 hr after they ingested the milk with alcohol. However, it is unclear how many of the infants were fed during this 3-hr period. Extensive research has shown that infant sleep states are dependent on factors related to feeding, such as amount of intake and time since last feeding (e.g., Myers et al., 1998). Thus, variations in feeding after the initial one containing the milk with alcohol may have accounted for these feedings. Indeed, although the authors reported that consumption of the breast milk containing alcohol did not change the pattern of feeding, no data were presented about the frequency and duration of feeding after the initial one and the relationships with duration of sleep. Thus, one purpose of this study was to replicate and extend the findings from the previous study by Mennella and Gerrish (1998) by using narrower age ranges and by standardizing the frequency of feeding and the amount of breast milk that the infants received.

Apart from direct pharmacological effects, one possible explanation for differences in infant behavioral state as a function of low alcohol exposure may be through mother–infant interactions. That is, mothers may behave differently toward their infants under the influence of alcohol compared to their behavior under nonalcohol conditions, and these changes in behavior may influence infants' behavioral state. In addition, other aspects of infant arousal, like crying and startle, as well as aspects of arousal modulation, like the number of state changes, remain uninvestigated to date. Therefore, the study was designed to examine the short-term impact of infant exposure to small amounts of alcohol in breast milk on mother–infant interactions and on infant arousal as measured by behavioral state, startle, and tremors.

METHOD

Participants

The participants were 14 lactating women who reported consuming at least one alcoholic beverage per week during lactation and their healthy, full-term (gestational age > 37 weeks), full-birthweight ($M = 3,360.29$ g, $SD = 345.35$) infants. Four of these infants were firstborn children, 8 were secondborn, 1 was a thirdborn, and 1 was a fourthborn child (maternal parity: $M = 0.93$, $SD = 0.83$). Mothers' ages ranged from 26 to 35 years ($M = 30.1$, $SD = 12.2$), and infants' ages ranged from 4 to 11 weeks ($M = 7.14$, $SD = 2.27$). There were 7 boys and 7 girls in this sample. The majority of the mothers in the study were White (86%), and 14% were African American. Participants were recruited from advertisements in local newspapers and through local lactation consultants, pediatricians, and breast-feeding classes. Mothers who expressed interest in the study were screened for eligibility. Mothers who engaged in binge drinking (i.e., five or more drinks per occasion), or who reported any illicit drug use or an average daily ethanol consumption of .50 oz (one drink a day) during pregnancy were excluded from participation in the study. Further, mothers who did not consume at least one drink per month during the postpartum period were excluded from the study. Additional criteria for exclusion were nicotine use, multiple births, maternal psychiatric disorder, maternal or infant HIV status, or any major medical or prenatal complications at birth or during the postpartum period. Finally, only infants who were exclusively breast-fed and had prior experience consuming breast milk in a bottle were included in the study.

Procedure

Eligible mother–infant dyads were scheduled for two laboratory visits about 1 week apart. Because foods consumed by a breast-feeding mother can impact the flavor of breast milk (Mennella, 1995), mothers were asked to consume a relatively bland diet to ensure that the breast milk would be as similar in flavor as possible. Mothers were also asked to refrain from consuming alcohol for 2 to 3 days before each visit. Mothers were told that they would be receiving alcohol during the visits. To keep mothers blind to the alcohol–placebo condition, all procedures, except for the content of the beverage consumed by mothers, were identical during both visits. On both days, mothers were weighed on arrival and given a Breathalyzer test (Intoxilyzer 5000) to ensure zero blood alcohol level (BAL). Mothers were then escorted to a comfortable room set up similar to a living room, with couches, comfortable chairs, and magazines. In the alcohol condition, women were given a 0.3 g/kg dose of alcohol (approximately one drink for an average-weight woman and a BAL of .03) and were asked to consume it within a 15-min period. Drinks

were prepared using a 3:5:1 ratio of tonic to vodka. Women in the placebo condition received an equivalent amount of tonic with only a negligible amount of vodka floated on top to enhance deception (see Rosenhow & Marlatt, 1981, for a description of placebo administration procedures). Half of these mother–infant dyads were exposed to the alcohol during the first visit, and half were exposed to the nonalcoholic beverage during the first visit, with the order of the visit counterbalanced. On completion of study procedures, mothers were debriefed, paid, and sent home by taxicab.

During the first 30 to 45 min of the visit, while the mother was consuming the beverage, a detailed maternal interview was conducted. This interview consisted of questions regarding alcohol use before, during, and after pregnancy, maternal reports of infant temperament, and a brief symptom checklist to assess symptoms of depression and anxiety.

About 30 min after drinking the beverage, mothers' BAL was checked again ($M = .03$, $SD = .01$) because previous studies suggest that the amount of alcohol in breast milk peaks at about 30 to 60 min after consumption (Kesaniemi, 1974). They were then asked to express 150 ml of their breast milk. Infants were then fed 100 ml of this milk. Two infants did not complete the entire 100 ml. Consequently, the visit was terminated and rescheduled for another day. The additional 50 ml of expressed breast milk was immediately frozen in an airtight, sterilized glass container prior to assessing ethanol levels. Mothers were asked to wait until the infant was hungry to ensure that the infant would consume the entire 100 ml of expressed milk. Consequently, the time between the mothers' consumption of the alcoholic beverage and the initial feeding of the infant varied slightly among infants ($M = 34.86$ min, $SD = 4.9$), however, there was no difference in the time between consumption of the beverage and feeding of the infant on the 2 testing days. These feeding interactions were videotaped for later analysis. In the hour following the initial feeding, infant arousal was assessed in a quiet, isolated room while placed in a supine position in a bassinet. Because the use of a pacifier may alter the pattern of behavioral state, all observations were conducted without the use of a pacifier. Further, to minimize the possibility of exogenous stimulation to the infant, mothers were not present during the observational portion of the laboratory visit. An observer who was blind to the alcohol condition recorded the infant's behavioral state, startles, and tremors every 30 sec for a continuous hour. Interrater reliability for behavioral state observations was established prior to any data collection and again with one participant. The percentage of agreement for each behavioral state observation and observed startles and tremors was calculated. Resulting percentages ranged from .89 to .99 ($M = .93$).

Feeding interactions. The laboratory visits were scheduled around a time when the infant was likely to be hungry. Mothers were asked to feed their infants in a comfortable, living room–type setting, as they normally would at home.

These interactions were videotaped and coded by a research assistant blind to the alcohol condition, using the Mother–Infant/Toddler Feeding Scale (Chatoor, 1986; Chatoor et al., 1997), which is designed for use in both bottle and breast-fed infants. This is a global rating scale consisting of 26 items focusing on the mother and 20 items focusing on the infant, which are rated along 4 points after the observation of 20 min of feeding. The items are composited into five subscales that are named according to the overriding theme of the individual items: (a) Dyadic Reciprocity, which describes positive engaging behaviors between the mother and infant; (b) Maternal Noncontingency, which describes inappropriate maternal behaviors (e.g., missing the infant's cues); (c) Dyadic Conflict, which describes various food refusal behaviors and negative affect of the infant, and negative comments and affect of the mother; (d) Bargaining about food, which describes both mother and infant engaging in distracting talk and play during feeding; and (e) Struggle for Control, which describes maternal controlling behaviors (e.g., overriding the infant's cues or forcing food into the infant's mouth) and the infant's resistance (e.g., spitting the food out). Scores on specific subscales are taken as indicators of feeding difficulties depending on the age of the child. The scale is completed after the entire observation has been viewed by the coders, who are required to be completely familiar with all the items on the scale. This scale has strong predictive validity and can discriminate between infants with and without feeding disorders (Chatoor et al., 1997). In addition, it has been used by several researchers to measure mother–infant feeding interactions among children with eating disorders (Chatoor, Ganiban, Colin, Plummer, & Harmon, 1998; Chatoor et al., 1997; Chatoor, Hirsch, Ganiban, Persinger, & Hamburger, 1998), and subscale scores have been found to vary as a function of maternal substance use (Eiden, 2001). The subscales of bargaining and struggle for control were not relevant for 4- to 11-week-old infants and were dropped from analyses. Interrater reliability was conducted on 15% of the dyads and ranged from .80 for dyadic reciprocity to .96 for maternal noncontingency (Pearson correlations).

Infant arousal. Infant behavioral states are a collection of recurring patterns of behavior that are qualitatively different from each other and indicate qualitatively unique levels of arousal (Prechtl & O'Brien, 1982). Consequently, behavioral state was used as a measure of infant arousal and was assessed using a 6-point scale, developed by Brazelton (1984), measuring sleep and awake states. These states include quiet sleep, active (rapid eye movement [REM] sleep, drowsy, quiet and alert, active and alert, and crying. Behavioral state was time sampled and recorded every 30 sec for 1 continuous hr. Six infants in the alcohol condition and 4 infants in the nonalcohol condition were unable to soothe themselves after crying for 5 min and, consequently, observations of behavioral state were terminated prior to 1 hr. Three of the infants that did not complete the entire observational session in

the alcohol condition also did not complete the observational session in the non-alcohol condition. Data from the observations of state were thus reduced to the proportion of time an infant was observed in each behavioral state and the proportion of times an infant changed behavioral state. In addition, the number of startles, defined as momentary abductions of the shoulders with extensions of the arms, elbows, wrists, and fingers, followed by a brief disturbance in respiration (Wolff, 1966), and tremors (observed quivering of extremities) that occurred during each 30-sec period were recorded. These methods and measures have been shown to be sensitive to individual differences in neonatal autonomic regulation that are due to varied prenatal and early postnatal experiences, including substance exposure (Schuetze & Zeskind, 1997; Zeskind, Goff, & Marshall, 1991; Zeskind, Marshall, & Goff, 1992). Interrater reliability was conducted on 15% of the observations and ranged from .91 to .95 (Pearson correlations).

Ethanol levels in milk samples. Ethanol levels in each sample of breast milk were analyzed to determine the amount of ethanol present in the breast milk samples collected after drinking the alcoholic beverage, as well as to ensure the absence of ethanol in samples collected during the nonalcohol condition. Because the ethanol analysis procedures required milk samples to be analyzed in batches rather than individually, the ethanol content analyses was conducted at the end of the data collection period. Consequently, milk samples were stored between 6 and 18 months. To prevent degradation of the ethanol content in the samples due to storage time, processed milk samples were immediately stored at -70°C . The time elapsed between collection of the milk sample and storage was less than 1 hr. The ultracold temperature served to prevent artefactual generation of ethanol. Whole milk was deproteinized by dilution (1:1) with 6% (w/v) trichloroacetic acid, which would have made enzymatic decomposition of ethanol in the samples highly unlikely. We have found that blood samples containing ethanol that were treated and stored under similar conditions remained stable for over 2 years. The mixture resulting from deproteinization of enzymes by trichloroacetic acid was centrifuged at 5°C at 2,200 rpm for 10 min. An aliquot of the nearly clear supernatant was taken, with care not to include any of the fatty upper layer, and stored at -70°C until used. Ethanol in the supernatant was analyzed by a spectrophotometric method using the Sigma Diagnostics Alcohol Reagent Kit (catalog no. 332-C). Twenty microliters of the supernatant were added to 1 ml of the alcohol reagent, and the mixture was incubated at 22°C for 10 min. The resulting formation of NADH was measured at 350 nm. Ethanol standards (range 5–40 mg/dl) and sample blanks were also included in the analysis. Ethanol levels ranged from 11.6 to 48.2 mg/dl ($M = 32.66$, $SD = 10.07$) in the samples of breast milk expressed after consuming the alcoholic beverage, which confirmed the fact that maternal ethanol consumption resulted in corresponding changes in ethanol levels in the breast milk.

RESULTS

Covariates

Correlational analyses examining the association between maternal and infant variables and measures of infant arousal and mother–infant interactions indicated that the infants' birth weight was associated with the proportion of time spent in a drowsy state after drinking breast milk with small amounts of alcohol ($r = .61$, $p < .05$) and after drinking plain breast milk ($r = .55$, $p < .05$) and the proportion of time spent in a quiet alert state after drinking milk with small amounts of alcohol ($r = .56$, $p < .05$). Higher birth weight was associated with more time spent in both drowsy and quiet alert states after drinking milk with small amounts of alcohol and with more time spent in a drowsy state in the nonalcohol condition. Birth weight was therefore included in all additional analyses of time spent in drowsy or quiet alert states.

The mother's BAL after consuming alcohol was associated with a higher proportion of time spent crying ($r = .56$, $p < .05$). Consequently, the mother's BAL was included as a covariate in all further analyses of time spent crying. In addition, parity was associated with the proportion of time infants spent in active sleep after consuming plain breast milk ($r = .59$, $p < .05$) and was therefore included in all analyses of time spent in quiet sleep. Mothers who had given birth more times had infants who spent more time in quiet sleep. None of the other demographic or perinatal variables were associated with measures of infant arousal or mother–infant interactions.

Infant Arousal

Differences in measures of infant arousal between the two alcohol conditions are presented in Table 1. Repeated measures analyses of covariance (ANCOVAs) were used to examine differences between the alcohol conditions on measures of infant arousal, including the proportion of time spent in each of the six behavioral states, proportion of startles, proportion of tremors, and the proportion of changes in behavioral state. These analyses yielded a significant effect of alcohol condition on the proportion of time infants spent in quiet sleep, $F(1, 12) = 6.77$, $p < .05$, in a quiet alert state, $F(1, 12) = 4.59$, $p < .05$, and in a crying state, $F(1, 12) = 4.56$, $p < .05$. After drinking milk with small amounts of alcohol, infants spent significantly less time in quiet sleep and significantly more time in quiet alert and crying states. Infants also changed behavioral state significantly more often, $F(1, 13) = 31.78$, $p < .001$, and exhibited more startles, $F(1, 13) = 8.62$, $p < .01$, after consuming small amounts of alcohol in breast milk. Observations of infant behavioral state were also terminated earlier due to extreme irritability

TABLE 1
Measures of Infant Arousal and Mother–Infant Interactions in the Alcohol and Nonalcohol Conditions

	<i>Breast Milk With Alcohol</i>		<i>Breast Milk Without Alcohol</i>		<i>F Value</i>	<i>p Value</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Arousal variables (proportion of total time observed)						
Quiet sleep	.16	.23	.28	.26	6.77	.02
Active sleep	.30	.33	.33	.18	1.75	<i>ns</i>
Drowsiness	.11	.11	.12	.12	0.03	<i>ns</i>
Quiet alert	.07	.12	.03	.03	4.59	.05
Active alert	.25	.29	.17	.17	3.67	.08
Crying	.11	.07	.06	.10	4.56	.05
Startles	.05	.04	.02	.02	8.13	.01
Tremors	.02	.07	0	0	1.00	<i>ns</i>
State changes	.85	.19	.50	.31	31.78	.001
Number of completed periods	97.4	24.04	111.79	25.53	5.03	.05
Interaction variables						
Noncontingency	0.93	1.27	0.21	0.42	4.92	.04
Dyadic reciprocity	31.86	5.79	33.79	4.84	1.17	<i>ns</i>
Dyadic conflict	0.43	0.36	0.14	1.34	4.04	.07

after infants had consumed breast milk containing alcohol than after consuming plain breast milk. Consequently, infants were observed for significantly fewer periods after consuming breast milk containing alcohol ($M = 97.4, SD = 24.04$) than after consuming plain breast milk ($M = 111.79, SD = 25.53$), $F(1, 13) = 5.03, p < .05$. No other differences in infant arousal were found between the two alcohol conditions.

It is important to note that all but 2 infants completed at least 45 min of the 60-min observational session. Because of the possibility that early termination of these observational periods could have affected the proportion of time spent in individual behavioral states, repeated-measures ANCOVAs were again conducted using the proportion of time spent in behavioral states during the first 45 min of the observational period as the dependent variable. The general pattern of results remained unchanged, although the effect of the alcohol condition on the proportion of time spent in a crying state did become marginal ($p = .06$). No other differences in infant arousal were found between the two alcohol conditions. Consequently, the premature termination of some observational sessions does not affect the findings that alcohol has a significant effect on the proportion of time spent in some behavioral states.

Mother–Infant Interactions

Repeated measures ANCOVAs were then conducted to examine differences between the alcohol conditions on the three subscales of mother–infant interaction quality. A significant difference between conditions was found for noncontingency, $F(1, 13) = 4.92, p < .05$. Mothers and their infants showed higher levels of noncontingency in the alcohol condition than in the nonalcohol condition. A marginal effect was also found for the dyadic conflict subscale, $F(1, 13) = 4.04, p = .07$. Higher levels of dyadic conflict were found in mother–infant interactions in the alcohol condition than in the nonalcohol condition. No other differences in mother–infant feeding interactions were found between the two alcohol conditions.

Mother–Infant Interactions and Infant Arousal

Correlational analyses were used to explore the associations between mother–infant feeding interactions and measures of infant arousal. These analyses indicated a significant association between the dyadic reciprocity subscale and the proportion of time infants spent in a quiet sleep state after consuming breast milk containing small amounts of alcohol, $r = -.61, p < .05$. More specifically, infants who had lower levels of dyadic reciprocity with their mothers during feeding spent a higher percentage of time in a quiet sleep. No other associations were found between mother–infant interactions and infant arousal.

DISCUSSION

The results of this study indicated that exposure to even small amounts of alcohol through breast milk can affect infant arousal. More specifically, after consuming breast milk containing small amounts of alcohol, infants spent proportionately less time in quiet sleep and more time in a quiet alert state. Although numerous studies have resulted in similar findings among infants who were prenatally exposed to a range of substances, including alcohol (Rosett et al., 1979) and marijuana (Scher, Richardson, Coble, Day, & Stoffer, 1988), the results of this study along with those of Mennella and Gerrish (1998) indicate that postnatal exposure to alcohol can also affect the amount of time infants spend in various behavioral states. After consuming breast milk containing small amounts of alcohol, infants also exhibited significantly more startles than after drinking plain breast milk. Spontaneous startles are abrupt motor discharges typically occurring during sleep states (Korner, 1969). It is believed that they may serve a regulatory function of counteracting low levels of CNS activity that occur during periods of nonrapid eye movement (NREM) sleep and that they are an indicator of CNS instability (Emory & Mapp, 1988). Thus, the

findings in this study suggest that exposure to alcohol may disrupt infant arousal to the extent that this regulatory function is activated.

The results of this study also provide important evidence that early postnatal exposure to alcohol can affect the stability of infant behavioral states. In addition to spending less time in quiet sleep and more time in a quiet alert state, after drinking breast milk containing small amounts of alcohol, infants changed behavioral state significantly more often than after drinking plain breast milk, indicating less stable autonomic organization (Thoman & Whitney, 1990). Individual differences in the stability of the temporal organization of behavioral states, as measured by the Range of State scale score on the Neonatal Behavioral Assessment Scale (Brazelton, 1984), have also been associated with prenatal exposure to drugs, including marijuana (e.g., Fried & Makin, 1987), alcohol (e.g., Coles et al., 1985), and cocaine (Chasnoff, Griffith, MacGregor, Dirkes, & Burns, 1989). Although it is unclear whether the behaviors observed in this study are due to the same underlying processes as those responsible for the patterns of arousal observed among infants prenatally exposed to substances, these findings indicate that exposure to alcohol beyond the prenatal period can impact regulatory processes in young infants.

Finally, after drinking breast milk containing alcohol, infants spent proportionately more time in a crying state. Further, they were more likely to have extended periods of fussiness that resulted in termination of the behavioral observations. These results were supported by the association between higher ethanol levels in the breast milk and increased crying. Together with the findings of increased state lability and proportionately less time spent in quiet sleep, these findings of increased fussiness suggest that postnatal exposure to alcohol leads to altered behavioral state and autonomic organization and a general pattern of increased arousal.

These findings are particularly significant when the amount of alcohol to which infants were exposed is considered. Mothers were administered 0.3 g of ethanol per kilogram of body weight. This translates to an average BAL of .03. Consequently, infants consuming 100 ml of breast milk ingested approximately 43.1 mg of alcohol, which translates to an estimated dose of 2 mg/kg of body weight (less than 1% of the maternal dose of 300 mg/kg of body weight; Mennella & Beauchamp, 1991). Despite this small amount of alcohol, a clear pattern of altered arousal was seen among infants who had recently consumed small amounts. These findings suggest that low doses of alcohol may not have a sedating effect, as commonly believed, and has important implications for the advice given to lactating women by medical professionals regarding the presumed calming effect of alcohol in breast milk.

The results also indicate that maternal alcohol use immediately before breastfeeding is associated with a higher risk for negative mother-infant interactions during feeding. In particular, mothers in the alcohol condition displayed higher levels of noncontingency and dyadic conflict compared to their behavior in the nonalcohol conditions. The items in the noncontingency subscale include

maternal behaviors such as inappropriate positioning, intrusiveness, and missing infant cues and infant behaviors such as cries when food is taken away. The items in the dyadic conflict subscale include maternal behaviors such as making negative or critical remarks to the infant and appearing angry or distressed, and infant behaviors such as angry food refusal, crying, and angry behavior in the context of feeding. Frequent interactions characterized by such behaviors may lead to difficulties in breast-feeding over time and may compromise infant growth. It is important to stress that although mothers in this study were less positive under the alcohol condition, their behaviors were well within normal ranges under both conditions; that is, the differences in behavior across the two conditions were relative. Further, it is important to note that although every attempt was made to ensure that mothers were blind to the alcohol–placebo condition, it is, of course, possible that they may have correctly guessed the alcohol condition. As such, their awareness that they were currently in the alcohol condition may have altered their behaviors, partially explaining their differences in maternal behaviors measured on the noncontingency subscale.

We hypothesized that differences in infant arousal may be due, in part, to changes in the infants' interactions with their mothers following consumption of the alcoholic beverage. The only association between quality of interactions and infant arousal was that higher dyadic reciprocity was associated with less time in quiet sleep. However, dyadic reciprocity did not change as a result of alcohol condition. Thus, these results do not indicate that one pathway to altered arousal states in the alcohol condition is through the impact of alcohol on maternal behavior during feeding. It is possible that the quality of mother–infant interactions during feeding may have long-term implications for infant arousal, independent of alcohol condition. This is an area for further research.

Individual differences in the ability of young infants to regulate arousal, as measured by time spent in behavioral states, as well as the stability of temporal organization of behavioral state, are predictive of later developmental outcomes. For example, young infants who showed a greater number of state changes were more likely to have poor clinical outcomes, such as developmental delays, seizures, and epilepsy at 3 to 4 years of age than infants who displayed a smaller number of state transitions (Lombroso & Matsumiya, 1985). In addition, early problems in physiological regulation have been shown to predict problems in self-regulation in later years (Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). Consequently, young infants who continually show altered patterns of arousal as a result of exposure to alcohol through breast milk may be at risk for regulatory problems later in life.

It is important to note that these findings reflect the short-term effects of exposure to alcohol through breast milk and, consequently, the pattern of hyperarousal seen among these infants may be a transitory outcome that dissipates as the alcohol is metabolized, with no lasting impact on infant regulatory processes. Future

studies should examine the impact of more frequent exposure to alcohol through breast milk on infants' regulation of arousal and should evaluate the extent to which these early disruptions in autonomic regulation predict regulatory processes beyond early infancy.

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