6-2008

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Recommended Citation

Mennella, Julie A. and Forestell, Catherine A., Children's Hedonic Responses to the Odors of Alcoholic Beverages: A Window to Emotions (2008). *Alcohol*, 42(4), 249-260.
https://doi.org/10.1016/j.alcohol.2008.03.129

Published in final edited form as:
Alcohol. 2008 June ; 42(4): 249–260. doi:10.1016/j.alcohol.2008.03.129.

Children's Hedonic Responses to the Odors of Alcoholic Beverages: A Window to Emotions

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INTRODUCTION

Alcohol is the most common and frequently used drug (Dube et al., 2006) and its use and dependence continue to be a leading public health problem plaguing our youth (American Academy of Pediatrics: Committee on Substance Abuse, 2001; Kulig and the Committee on Substance Abuse, 2005). From an early age and even before their first taste, children have a well developed cognitive schema about alcohol (Fossey, 1993a; Jahoda et al., 1980). They know adults drink more than children and men more than women (Noll et al., 1990; Zucker et al., 1995). They learn from and are influenced by advertisements in the media, on the internet, and during sporting events (American Academy of Pediatrics: Committee on Substance Abuse, 2001; Villani, 2001). Fifth and sixth graders who had more exposure to beer advertising were better able to recall brand names and characters and more likely to hold positive beliefs about drinking and to intend to drink as adults (Grube and Wallack, 1994).

Such observational learning extends beyond the realm of media exposure and purely visual and verbal experiences to direct contact with alcoholic beverages, most often in the context of the family (Jahoda et al., 1980). Because olfaction can only be experienced by direct exposure, we and others have been studying children's responses to the smell of alcohol as a means of assessing early socialization of alcohol in the home (Fossey, 1993b; Mennella and Garcia, 2000; Noll et al., 1990). In addition to determining whether children could name the odor, our research focused on whether children liked the odor since the most salient psychological attribute of an odor is its hedonic valence (Khan et al., 2007; Winston et al., 2005). We also focused on the emotional context of their experiences since associative learning in the context of emotionally salient conditions is a powerful mechanism by which odors acquire personal significance (Epple and Herz, 1999; Herz, 1997; Herz and Cupchik, 1995) and become effective memory cues that can influence subsequent behaviors (Epple and Herz, 1999).

In a set of studies, we found that children whose parents use alcohol to change their state of mind and reduce feelings of dysphoria (hereafter referred to as escape drinkers; Cahalan et al., 1969) were no better at identifying the odor than children of non escape drinkers. However, they were more likely to dislike the odor of beer when compared to children whose parents did not drink to escape (Mennella and Garcia, 2000). Similarly, children whose mothers smoked cigarettes to relieve tension disliked the odor of cigarette smoke more than children whose

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mothers smoked for reasons other than tension relief (Forestell and Mennella, 2005). In other words, when children experienced odors during negative emotional situations, they were less likely to prefer that odor. Their learning about alcohol and tobacco was not just based on the frequency of exposure, but rather on associations made between the sensory experience and the emotional context in which their parents drink or smoke.

The present study followed from these findings and the goals were twofold. The first goal was to further describe the context in which children experience escape drinking by their mothers. To this end, we assessed maternal mood states and depression as well as their drinking and food habits. We focused on mothers, who are more likely to be the primary caretakers of young children, because much of the children's responses to alcohol odors could be explained by maternal drinking habits, especially their use of alcohol for escape (Mennella and Garcia, 2000). The second goal was to study an older age range of children than our previous study so that, in addition to determining liking, we were able to use more complicated tasks and assess how children's responses to a variety of odors related to mothers' escape drinking habits. Here we used two age-appropriate tasks, both of which were embedded in the context of games that were fun for children and minimized the impact of language development. Each task has been shown to reveal different aspects of hedonic judgment in children of this age range (Forestell and Mennella, 2005).

MATERIALS AND METHODS

Subjects

Women, whose children were between the ages of 5 and 8 years, were recruited from advertisements in local newspapers for a research "smell" study. During the telephone interview, mothers were told that their children would be asked to judge a variety of odors of everyday items including foods and beverages. Mothers and children were unaware of the hypothesis of the study. The subjects included 145 healthy children and their mothers. There were 78 girls and 67 boys from 133 families; 12 of the families had two siblings participate in the study. None of the children had allergies and none were reported by their mothers to have any olfactory deficits. Sixteen additional mother-child pairs began testing but were excluded because the child could not complete or understand the task. Written informed consent was obtained from each mother. All testing procedures were approved by and in accordance with the ethical standards of the Office of Regulatory Affairs at the University of Pennsylvania.

Test Stimuli

Using methods established at Monell (Mennella and Garcia, 2000; Schmidt and Beauchamp, 1988), we determined children's liking/preference, identification, and reaction times to a variety of odors which differed in hedonic valence. Before the start of the study, we used an adult panel to match the odors for perceived intensity because psychophysical testing revealed that children's sense of smell is on par with that of adults (see Mennella, 2006 for a review). The odors included bubblegum (5 ml of a 0.03% solution; Takasago), chocolate (5 ml of a 0.02% solution; International Flavors and Fragrances), cola (5 ml of Coca Cola™), coffee (2 g of coffee grounds; Maxwell House™), green tea (5 ml of a 0.10% solution; Takasago), strawberry (3 ml of a 0.06 % solution; Takasago), pyridine (3 ml of a 0.03% solution; ACROS), the odor of "spoiled milk" which is also a component of cigarette smoke (Furia and Bellanca, 1975), tuna (5 ml of a 0.02% solution; Takasago), cigarette smoke odor (the exhaled smoke of one half of a cigarette from a female smoker which was directed into a squeeze bottle containing 5 ml of mineral oil), beer (5ml; Rolling Rock™), whiskey (1 ml; Jim Beam™) or a blank bottle which contained 5 ml of mineral oil (Grusser et al., 2000). Both the beer and whiskey were presented at room temperature. The bottle of beer was left open for several hours to lessen the

stinging effects of carbonation to the nasal cavity. All odor stimuli were presented individually in foil-covered, 250-ml polyethylene plastic squeeze bottles with flip-up caps.

General Procedures

Children were tested in a closed room with a high air-turnover ventilation system specifically designed for sensory testing. Each participant sat at a small table on which two Sesame Street character toys, Big Bird™ and Oscar the Grouch™ were placed; the position of the characters (i.e., right versus left) was randomized. During each trial, the experimenter presented the odor by holding the stimulus bottle about 3 cm from the subject's nose and gently delivering three puffs of air to the nostrils; the inter-stimulus interval was approximately 60 seconds. Because previous research revealed that children were reluctant to participate in a research study when the first odor stimulus was "unpleasant" (Schmidt and Beauchamp, 1988), each test session began with a hedonically positive odor (e.g., bubblegum). Otherwise, the order of stimulus presentation was randomized.

During testing, each mother sat approximately two feet behind her child, out of the child's view. This distance was chosen because previous work in our laboratory revealed that individuals could not smell the contents of the squeeze bottles when seated this far away from the odor source (Mennella and Garcia, 2000). Mothers were asked to refrain from talking during the test session. They wore a face mask which covered their nose to prevent them from smelling the odors and listened to music with headphones to prevent them from hearing their children's answers.

Odor Liking/Preference, Identification and Reaction Times

Children participated in two tasks. In Task 1, odor liking was assessed by asking children to give the odors they liked to Big Bird and those they disliked to Oscar the Grouch. Odors were presented individually in 250-ml plastic squeeze bottles with flip-up caps; the inter-stimulus interval was 60 seconds. After the child gave each bottle to one of the characters, he or she was asked to identify the odor. The response was categorized as a correct identification (Desor and Beauchamp, 1974; Forestell and Mennella, 2005; Mennella and Garcia, 2000) if it was either an exact designation of the stimulus or an item that is in the same narrow class as the stimulus (e.g., "smoke", "ash tray", "fire", "trash" for cigarette, "rotten food" for pyridine, "candy" for bubblegum, and "air" for the blank). In Task 2, only big bird was placed on the table and children were presented with seven pairs of odors, one member of the pair was always beer whereas the comparison odors (i.e., bubblegum, cola, chocolate, green tea, coffee, cigarette smoke, pyridine) differed widely in hedonic valence. Children were asked to give the bottle containing the odor they liked better to Big Bird.

The entire session was videotaped and trained observers, who were blind to the drinking habits of the child's mother and the order in which the odors were presented, later coded the videotapes. For Task 1, they determined reaction times, defined herein as the number of seconds from the moment the experimenter placed the bottle on the table to the moment the subject made a hedonic judgment for each odor (i.e., by pointing to Big Bird or Oscar, verbally indicating that it smelled good or bad, or placing the bottle in front of one of the characters). In Task 2, reaction times were measured from the moment the experimenter placed the second bottle onto the table until the child indicated his or her preference. A reaction time of zero was assigned if the child indicated their liking for the odor (Task 1) or an odor preference (Task 2) before the experimenter placed the bottle on the table. None of the children made a judgment before smelling the odor. Inter-rater reliability, which was determined by correlating two raters' determinations of the reaction times from a random sample of 110 trials was 99% ($P<0.001$). A paired samples t-test revealed that the mean difference between the raters' measures of reaction time was not significantly different from zero ($t(109df)=1.32$, $P>0.18$).

Measures of Maternal Drinking, Food Habits and Mood States

Mothers were interviewed and completed a variety of questionnaires to assess their cigarette usage, and drinking habits (e.g., when they drank, what they drank, how they felt about their drinking). They also completed an 11-item questionnaire developed by Cahalan and colleagues (1969) to determine their reasons for drinking and the extent to which they consume alcohol to change their state of mind or reduce dysphoric feelings. To be classified as an escape drinker, the subject answered in the affirmative for two or more of the five escape items for drinking (i.e., helps to relax, need when tense and nervous, helps to cheer up when in a bad mood, helps to forget worries, or helps to forget everything).

The frequency of drinking, amount of alcohol consumed on a single occasion, type of alcoholic beverages consumed (i.e., beer, wine, liquor) and size of beverage was determined by interviewing the participants with a time-line follow-back questionnaire. From these data, we estimated the number of standard drinks of alcohol consumed during the previous three weeks. The Michigan Alcohol Screening Test (MAST) was completed to screen for lifetime alcohol-related problems and alcoholism; a cutoff of 5 or higher was used (Selzer, 1971). Each mother was interviewed to determine whether she or the child's father ever had any alcohol abuse problems, using DSM-III criteria.

Mood states were assessed via the Profile of Mood States Questionnaire (POMS) and the Beck Depression Inventory (BDI). All but two women completed the 65-item POMS (McNair, Lorr and Droppleman, 1992) that measured six independent, transient, mood states: Tension (range: 0–36), Depression (range: 0–60), Anger (range: 0–48), Vigor (range: 0–32), Fatigue (range: 0–28), and Confusion (range: 0–28). Higher scores reflect higher intensity of the mood states. Additionally, a Total Mood Disturbance score, which is considered a global measure of mood disturbance, was calculated by subtracting the one positive mood (Vigor) from the sum of the remaining five negative mood scores. All but two mothers completed the 21-BDI which measures characteristic attitudes and symptoms of depression (Beck et al., 1961). BDI scores could range from 0 to 63, with scores greater than 18 considered indicative of moderate to severe depression.

Because many of the test odors were of food items, we asked mothers to report how often per week they and their children ate the foods or drank beverages associated with the odors under study; all but 8 completed the reports on their own eating habits and all but two completed reports of their child's habits. Mothers also completed various scales to determine their propensity to approach or avoid novel foods (range=10–70), their willingness to experience new situations and people (range=8–56) and their perceptions of their children's temperament and reaction to foods (i.e., shyness, emotionality, activity, sociability, negative reactivity to food, and food neophobia; Pliner and Hobden, 1992). Each temperament score could range from 1 to 5; higher numbers reflect more of the trait (Pliner and Loewen, 1997). Subjects were also weighed and measured and their body mass indices (BMI; kg/m^2) were calculated.

Statistical Analyses

Cochran's Q tests were performed to determine whether their liking and their ability to identify the odors varied as a function of odor quality. Mothers and their children were then placed in one of two groups based on the escape drinking of the mothers. Depending on the type of data, Pearson Chi-Squares or One-Way ANOVAs were conducted to determine whether there were differences between the two groups of mothers in a variety of measures including demographics, drinking habits and mood states. Separate Pearson Chi-Square analyses were conducted to determine whether children's classification (i.e., gave to Big Bird or Oscar) and identification of individual odors (Task 1) and their preference for beer relative to the other odors (Task 2) differed as a function of maternal escape drinking. Because one comparison

odor was the breath of a female smoker and another was pyridine, a component of cigarette smoke (Furia and Bellanca, 1975), and because more children of smokers liked the odor of cigarette smoke (see below), the children of smokers were analyzed separately for these comparisons from those whose mothers do not smoke. We also determined for each child the proportion of time that beer was preferred to the seven other odors in Task 2. An Analysis of Variance with group (escape, non escape) as the independent variable was then conducted on these data.

Separate 2 × 2 ANOVAs were conducted on the reaction time data with the type of hedonic response made by the child (Task 1: like vs. dislike; Task 2: beer preferred vs. comparison odor preferred) and maternal escape drinking status as the between-subjects factors. In addition, we determined the percentage of children who classified each odor as pleasant (i.e., gave it to Big Bird) or unpleasant (i.e., gave it to Oscar the Grouch) and who correctly identified each odor from Task 1. All summary statistics reported in this article are expressed as means ± *SEM*, and all *P* values represent two-tailed tests.

RESULTS

Subject Characteristics

Approximately one third of the mothers were classified as escape drinkers, a percentage which is quite similar to that previously reported in 1969 (Cahalan et al., 1969) and again in 2000 (Mennella and Garcia, 2000). As shown in Table 1, women who were escape drinkers were significantly older, and more likely to drink at home, drink in the morning and afternoon, feel guilty and worry about their drinking. They were more likely to be depressed, but this was marginally significant (P=0.08). Escape drinkers reported drinking more often and more alcoholic beverages during the past three weeks, as has been previously reported (Mennella and Garcia, 2000). However, there was no significant group difference in the percentage of women who were alcohol dependent, as determined by the MAST. No significant differences between the groups of mothers were observed for a variety of demographic characteristics (see Table 1) and whether or how often they drank coffee, cola and green tea, ate strawberries, tuna, and chocolate or chewed bubblegum.

Table 2 shows that the two groups of children were similar in age, sex ratio, BMI and temperament, as perceived by the mothers. Both groups were similar in their prior experiences with the food, beverage or candy sources of the odors used in the present study and how often they ate or drank these foods or beverages (data not shown). This was also true for the children's exposure to cigarette odor. As shown in Table 1, the percentage of mothers (Table 1) or fathers (21.3% in Escape group vs. 26.8% in Non Escape group) who smoked cigarettes was similar between the groups. Approximately 21% of the Non Escape group and 32% of the Escape group reported that they had tasted or sipped alcohol ($\chi^2(1df)= 1.90$, P=0.17).

Task 1: Odor Liking, Identification and Reaction Times

As shown in Figure 1A, odor was a powerful determinant of liking for children ($Q(11df)$ =1843.80, P<0.0001). The vast majority of children (>73%) liked the strawberry, bubblegum, chocolate and cola odors, and disliked the odors of beer, whiskey, pyridine, cigarette smoke, and tuna. There were no differences between the two groups of children (escape, non escape) in their liking of the odors, with the exception of tuna ($\chi^2(1df)= 7.34$, P<0.01). More children of escape drinkers liked this odor than children of non escape drinkers. Additional analyses, which factored in whether the mother drank beer, wine or liquor, revealed that the type of alcohol mothers consumed did not affect children's hedonic judgments of either the whiskey (all P's>0.37) or beer odors (all P's > 0.15). Although the percentages were low, more children

whose mothers smoked liked cigarette smoke odor (17.3%) than children of nonsmokers (4.9%; $\chi^2(1df)= 3.82$, $P=0.05$).

Identifying an odor was a more difficult task for children than deciding whether they liked it or not. For example, 73.1% of the children liked the odor of cola but only 15.9% could identify it. Similarly, the vast majority disliked beer (77.2%) and whiskey (80.7%) odors, but less than 11% of the children could identify these odors by name. In general, children were better able to identify the odors they liked (i.e., bubblegum, strawberry, chocolate; $Q(11df)=12.68$, $P<0.001$) as well as the coffee odors ($Q(11df)=8.54$, $P<0.001$).

Figure 1C shows that differences emerged when we examined the children's reaction times to make a hedonic judgment. There were significant main effects for group ($F(1,139df)=9.36$; $P<0.01$) and odor type ($F(11,1529df)=1.95$; $P<0.03$). Children of escape drinkers took significantly longer to decide whether they liked the odors (3.3±0.3 sec) than children of non escape drinkers (2.3±0.2 sec). When children smelled the odors that had a strong hedonic valence, either positive (i.e., strawberry, bubble gum, chocolate, cola: mean=2.4±0.2 sec) or negative (i.e., pyridine, cigarette, beer, whiskey, tuna: mean=2.4±0.2 sec), they took less time to make their hedonic judgment when compared to when they smelled more neutral or unambiguous odors such as green tea or clean air (2.9±0.2 sec; $F(1,140df)=5.47$, $P<0.03$ for comparison with pleasant odors; $F(1, 141df)=6.27$, $P<0.02$ for comparison with unpleasant odors).

Task 2: Odor Preferences and Reaction Times

Children whose mothers drink to escape chose beer less often (0.28±0.03) as the preferred odor than children of non escape drinkers (0.37±0.02; F(1,143df)=4.68; P<0.04). Additional analyses, which factored in whether the mother drank beer, wine or liquor, or if the child had ever tasted or sipped alcohol, revealed that the type of alcohol the mothers consumed was not significant (all *P*'s>0.16), nor was the child's previous experience with the flavor of alcohol ($F(1,141df)=0.73$, $P>0.39$).

As shown in Figure 2, both groups of children preferred the odors of bubblegum, cola, chocolate and green tea to beer odors. However, group differences emerged when we considered the children's responses to beer odors relative to unpleasant odors. Children of escape drinkers were significantly less likely to choose beer as the preferred odor when it was paired with coffee ($\chi^2(1df)=4.69$, $P<0.04$). We found that whether the child's mother was an escape drinker or not interacted with the child's odor preference in determining how long they took to make a hedonic judgment for the beer and coffee comparison ($F(1,132df)=3.49$; $P=0.06$) and beer and pyridine comparison ($F(1,132df)=4.45$; $P<0.04$). Children of escape drinkers who chose beer over coffee took significantly longer to make their decision than those who chose coffee (8.5±4.7 sec vs. 2.3±0.3 sec; $F(1,32df)=4.95$, $P<0.04$). Children of non escape drinkers took longer time if they chose pyridine when compared with beer (4.9±1.1 sec vs. 2.5±0.3 sec; $F(1,100df)=7.88$, $P<0.01$).

When children compared beer to cigarette smoke odor, children of escape drinkers were significantly less likely to choose beer as the preferred odor ($\chi^2(1df)=9.72$, $P<0.01$; Figure 2). We conducted additional Chi-Square analyses to determine whether mothers' smoking status interacted with their escape drinking status on children's preference for odors in Task 2, particularly for the comparisons between beer and cigarette smoke and between beer and pyridine. These analyses revealed that the preference for cigarette smoke over beer odor was only observed in the children of escape drinkers who did not smoke. As shown in Figure 3A, of those children whose mothers did not smoke, more children of escape drinkers preferred cigarette smoke relative to beer than did children of non escape drinkers ($\chi^2(1df)=9.87$, $P=0.01$). Children whose mothers smoked were as likely to choose beer as cigarette smoke,

regardless of the escape drinking status of the mother. Similar findings were observed with the beer and pyridine comparison ($\chi^2(1df)= 4.91$, $P<0.03$; see Figure 3B).

To determine whether it was the frequency of alcohol consumption or dependence of alcohol by mothers and not escape drinking *per se* that affected their children's hedonic responses to alcohol odors, four additional analyses were performed. First, we conducted an analysis of covariance that included group (escape, non escape) as the grouping variable and adjusted for the mothers' alcohol consumption during the previous three weeks. This covariate was not significant ($F(1,141df)=0.01$, $P=0.92$) and, as in our previous analysis, the main effect of group was significant ($F(1,141df)=4.37$; $P<0.04$), indicating that children of escape drinkers preferred the odor of beer less than those of non escape drinkers regardless of the amount of alcohol their mothers reported consuming. Second, correlational analyses on the relationship between the proportion of times each child chose beer in Task 2 and the frequency of maternal alcohol and beer consumption further yielded no significant relationships ($r=-0.07$ for beer and -0.05 for alcohol; P's>0.39). Third, we repeated these analyses on a subset of the children. Here we matched the two groups of women on the frequency of alcohol consumption by focusing only on escape drinkers who drank less than 14 drinks during the past three weeks. Consistent with our other findings, children of escape drinkers were significantly less likely to choose beer (0.25±0.04) as the preferred odor than children of non escape drinkers (0.37±0.02; $F(1,134df)=6.7$; $P<0.01$). And finally, we repeated the analyses but focused only on the children whose mothers were not alcohol dependent, as determined by the MAST, to investigate whether the effects observed in Task 2 were due to maternal alcohol dependence. The results remained unchanged. Children of escape drinkers chose beer less often (0.28±0.03) as the preferred odor than children of non escape drinkers (0.36±0.02; $F(1,126df)=3.67$; $P=0.05$). All other significant effects for Task 2 reported above were also observed in this subset of children.

DISCUSSION

The type of task and behavioral measure revealed different aspects of children's response to odors. Consistent with previous research (Forestell and Mennella, 2005; Mennella and Beauchamp, 1998; Mennella and Garcia, 2000; Schmidt and Beauchamp, 1988), the most salient psychological attribute of an odor for children was its hedonic valence. Unlike other sensory systems, the first cortical relay is not the thalamus but rather the primary olfactory cortex which then links with the amygdala-hippocampus complex of the limbic system (Aggleton and Mishklin, 1986; Cahill et al, 1995). The unique processing of olfactory information and the olfactory system's immediate access to these neurological substrates underlying non-verbal aspects of emotion and memory (Royet and Plailly, 2004 for review), explains why verbally identifying an odor was a more difficult task for children than deciding whether they liked the odor. The difficulty in naming odors is not unique to children but evident throughout the lifespan (Desor and Beauchamp, 1974; Forestell and Mennella, 2005; Murphy et al., 1991).

When presented individually in Task 1, the hedonic judgment of the odors of alcoholic beverages did not differ if the child's mother was an escape drinker or not. The vast majority did not like the odors of beer or whiskey, nor could they correctly identify them. Although these children were older than the children in our previous study (Mennella and Garcia, 2000), both studies revealed that children of escape drinkers disliked the odor of beer. What differed from our previous findings was the hedonic response of the children of non escape drinkers. In our previous study, the children of non escape drinkers, the majority of whom were younger than 5 years of age, judged the beer odor as pleasant (Mennella and Garcia, 2000). In the present study of 5- to 8-year-old children, most disliked beer odor. Whether this shift in

the response to beer odor reflects some type of socialization in the older-aged children requires further study (Noll et al., 1990; Wiers et al., 1998; Zucker et al., 2006).

With the exception of tuna, the groups were quite similar in their liking of the odors during Task 1. However, children whose mothers drink to escape took significantly longer to make their hedonic judgments. One explanation is that the longer reaction times reflect cognitive impairments due to alcohol exposure early in life. That is, prenatal alcohol exposure has been linked to slower processing speeds during childhood and reaction time deficits are often found within the context of complex cognition (Burden et al., 2005; Simmons et al., 2006). Another explanation, not mutually exclusive, is that the longer reaction times may reflect olfactory deficits caused by prenatal alcohol exposure, as has been suggested by animal model studies (Maier et al, 1999; Youngentob et al, 2007). To be sure, the finding that escape mothers are drinking more alcohol and on more occasions when their children are 5 to 8 years of age does not imply that they drank this amount during pregnancy. Because it is unlikely that women could accurately recall their drinking habits during a pregnancy which occurred 5 to 8 years earlier, we emphasize the need for research which prospectively measures the relationship between alcohol use during pregnancy and lactation and children's later olfactory and cognitive performance.

In Task 2, children were posed with a more difficult task than deciding whether they just liked an odor or not. Here they were asked to compare the odor of beer with a variety of odors that differed in hedonic valence and asked to choose which one smelled better. Children of escape drinkers chose beer less often as the preferred odor than children of non escape drinkers. The difference between the groups was not due to their choices when beer was compared to pleasant odors. Both groups of children preferred the odors of bubblegum, cola, chocolate and green tea. The differences emerged when the beer odor was compared to less pleasant odors.

Unlike the non escape group, children of escape drinkers preferred the odors of coffee and cigarette smoke when compared to beer odors. However, preference for cigarette smoke and pyridine, a component of cigarette smoke (Furia and Bellanca, 1975), was only evident in children of escape mothers who did not smoke cigarettes. Children whose mothers smoked were as likely to choose beer over cigarette smoke or pyridine, regardless of escape drinking status of the mother. These findings may reflect complexity of the learning that occurs when children are exposed to both alcohol and tobacco in the home which results from the significant comorbidity between tobacco and alcohol use and abuse (Perkins, 1992; Sher et al., 1996). Why some children of smokers preferred the beer odor whereas others preferred smoke odors requires further attention (Forestell and Mennella, 2005).

Children of escape drinkers who preferred the smell of beer to coffee took a longer time to make their hedonic judgment than children of escape drinkers who preferred coffee odors. Because the difference in reaction time was specific to this pair of odors, we suggest that those who rely on alcohol for stress relief (Cahalan et al., 1969) may also depend on coffee to regulate mood states and stress. Therefore, longer time in making a hedonic judgment between coffee and beer may reflect the occurrence of conflict resolution. Reaction times are commonly used in attitude or belief research to measure automatic subconscious associations between objects and evaluations, whereas explicit attitudes are thought to reflect more deliberative responding (Rudman, 2004). Since response times to express explicit attitudes are increased when they are incongruent with implicit attitudes (Greenwald and Banaji, 1995), our observation that children whose mothers are escape drinkers are slower to choose beer as the preferred odor suggests that their explicit positive hedonic judgments are inconsistent with their implicit judgments of beer odor.

The sources of alcohol odors were flat beer and whiskey for Task 1 and flat beer for Task 2. Although distinct, children rejected these odors. Moreover, regardless of the type of alcoholic beverage their mothers drank, children of escape drinkers disliked beer in Task 2 thus suggesting that there are common volatiles in beer and other alcoholic beverages (e.g., ethanol) that children generalize to the context of their parents' drinking. In fact, a prior study revealed differential reaction to ethanol odors as a function of parental drinking habits. Breastfed infants who had more exposure to alcohol mouthed an ethanol-scented toy more than less exposed infants (Mennella and Beauchamp, 1998).

Those who drink to an extent beyond that which is reasonable within their own culture are not engaging in social drinking even if they are drinking in the presence of others (Cahalan et al., 1969). It was for this reason that Cahalan and colleagues aimed to determine not just the circumstances but the reasons for drinking. Consistent with their original findings, we found that women who drink to escape, drink more often and for different reasons. Consequently, their children smell the odors of alcoholic beverages in the home or emanating from their mother's breath more frequently and within the emotional context of a mood disturbed mother who drinks throughout the day and feels guilty and worried about her drinking.

Although children of escape mothers were more frequently exposed to the odor of alcohol than those in the non escape group, our analyses suggested that the differences in children's relative dislike of the alcohol odors was not due to the frequency of exposure (how much their mothers drank) but rather the context in which they were exposed to alcohol. If the escape children's responses were solely due to more frequent exposure to alcohol, we would have expected the opposite effect, preference for the alcohol odors. Animal model studies have consistently revealed that early exposure to alcohol in the absence of negative consequences facilitates infantile appetitive responses to alcohol and increased the affinity for its orosensory properties (see Molina et al., 2007 for review). On the other hand, if the early exposure occurred with negative consequences, such as that which occurs when the dam is intoxicated and neglects the pups (Pepino et al., 2002), the hedonic value of alcohol odor became aversive (Molina et al., 2000; Pepino et al., 2001). This associational learning about alcohol odors has also been observed within the context of other social counterparts (Hunt et al., 2001). Paradoxically, such types of early experiences with alcohol lead to increased voluntary ethanol intake during adolescence (Pepino et al., 2004; Ponce et al., 2004).

We acknowledge that research investigating the effects of early exposure to the odor of alcohol in humans can not randomize children to experimental groups (the hallmark of scientific design) which differ in the context of such exposure as it relates to maternal drinking. Nevertheless, the findings reported herein are consistent with experimental studies in humans using food-related odors which revealed that early experiences bias behaviors and preferences during infancy and childhood (Mennella et al., 2001; Mennella, 2007) and experimental studies in animal models which revealed the complexity and long-lasting nature of odor associations acquired in the context of the mother (Moriceau and Sullivan, 2005; Molina et al., 2007). Thus, the present findings, along with those gleaned from a large body of experimental animal model studies reviewed herein and elsewhere (Molina et al., 2007), lead us to hypothesize that children of escape drinkers associated the smell of alcohol and the negative emotions they observed or experienced when their mothers, and in some cases fathers, drank.

In the future, investigations into the development of alcohol-related cognitions could be facilitated by studying children's behavioral response to odors as a function of the context in which their parents drink for several reasons. First, the early state of maturity and plasticity of the olfactory system favors its involvement in the adaptive responses to the challenges of normal or atypical development (Sullivan et al., 1991). Experience-induced plasticity in response to odors is a means by which the olfactory system can be tuned to emphasize

transduction of stimuli deemed relevant within an individual's environment. Second, salient memories formed during the first 10 years of life will likely be olfactory in nature. That is, autobiographical memories triggered by olfactory information mainly occurred during the first decade of life, whereas those associated with verbal and visual cues peaked later in adolescence and early adulthood (Willander and Larsson, 2006; 2007). Third, alcohol-related memories formed during childhood are better understood when considering children's perception of the effects of parental intoxication including the emotional aspects linked with maternal and paternal use of the drug (Spear and Molina, 2005; National Institute on Alcohol Abuse and Alcoholism, 2007).

The present study focused on maternal drinking for several reasons. First, maternal alcohol problems often coexist with paternal alcohol problems since women with alcohol problems are more likely to have partners with alcohol problems (Agrawal et al., 2006). Second, women who are dependent on alcohol are more likely to report emotional problems and have more symptoms of dependence than men (Farid and Clarke, 1992; Ross, 1989). Of interest are the original findings that among heavy drinkers, women were more likely to be escape drinkers than men (Cahalan et al., 1969). Third, past research revealed that much of the hedonic responses to alcohol odors could be explained by maternal drinking, perhaps because children of this age spend more time with their mothers (Agrawal et al., 2006). However, this is not meant to imply that children are not associating alcohol odors with the emotional context in which their fathers or other caretakers drink (Das Eiden and Leonard, 2000; Mennella and Garcia, 2000). Nor does it imply that children of this age are not acquiring experiences with alcohol directly. Recall that 21% of children in the Non Escape group and 32% in the Escape group had already tasted or sipped alcohol, a percentage similar to that recently reported for 8-year-old children by Donovan and Molina (2008). These are important areas for further research.

One of the most significant costs of alcohol abuse is its detrimental effect on children. Recognizing the gaps in knowledge, the Surgeon General called for a systematic approach that addresses alcohol problems within a developmental perspective (US Department of Health and Human Services, 2007). Likewise, the most recent strategic plan of the National Institute on Alcohol Abuse and Alcoholism identified several research priorities, one of which focused on the period from birth to age 10 (National Institute on Alcohol Abuse and Alcoholism, 2007). During this time period, children undergo a considerable amount of change and ultimately achieve some stability in adapting to their environment, including the means by which they perceive and learn, problem solve, communicate, regulate emotions, respond to stress, and relate to others.

Early childhood represents a "sensitive period" for the development of expectancies and cognitions about and the affective disposition towards alcohol which may impact on its use during adolescence and adulthood (Cable and Sacker, 2008; Lieberman, 2000; Wiers et al., 1998). Our data support the hypothesis that associative learning in the context of emotionally salient conditions is a powerful mechanism by which odors acquire personal significance and that the emotional context in which their mothers drink and children experience an odor can influence subsequent behaviors. Clearly, more research is needed to determine whether children who dislike the odor of alcoholic beverages and associate it with such emotional contexts display a trajectory towards or against using alcohol to escape during adolescence and adulthood. We suggest that it is imperative to understand the development of these alcohol-related memories and beliefs in childhood, before drinking has begun, so that primary prevention programs can be better informed.

ACKNOWLEDGMENTS

This project was funded by NIH Grant AA09523 and a grant from the Pennsylvania Department of Health. The Department specifically disclaims responsibility for any analyses, interpretations or conclusions. We acknowledge the expert technical assistance of Allison Steinmeyer, Lindsay Morgan, Carla Henry, and Sara Lehmann and valuable comments by Dr. M. Yanina Pepino on the manuscript.

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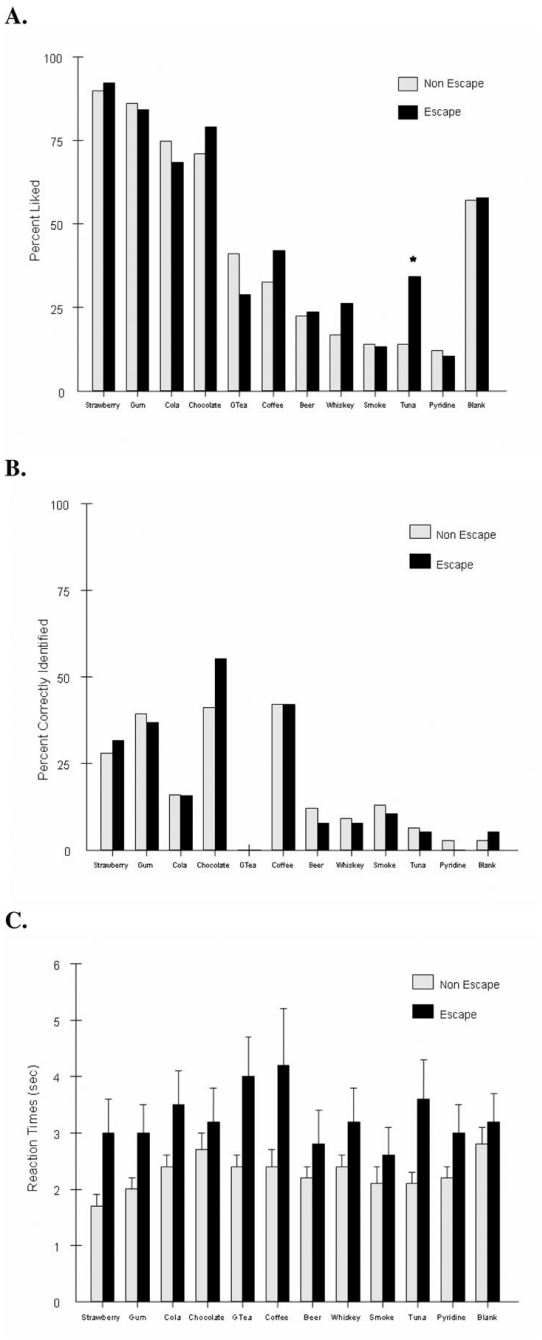

Figure 1.

Percentage of children who liked (Panel A) and correctly identified (Panel B) each of the 12 odors and the number of seconds (±SEM) it took children to decide whether they liked the odor or not (Panel C) in Task 1. Children were placed in one of two groups based on their mothers' drinking. One group of children's mothers drinks alcohol to escape tension or relieve worries (Escape Group, dark bars), whereas the other group does not (Non Escape Group, grey bars). *$p<0.05$ for the comparison with the Non Escape Group. There was a significant group effect for reaction times (Panel C) such that children of escape drinkers took significantly longer to decide whether they liked the odors in general than children of non escape drinkers ($p=0.01$).

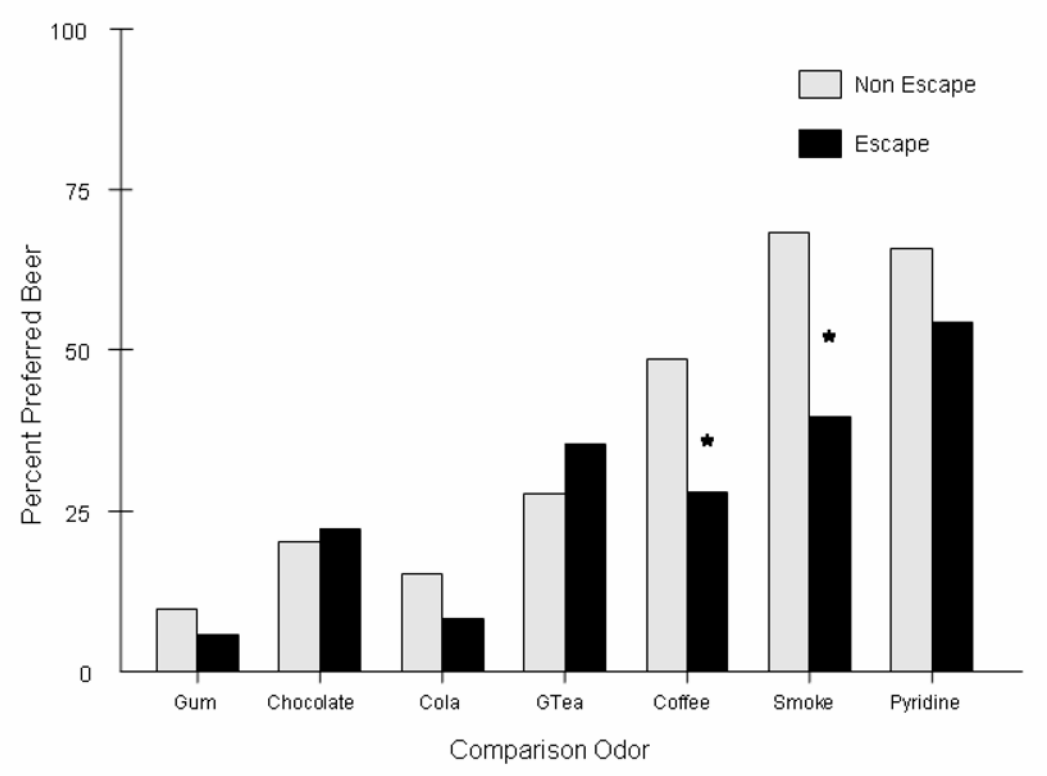

Figure 2.
Percentage of children who preferred beer odors to each of the seven comparison odors in Task 2. Children were placed in one of two groups based on their mothers' drinking. One group of children's mothers drink alcohol to escape tension or relieve worries (Escape Group, dark bars) whereas the other group does not (Non Escape Group, grey bars). *$p<0.05$ for the comparison with the Non Escape Group.

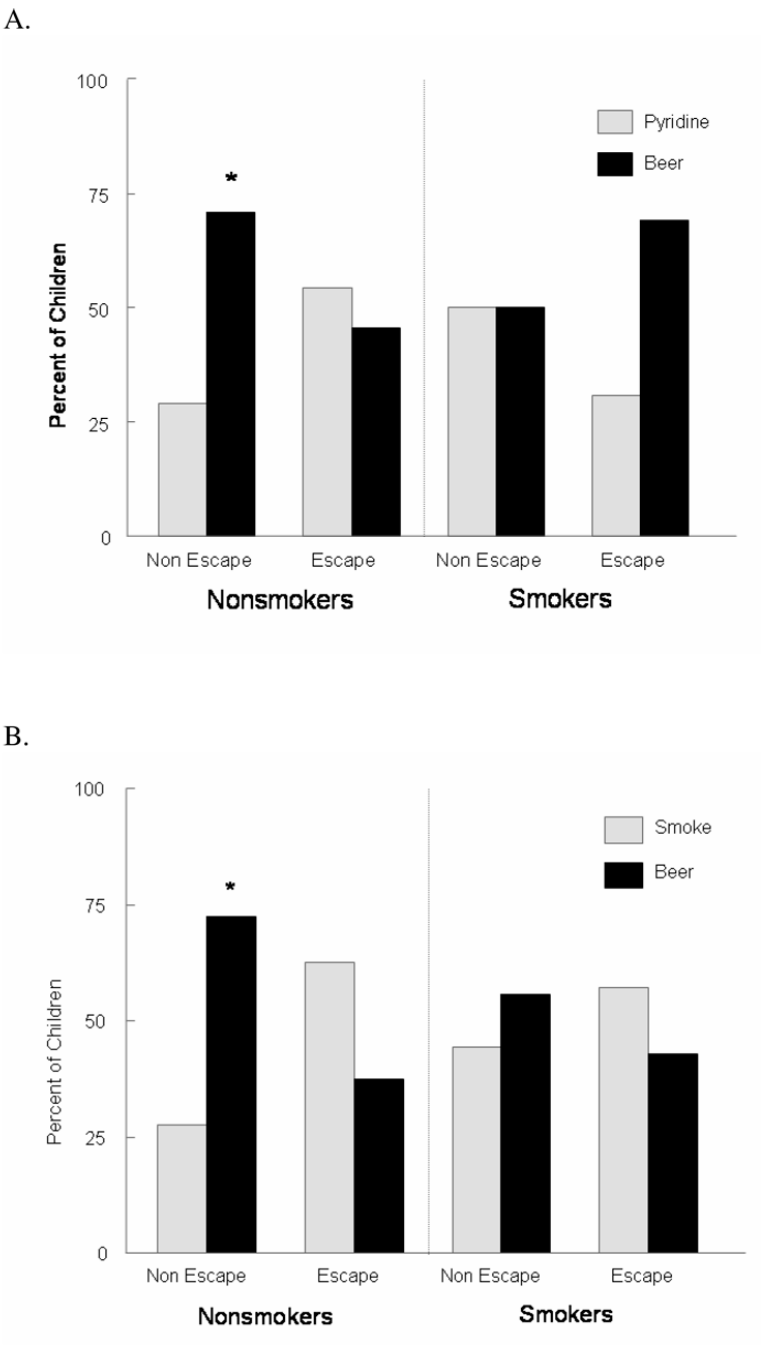

Figure 3.

Percentage of children who preferred odor of beer (black bars) or pyridine (grey bars) for the beer-pyridine comparison in Panel A, and the percentage of children who preferred odor of beer (black bars) or cigarette smoke (grey bars) for the beer-cigarette smoke comparison in Panel B. Children were grouped on the basis of their mothers' escape drinking (Escape vs. Non Escape) and cigarette smoking (Smokers, Non Smoker). *$p<0.05$ for the comparison with children whose mothers are Non Escape drinkers and nonsmokers.

Table 1

Maternal Characteristics[a]

	Non Escape Drinkers	Escape Drinkers
Age in years	32.7±0.7	35.8±1.1[b]
BMI (kg/m^2)	28.8±0.8	26.7±1.0
Parity (% multiparous)	86.3%	77.1%
General Neophobia score	24.8±0.9	23.7±1.6
Food Neophobia score	34.5±1.2	31.5±1.9
% Married	49.0%	51.4%
% Smokers	25.5%	37.1%
Education (Highest level completed)		
≤ High School	34.7%	20.6%
College/Technical	54.1%	55.9%
Graduate/Professional	11.2%	23.5%
Drinking Measures:		
Age started drinking	20.6±0.5	20.7±0.9
Drink at home	24.5%	62.9%[b]
Drinks in the afternoon	8.8%	48.6%[b]
Ever drink in the morning	0%	11.4%[b]
Drinks with meals	49.0%	60.0%
Forget events after drinking	3.1%	40.0%[b]
Feels that she should cut down	1.0%	22.9%[b]
Feels guilty about drinking	2.0%	37.1%[b]
Others worry about her drinking	0%	14.3%[b]
Has an alcoholic partner	7.2%	17.1%
MAST Score		
% Risk drinkers (≥5 on MAST)	9.3%	20.0%
Drank alcohol during past year	71.4%	97.1%[b]
Type(s) of alcoholic beverages mother drinks:		
Beer	38.8%	62.9%[b]
Wine	50.5%	71.4%[b]
Liquor	53.1%	68.6%
Number of standard drinks during past 3 weeks:		
Beer	1.0±0.3	3.7±1.2[b]
Wine	0.6±0.2	2.1±1.0[b]
Liquor	1.0±0.3	3.5±0.9[b]
Total drinks	2.5±0.5	9.3±2.0[b]
Number of drinking occasions during past 3 weeks	1.1±0.3	3.1±0.5[b]
Number of drinks per drinking occasion[c]	2.6±0.6	2.7±0.4
Mood States Measures		
POMS Total Score	13.6±2.8	25.9±5.1[b]
Tension	7.4±0.6	10.0±1.0[b]
Depression	6.4±0.8	9.0±1.6
Anger	6.0±0.6	7.8±1.1
Confusion	5.3±0.4	7.1±0.7[b]
Fatigue	6.4±0.5	7.6±0.9
Vigor	17.9±0.6	15.6±1.2
BDI Score	7.1±0.7	9.8±1.5
% Mod-High depressed	9.4%	17.1%
Prior Experiences with Odor Sources		
% who eat or drink the following:		
Coffee	92.5%	96.9%
Bubblegum	100%	100%
Cola	97.8%	100%
Green tea	62.4%	68.8%
Tuna	96.8%	100%
Chocolate	100%	100%
Strawberries	100%	100%
Eggs	100%	100%
Fish	95.7%	100%
Number of women	98	35

[a] The plus-minus values are means ± standard error of the means (SEM)

[b] $p<0.05$ when compared to Non Escape Drinkers

[c] reported values include only those mothers who reported at least one drinking bout over the previous weeks.

Table 2

Children's Characteristics[a]

	Children of Non Escape Drinkers	Children of Escape Drinkers
Sex (% female)	52.3%	57.9%
Age in years	6.4±0.1	6.2±0.2
BMI (kg/m^2)	16.4±0.2	15.8±0.4
Race		
African American	52.3%	39.5%
Asian	0%	2.6%
Caucasian	29.9%	44.7%
Hispanic	3.7%	2.6%
Admix/Other	14.0%	10.5%
% Breastfed	50.0%	62.2%
Temperament Measures		
Shyness	2.4±0.1	2.4±0.2
Emotionality	2.8±0.1	3.0±0.2
Sociablity	3.2±0.1	3.3±0.1
Activity	3.0±0.1	3.0±0.1
Negative Reactions to Foods	3.2±0.1	3.3±0.2
Food Neophobia	3.1±0.1	3.3±0.1
Prior Experiences with Odor Sources % children who have eaten/drunk:		
Bubblegum	99.0%	100%
Cola	94.3%	97.3%
Tuna	83.8%	76.3%
Strawberry	95.2%	100%
Chocolate	99.0%	100%
Green tea	22.9%	26.3%
Coffee	49.5%	52.6%
% children who tasted alcohol	20.6%	31.6%
Number of Children	107	38

[a]The plus-minus values are means ± standard error of the means (SEM)