Infants' Exploration of Scented Toys: Effects of Prior Experiences

Julie A. Mennella and Gary K. Beauchamp

Monell Chemical Senses Center, Philadelphia, PA 19104-3308, USA

Correspondence to be sent to: Julie A. Mennella, Monell Chemical Senses Center, Philadelphia, PA 19104-3308, USA

Abstract

To evaluate breastfed infants' responses to scented objects, we videotaped the facial and bodily reactions of sixty-three infants as they explored, in succession, three toys that were identical in appearance but different in their characteristic odor. Two of the toys were scented with odorants previously shown to be transmitted to human milk, one with ethanol and the other with vanilla, whereas the third toy was unscented. Each videotape was subjected to frame-by-frame analysis to measure a variety of behaviors that are considered either to be exploratory in nature in that they lead to perceptual information about the object or to reflect the infants' hedonic reaction. Analyses of these behaviors revealed that the infants looked more and vocalized less in the presence of the vanilla-scented toy and spent less time manipulating the ethanol-scented toy when compared with the unscented toy. Moreover, differential exposure to the odors of ethanol and vanilla, as indicated by differential consumption of alcohol by a parent or use of vanilla-scented product by the mother, was related to differential responses to these odors. These findings suggest that human infants are able to detect and retain information about the chemical features of their environment.

Introduction

Very young human infants can detect and discriminate among a variety of qualitatively distinct odorants as evidenced by changes in their facial responses, body movements, heart rate, respiratory rate and head-turning during exposure to the odor (for reviews see Schaal, 1988; Mennella and Beauchamp, 1991a). That complex processing of olfactory information can occur as early as the first hour of life is indicated by the finding that newborns preferentially turn towards odors that have been previously associated with a reinforcer such as stroking (Sullivan et al., 1991). In spite of this evidence, there are few studies of responsiveness to odors in infants older than 2 weeks of age. Preliminary studies reported that 5- to 9-month-old infants explored scented objects differently than unscented objects (Schmidt and Beauchamp, 1989; Schmidt, 1990). Whether prior experiences can modulate the infant's behavioral response to odors is unknown, however.

Differential exposure to specific odorants during development provides a natural 'experiment' to explore the role of early experiences on olfactory preferences. For example, breastfed infants may be exposed to the odors of vanilla and ethanol as a function of how much, and often the mother consumes foods containing these flavors since both are transmitted to human milk at levels that can be detected by the infant (Mennella and Beauchamp, 1991b, 1994; 1996a; Mennella, 1997). These odors may also be detected in a parent's breath and most likely ambient sources in the home environment. Moreover, exposure to at least one of these odors, ethanol, may also occur prenatally among infants whose mothers consumed alcohol during gestation, as has been demonstrated in animal model studies (for review see Molina et al., 1995).

The following study had three purposes. First, we modified a method described briefly by Schmidt and Beauchamp (Schmidt and Beauchamp, 1989; Schmidt, 1990) that makes use of scented objects to investigate the young infants' behavioral responses to odors. Second, we attempted to verify preliminary reports that indicated that infants differentially explore toys as a function of whether or not they are scented. Third, we investigated whether differential exposure to the odors of ethanol and vanilla, as determined by differential consumption or use by the parents, was related to their infants' behavioral responses to these odors.

Materials and methods

Subjects

Sixty-two non-smoking women (13 African American; 43 Caucasian; 6 other) who were breastfeeding their infants, two of whom were twins, were recruited from advertisements in local newspapers and from the Women, Infants and Children (WIC) Centers in Philadelphia, PA. The mothers (31 primiparous, 31 multiparous) ranged in age from 18 to 43 years (mean = 30.8 ± 0.6; median = 310) and their infants (29 girls, 34 boys) ranged in age from 6 to 13 months (mean = 7.5 ± 0.2; median = 7.2 months). Each...
infant had been breastfed since birth, but only four remained exclusively breastfed at the time of testing. The other infants received complementary foods such as cereal (n = 59), juices (n = 34), fruits (n = 54), vegetables (n = 52) and meats (n = 5) in addition to breast milk. Two additional mother–infant pairs began testing but were disqualified because the infants cried and refused to sit in the booster seat. All procedures used in this study were approved by the Committee on Studies Involving Human Beings at the University of Pennsylvania and informed consent was obtained from each woman prior to testing.

Alcohol screening questionnaires and maternal drinking measures

Because previous research revealed that 2- to 6-year-old children's ability to identify the smell of alcohol was related to the drinking habits of both parents (Noll et al., 1990), the Michigan Alcoholism Screening Test (MAST) was administered to the mother at the end of the testing session and, when possible, to the father of the infant. In brief, the MAST includes 25 questions designed to detect alcoholism; it identifies chronic alcoholism and assesses symptoms and problems over one's lifetime, including dependence, previous treatment of alcohol-related problems and medical consequences of alcohol dependence. Because it does not assess the recency of symptoms nor alcohol consumption, we also administered the CAGE questionnaire which is geared toward identifying risk drinking. In brief, this questionnaire consists of four questions: C = Have you every felt you should Cut down on your drinking?; A = Have people Annoyed you by criticizing your drinking?; G = Have you ever felt bad or Guilty about your drinking?; E = Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (Eye opener)? Approximately 36% of the fathers (n = 45) were alcoholics as determined by the MAST and 34% of the fathers (n = 44; one father did not complete the CAGE) were assessed to be risk drinkers as determined by the CAGE test. Being an alcoholic was significantly related to paternal risk drinking [Yates $\chi^2$ (1 df) = 11.12; $P = 0.0008$].

Nineteen percent of the mothers were also judged to be alcoholics as determined by the MAST. These women were more likely to live in a household in which either the father was an alcoholic or the father would not complete the MAST questionnaire when compared to women who were not alcoholics [Yates $\chi^2$ (1 df) = 6.58; $P < 0.02$]. Using a time line follow-back questionnaire which was developed to assess drinking behavior during pregnancy (Hankin et al., 1996) and modified to assess drinking during lactation (Mennella and Beauchamp, 1991b), each woman was interviewed about the number and types of alcoholic beverages consumed during both pregnancy and lactation. Mothers reported that they drank very little during pregnancy [mean = 1.3 ± 0.7 drinks per month; range = 0–40 drinks per month], but that alcohol consumption increased slightly during lactation [mean = 4.0 ± 0.9 drinks per month; range = <1–46 drinks per month]; these numbers probably underestimate alcohol use (Little et al., 1984). Those women who were alcoholics reported drinking significantly more alcohol than those not at risk [$F(1,61) = 5.16; P = 0.026$].

To determine whether parental drinking habits were related to the infants' exploration of the scented toys, infants were placed in one of two groups. The 'risk' group included those infants who lived in a household in which either one or both parents were alcoholics, whereas the 'no risk' group comprised infants neither of whose parents was an alcoholic. Those infants who lived in a household with both parents and whose mothers were not alcoholics but whose fathers did not complete the MAST (n = 7) were not included in this analyses. Five of the infants lived in a household occupied by only the mother; these infants were included in the analyses and were placed in the category of their mother's risk factor.

Maternal use of vanilla-scented products and vanilla-flavored foods

To assess how often each mother consumed vanilla-flavored foods during lactation, a food frequency questionnaire was completed by each subject (Mullen et al., 1984). Women who reported eating vanilla-flavored foods four times a week or more were classified as frequent consumers (n = 25), whereas those who ate such foods less than once per month but more than once every 3 months were classified as occasional consumers (n = 37). Mothers also answered a series of questions about the types of perfumes and scented products (e.g. candles, room fresheners) they used. Seven of the women reported using vanilla-scented products four times a week or more whereas the remaining women reported using such products only occasionally. There was no relationship between the frequency of using vanilla-scented products and the frequency of consuming vanilla-flavored foods [Yates $\chi^2$ (1 df) = 0.35; $P = 0.55$]. Mothers were instructed not to wear perfumes or use scented deodorants on the day of testing.

Stimulus objects

The stimulus objects were designed by Schmidt and Beauchamp (1989) to be of an appropriate size for an infant of this age range to grasp easily. In brief, the toy was red, plastic and ventilated, and had a rounded base and handle (Loral, Garwood, NJ). A cotton ball, containing either 1.0 ml ethanol, 0.6 ml of vanilla extract in a (non-alcohol) propylene-glycol base (McCormick, Inc., Hunt Valley, MD) or 1.0 ml distilled water, was placed in the hollow center of the base upon which a ventilated cap (Sigma, St Louis, MO) was secured, resulting in the object smelling like that particular odor. Vanilla and ethanol were chosen as the test odors because previous research in our laboratory revealed that both are detectable in human milk following the
mother's ingestion of vanilla flavor or ethanol, respectively (Mennella and Beauchamp, 1991b, 1994), and because both are hedonically positive odors.

We chose these concentrations of vanilla and ethanol because they were judged to be equated for overall intensity by a trained panel of six adults (median age = 26 years). In brief, panelists were presented individually with pairs of toys, one of the pair being scented with 1 ml ethanol whereas the other was scented with various amounts (0.6, 1.0, 1.25 ml) of vanilla. Using a forced-choice procedure, each panelist was asked to determine which of the pair smell stronger. This was repeated four times for each pair of toys (total number of pairs presented to each panelist was 12) and the order of presentation was counterbalanced (for methods see Meilgaard et al, 1991). Panelists, as a group, chose the toy scented with 0.6 ml of the vanilla as smelling stronger than the toy scented with 1.0 ml ethanol 45.8% of the time; this was not significantly different from chance. In contrast, they judged the toys scented with either 1.0 or 1.25 ml vanilla as smelling stronger (75 and 95.8% respectively) than the toy scented with ethanol (P < 0.05 for both).

Procedures

Each mother–infant pair was tested in a quiet, private testing room at the Monell Center. After acclimatization to the room and personnel, the infant was placed in a booster seat with an attachable tray (Pansy Ellen Products, Inc., Alpharetta, GA) which enabled the infant to easily manipulate the objects on its surface. After a 60 s familiarization period with an unscented toy which was identical to the test toys, the infant's facial and bodily reactions were videotaped as they explored, in succession, three toys that were identical in appearance but different in their characteristic scent. One of the toys was odorized with ethanol and another with the vanilla extract, whereas the third toy was unscented. Each toy was presented individually and in random order to the infants for 60 s, with a 30 s interval separating each trial. There were no significant effects of the order of presentation or the parity of the mother for any of the variables tested. At the end of each 60 s trial, the experimenter gently removed the toy from the child's hand or the tray of the booster seat. Any objects that were dropped onto the floor were retrieved by the experimenter. Otherwise the experimenter sat quietly behind the video camera set-up, which was located ~6 ft away from the mother and child.

To eliminate any potential influence of the mothers' facial or verbal responses on their infants' behaviors (Gunnar and Stone, 1984), each mother sat in a chair immediately behind her infant and reported that she was not aware of the scent of each toy. If the baby turned around to look at the mother, the mother was instructed to look at the baby but refrain from talking or smiling. There was no effect of the scent of the toy on the number of times the infant turned around to look at the mother, which was exhibited by approximately half (n = 33) of the infants [F(2,64) = 0.74; P = 0.48].

Videotape analyses

Each videotape was subjected to frame-by-frame analysis by means of an IBM-based event recorder program called Observer (Noldus, Inc., Wagenigen, The Netherlands) to determine whether the infant explored the object differently as a function of its odor. Raters, who were unaware of the experimental conditions and the hypotheses of the study, scored the videotaped records in real time, and the proportion of total time that the infant was engaged in the behavior was determined.

The first three behaviors listed below were analyzed because they are considered to be exploratory in nature in that they lead to perceptual information about the toy (Ruff, 1984; Schmidt and Beauchamp, 1989), whereas the latter two were analyzed to evaluate the infant's hedonic reaction to the toy. The behaviors were defined as follows:

1. Mouth. The proportion of time that the infant's mouth contacted the stimulus object.
2. Manipulating. The proportion of time that the infant manipulated the stimulus object with one or both hands (Steel and Pederson, 1977).
3. Looking. The proportion of time that the infant looked at the stimulus object.
4. Facial expressions. The proportion of time the infant displayed a neutral, positive or negative facial expression. During scoring, the sound was turned off so that the raters would not be influenced by the infant's vocalizations. Because the vast majority of facial expressions were classified as neutral (>0.90 in all cases), these data were not analyzed due to ceiling effects.
5. Vocalizations. The proportion of time the infants emitted a vocalization. During scoring, the video screen was covered so that the raters would not be influenced by the infants' facial responses.

Reliabilities for each measure were determined by correlating the scoring of at least two observers. The mean Pearson product–moment coefficients for the scoring of all behaviors were >0.90.

Statistical analyses

To determine whether the infants responded differently to the stimulus object as a function of its scent, an ANOVA was conducted. An arcsin transformation of the proportional data was conducted to stabilize the variance before analysis. All summary statistics reported in this article are expressed as means ± SEM, and all P values represent two-tailed tests.
Table 1  Infants' behavioral responses to scented toys

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<th>Vanilla</th>
<th>Plain</th>
<th>Alcohol</th>
<th>Statistical analyses</th>
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| Looked at toy (n = 63)
| (1.629 ± 0.055)<sup>c</sup> | 0.524 ± 0.025    | 0.479 ± 0.026    | 0.485 ± 0.026     | F(2,124) = 3.30; P = 0.04 |
| Mouthed toy (n = 54)
| (1.059 ± 0.091)       | 0.300 ± 0.033    | 0.268 ± 0.031    | 0.291 ± 0.029     | F(2,106) = 0.96; P = 0.39 |
| Manipulated toy with hands (n = 38)
| 0.087 ± 0.017         | 0.114 ± 0.020    | 0.072 ± 0.015    | 0.374 ± 0.064     | F(2,74) = 2.47; P = 0.09 |
| Emitted vocalizations (n = 46)
| (0.452 ± 0.063)       | 0.116 ± 0.025    | 0.169 ± 0.033    | 0.699 ± 0.089     | F(2,90) = 3.86; P = 0.02 |

*The behaviors scored are not mutually exclusive (e.g. an infant could be looking at the toy and manipulating it at the same time) so the total proportions do not add to 1.00.

**Not all subjects contributed data for each measure. The number in parentheses represents the number of infants who exhibited the behavior during at least one of the three 60 s trials.

Proportions were subjected to arcsin transformation prior to parametric analyses. The number in parentheses represents the arcsin value (means ± SEM).

Results

Effect of scent

Table 1 shows that the scent of the toys significantly influenced how long the infants looked at (P = 0.04) and emitted sounds (P = 0.02) while playing with the toys, and tended to influence how long they manipulated the toys with their hands (P = 0.09), thereby indicating that they did indeed detect the odors. As a group, infants looked longer at the vanilla-scented toy when compared with either the unscented [paired t(62 df) = -2.29; P = 0.03] or alcohol-scented [paired t(62 df) = -1.92; P = 0.06] toys. Similarly, they emitted less vocalizations when playing with the vanilla-scented toy than with either the unscented [paired t(45 df) = -2.67; P = 0.01] or alcohol-scented [paired t(45 df) = -1.89; P = 0.06] toys. Infants also manipulated the alcohol-scented toy less with their hands when compared with the plain toy [paired t(37 df) = 2.33; P = 0.03]. There was no significant effect of the sex of the infant for any of the variables analyzed.

Relationship to parental alcoholism

There was a significant interaction between parental alcoholism and the infants' mouthing response to the toys [F(2,92) = 3.90; P = 0.02]. Figure 1 shows that infants who lived in a household where one or both parents were alcoholics mouthed the alcohol-scented toy more than infants whose parents were not alcoholics [F(1,46) = 5.27; P = 0.02]. This response was specific to the ethanol odor, since it did not extend to the somewhat similar odor of vanilla [F(1,46) = 0.00; P = 0.99] or the unscented toy [F(1,46) = 0.00; P = 0.99]. There was also a significant interaction between parental drinking and proportion of time the infant spent vocalizing [F(2,80) = 3.19; P = 0.05]. However, further analyses revealed that there was a trend for infants whose parents were alcoholics to vocalize more when playing with the vanilla-scented toy than when playing with the unscented toy [F(1,40) = 3.85; P = 0.06].
frequency of using vanilla-scented products. Mothers who reported using
the vanilla-scented, unscented and ethanol-scented toys (mean ± SEM). The
infants were divided into two groups based on their mother's reported
transformation prior to parametric analyses.

Mothers rarely used such products \( F(1,61) = 5.51; P < 0.01 \). Further analyses
did not extend to the somewhat similar odor of ethanol in the context of parental drinking could alter the
infants' response to these odors during brief tests in the laboratory. The only experimental study we are
aware of which directly examined this issue was that of Schleidt and Genzel (1990), who found that during the first
weeks of life, breastfed infants turn toward a perfume that had been worn on their mothers' breasts during feeding in
preference to an unfamiliar perfume.

In the current experiment, we chose a correlational rather than experimental approach because of our particular
interest in the possibility that early exposure to the odor of ethanol in the context of parental drinking could alter the
infants' responsiveness to this odor in other contexts. Results from animal model studies make this hypothesis
important to test in humans. For example, learning occurs when the young animal experiences alcohol in amniotic fluid
(Chotro and Molina, 1990; Dominguez et al., 1993), mother's milk (Phillips and Stainbrook, 1976; Hunt et al.,
1993), as an ambient odor (Molina and Chotro, 1989), when the drug is infused i.a. (Molina et al., 1986) and even during
acute stages of intoxication when perception is probably mediated by non-metabolic routes of elimination such as
respiration or salivation, or both (Molina et al., 1989; Molina and Chotro, 1989). Moreover, sensory experiences
with ethanol during the neonatal period affect voluntary alcohol intake during adulthood (Randall and Lester, 1975;

Whether early experience with the smell and taste of alcohol has similar effects in humans remains to be
determined. Young children have a well-developed cognitive schema for alcoholic beverages. They know that adults drink
more than children, and that men drink more than women (Fossey, 1993; Zucker and Noll, 1987). When children are
asked about actual experiences with alcohol, the vast majority reported experiences with parents and more often

![Figure 2](http://chemse.oxfordjournals.org/)

Figure 2 The proportion of time that the infants \( n = 63 \) spent looking at the vanilla-scented, unscented and ethanol-scented toys (mean ± SEM). The infants were divided into two groups based on their mother's reported frequency of using vanilla-scented products. Mothers who reported using vanilla-scented products four times a week or more were classified as 'frequent users' \( n = 7 \) whereas the remaining women reported using such products only occasionally \( n = 56 \). Proportions were subjected to arcsin transformation prior to parametric analyses.

**Relationship with maternal use of vanilla-scented products and vanilla-flavored foods**

Figure 2 shows that there was a significant interaction between the mothers' frequency of using vanilla-scented products and the proportion of time their infants looked at the toys \( F(2,122) = 4.78; P = 0.01 \). Further analyses revealed that the infants whose mothers were frequent consumers of vanilla-scented products spent more time looking at the vanilla-scented toy than infants whose mothers rarely used such products \( F(1,61) = 5.51; P = 0.02 \). This response was specific to the vanilla odor, since it did not extend to the somewhat similar odor of ethanol \( F(1,61) = 0.02; P = 0.89 \) or the unscented toy \( F(1,61) = 0.00; P = 0.99 \). There was no significant interaction between the frequency of the mother's consumption of vanilla-flavored foods and any of the behaviors analyzed. Moreover, there were no significant interactions between the types of foods consumed by the infants (e.g. fruits, vegetables, juices) and any of the behaviors analyzed.

**Discussion**

Six- to 13-month-old infants responded differently to toys which were scented with either ethanol or vanilla than to identical, unscented toys. Infants looked more and vocalized less in the presence of the vanilla-scented toy and spent less time manipulating the ethanol-scented toy when compared with the unscented toy (see Table 1). We conclude that this method is sufficiently sensitive to reveal differences in response to odorized versus non-odorized objects in human infants. However, the differential responses are subtle and require a rigorous analysis to reveal. Moreover, since infants were pre-exposed to an unscented toy during the familiarization trial, we cannot conclude from this study that scented toys are inherently more salient or elicit more looking or less vocalizations; differences could be due to contrast or habituation effects.

Although behavioral and hedonic responsiveness to major categories (i.e. sweet, sour, some bitters) of the sense of taste are evident at birth (for review see Mennella and Beauchamp, 1996b), parallel evidence for innately preferred or rejected odors (as distinct from volatile compounds that stimulate the pain system) is virtually non-existent (for review see Bartoshuk and Beauchamp, 1994). Thus, it has been suggested that whereas taste preferences and aversions are hard-wired, olfactory likes and dislikes are learned during development (Bartoshuk, 1991). Consequently, a major goal of this study was to initiate an investigation of whether prior exposure to odors in the home would influence the infants' response to these odors during brief tests in the laboratory. The only experimental study we are aware of which directly examined this issue was that of Schleidt and Genzel (1990), who found that during the first weeks of life, breastfed infants turn toward a perfume that had been worn on their mothers' breasts during feeding in preference to an unfamiliar perfume.

In the current experiment, we chose a correlational rather than experimental approach because of our particular interest in the possibility that early exposure to the odor of ethanol in the context of parental drinking could alter the infants' responsiveness to this odor in other contexts. Results from animal model studies make this hypothesis important to test in humans. For example, learning occurs when the young animal experiences alcohol in amniotic fluid (Chotro and Molina, 1990; Dominguez et al., 1993), mother's milk (Phillips and Stainbrook, 1976; Hunt et al., 1993), as an ambient odor (Molina et al., 1984, 1985), when the drug is infused i.a. (Molina et al., 1986) and even during acute stages of intoxication when perception is probably mediated by non-metabolic routes of elimination such as respiration or salivation, or both (Molina et al., 1989; Molina and Chotro, 1989). Moreover, sensory experiences with ethanol during the neonatal period affect voluntary alcohol intake during adulthood (Randall and Lester, 1975; Phillips and Stainbrook, 1976; Molina et al., 1985, 1986; Molina and Chotro, 1989).

Whether early experience with the smell and taste of alcohol has similar effects in humans remains to be
determined. Young children have a well-developed cognitive schema for alcoholic beverages. They know that adults drink
more than children, and that men drink more than women (Fossey, 1993; Zucker and Noll, 1987). When children are
asked about actual experiences with alcohol, the vast majority reported experiences with parents and more often
with the father than the mother (Zucker and Noll, 1987). That this learning extends beyond the realm of purely verbal experience and media exposure to sensory experience is suggested by the finding that 2- to 6-year-old children were able to correctly identify alcohol by smell alone, and they were as successful in identifying the odor of alcohol as they were other familiar odors, such as popcorn and Play-Doh (Noll et al., 1990). Moreover, the child's success at recognizing the smell of alcohol was significantly related to the heavier drinking habits of both parents (Noll et al., 1990).

The present study extends these findings to younger-aged infants. Those infants who had more exposure to ethanol, as inferred from questionnaires about parental alcoholism and alcohol intake, behaved differently in the presence of the ethanol-scented toy when compared with less exposed infants. The role that genetic factors play in the behavioral reactions to the sensory properties of alcohol could not be determined since infants who were 'at risk' for alcoholism lived in a household of heavier drinking parents and thus were more likely to be exposed to alcohol than infants who were 'not at risk' (see also Alford et al., 1991). Likewise, the role that prenatal exposure to alcohol has on the infants' response to the scent of ethanol could not be determined since the mothers in the present study drank very little during pregnancy. Nor could we assess the potential impact of exposure to alcohol in human milk since women who drank more were more likely to live in a household with a partner who was an alcoholic. Future studies should address these issues. Nevertheless, these findings, together with those of Noll and colleagues (1990), suggest that at least some of the early learning about alcohol is based on sensory experiences and clearly anchor it to the child's experiences at home.

Of the four behaviors monitored in the study (mouthing, looking, manipulating the toy and vocalizing), this differential response was manifested in mouthing the ethanol-scented toy more. This finding might be anticipated based on animal model studies that indicated that pups exposed to the flavor of ethanol in milk increased their mouthing rates to the odor of ethanol and were more willing to ingest ethanol-flavored solutions (Hunt et al., 1993). Whether mouthing the ethanol-odorized toy more reflects their familiarity with the flavor of ethanol which, in turn, leads to a greater willingness to accept ethanol-flavored substances remains to be investigated. Nevertheless, these data provide circumstantial evidence that prior ethanol exposure in humans alters the willingness of infants to orally explore toys scented with this odor. Moreover, this learning appears to be keenly selective, as it allows for the discrimination of the closely related aromas of vanilla and ethanol (see Figure 1).

The vanilla-scented toy served both as a control odor (for the above analysis of ethanol exposure) and as an experimental odor itself since we anticipated that the infants would be differentially exposed to this odor as well. Indeed, it was possible to classify infants into two groups with more or less exposure to vanilla as determined by maternal responses on questionnaires designed to evaluate the extent of use of vanilla-flavored foods and vanilla-scented products. The infants more highly exposed to the aroma of vanilla looked at the vanilla-scented toy more. Why exposure to the odor of vanilla would alter the behavior of looking at the odorized object is not known, however.

In summary, this study has shown that videotape analyses of the infants' behavioral responses to scented toys is sufficiently sensitive to reveal differential responses as a function of odor. The data implicated prior exposure to the odors as one factor in influencing behavioral responses to the scented toys, although this conclusion rests on correlational rather than experimental data. Given the public health importance of excess ethanol intake, however, the current correlational study, in conjunction with animal model work consistent with the results reported herein, is an important addition to our growing understanding of the potential importance of early exposure to ethanol.

A more complete understanding of the short- and long-term effects on behavior of exposure of infants to odors (through both orthonasal and retronasal routes) will require experimental studies. For example, controlled differential exposure from gestation through weaning to different flavors such as those of garlic or vanilla should be undertaken. Our findings that (i) volatile components of flavors, when consumed by a pregnant or nursing woman, are transmitted to her amniotic fluid (Mennella et al., 1995) and milk (for review see Mennella and Beauchamp, 1996b) and (ii) these flavors in milk are detected by the nursing infant (for review see Mennella and Beauchamp, 1996b) provides obvious scope for future experimental studies.

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