Oral Capture and Grasping of an Artificial Nipple by Rat Fetuses

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Although born blind and deaf, newborn rats exhibit a remarkable capacity to recognize and gain access to the nipples of the lactating mother. However, it is well-known that full-term rat neonates will not attach to an artificial nipple. In the present study, an artificial nipple fashioned from soft vinyl was presented to rat fetuses from E17-E21 of gestation. Fetuses showed side-to-side head movements that resulted in oral capture of the nipple on E18 and exhibited a direct nipple-grasping response from E19 through term. Frame-by-frame analysis of videotape records of E21 rat fetuses revealed that tactile contact with the artificial nipple elicited mouthing, licking directed at the nipple, forelimb treadling, and grasping of the nipple. Fetuses also exhibited components of aversive behavior, including facial wiping and head turning, that appeared to terminate oral contact with the nipple. Morphine pretreatment reduced the expression of aversive responses and promoted licking and grasping of the artificial nipple. In addition to documenting the prenatal ontogeny of this important neonatal behavior, these findings imply a role for endogenous opioids in the newborn rat's first suckling episode.

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Introduction

Identification of simple, stereotypic patterns of behavior that can be evoked reliably by specific forms of sensory stimulation has promoted understanding of the prenatal development of behavior and the nervous system. For example, fetal rats exhibit a leg extension response (LER) to repeated brushing of the anogenital region (Smotherman & Robinson, 1988) which is identical to the response of rat pups exposed to maternal licking after birth (Moore & Chadwick-Dias, 1986). Fetuses also express bilateral facial wiping strokes following intraoral infusion of many chemosensory fluids (Robinson & Smotherman, 1991) or unilateral wiping strokes in response to punctate tactile stimuli applied to the perioral region (Smotherman & Robinson, 1992a). Facial wiping resembles the face-washing behavior expressed by older pups and adult rats during spontaneous grooming and aversion sequences (Berridge & Grill, 1983; Johanson & Shapiro, 1986). On the last 2 days of gestation, fetal rats exhibit a stretch response to intraoral infusion of milk (Robinson & Smotherman, 1992) that is similar to the postural extension shown by suckling pups at the nipple (Hall & Rosenblatt, 1977). Experimental analysis of these simple motor patterns, which occur in response to the first presentation of appropriate stimuli, has provided a set of bioassays for investigating central nervous system substrates and the role of environmental context in the prenatal ontogeny of behavior (Smotherman & Robinson, 1992b).

The stretch response of the newborn rat occurs at the time of milk letdown, and thus represents the terminal event in a bout of suckling behavior at the nipple. Suckling actually comprises a collection of motor patterns that commence with the pup's approach to the maternal ventrum and attachment to a nipple (Drewett, Statham, & Wakerley, 1974; Hall, 1990). Nipple attachment represents an essential event in the sequence of activities that provide the newborn with fluids, minerals, and nutrients during early development. Yet relatively little is known about the factors promoting initial neonatal responses to the nipple. Blass and colleagues have reported that chemosensory cues experienced late in gestation and during parturition are influential in directing the attachment preferences of newborn rats (Pedersen & Blass, 1982), suggesting that components of nipple attachment behavior have their origin during the prenatal period.

The aim of the present study was to investigate the prenatal development of nipple attachment behavior. Specifically, an in vivo preparation that permits direct observation and videotaping of rat fetuses was employed to characterize the behavior expressed by fetuses in response to an artificial nipple. Fetal responsiveness to the artificial nipple was measured over the last 5 days of gestation (E17-E21). Measurement of oral pressure changes during fetal attachment to the nipple and frame-by-frame videotape motion analysis provided more detailed information about the responses of E21 rat fetuses to the artificial nipple.

Method

Subjects

Rat fetuses were the progeny of Sprague-Dawley rats (Charles River Laboratories, Wilmington, MA) time-mated in our laboratory. Breeding females were

housed in groups of three in plastic breeding cages (36 × 47 × 20 cm) under constant room temperature (22°C) and 12 : 12 hr light/dark cycle (lights on at 0700/hr), with food and water freely available. Vaginal smears were collected daily during a 4-day breeding period, with the first date of detectable sperm designated as the date of conception (E0). Animals were maintained and treated following guidelines of the National Institutes of Health (PHS publication 86–23), International Society for Developmental Psychobiology, and Society for Neuroscience. To avoid confounding litter effects with treatment effects in testing multiple offspring (Abbey & Howard, 1973), different experimental conditions were represented at least once and not more than twice in each pregnant female.

Prenatal Preparation

Pregnant rats were prepared for fetal testing on E17, E18, E19, E20, or E21 of the 21.5-day gestation. Under brief ether anesthesia, the pregnant rat received a 100 μl injection of 100% ethanol into the spinal cord between the first and second lumbar vertebrae. This procedure produces an irreversible spinal blockade at the low thoracic level and eliminates sensation in the lower half of the rat's body. The prepared rat was placed in a Plexiglas holding apparatus and immersed to chest depth in an isotonic saline bath maintained at body temperature (37.5°C). The condition of the prepared rat was monitored throughout the period of fetal observation. The prepared rat was allowed to acclimate to the bath environment for 20 min before fetal observation. To gain direct visual access to fetuses, the uterus was externalized through a low midline laparotomy and individual fetal subjects were delivered from the uterus and amniotic sac into the saline bath, taking care to maintain the integrity of the umbilical cord and placental attachment to the uterus. Coloration of the fetus and umbilical cord was continuously monitored to ensure that the subject remained fully oxygenated during observation (Smotherman & Robinson, 1991).

Nipple Presentation

The artificial nipple, which was fashioned from a block of soft vinyl material (vinyl dissecting pad, Carolina Biological Supply Co., Burlington, NC), was 25 mm long, round in cross section, and tapered from 5 mm wide at the base to 1 mm wide at the rounded tip. A smaller version of this nipple (tapering to about 0.5 mm) was made for testing younger fetuses (E17-E18). The base of the artificial nipple was attached to a handle to facilitate manual presentation by the experimenter. Presentation consisted of gently holding the tip of the nipple in contact with the oral aperture without forcing the tip into the mouth. Each fetus was presented with the nipple for a period of 60–180 s, during which grasping of the nipple and other behavior was scored.

Measurement of Oral Pressure

To measure changes in oral pressure following grasping of the artificial nipple by the fetus, two different pressure sensing nipples were designed and presented to fetuses on E21. The first nipple employed a closed system and was designed to

measure compression force (biting) exerted by the fetus on the surface of the nipple. It consisted of a thin-walled hollow vinyl tube, about 1 mm in diameter, which was closed and rounded at the tip. The second nipple employed an open system and was designed to measure negative pressure (sucking) exerted by the fetus at the tip of the nipple. It consisted of PE-10 polyethylene tubing, open at the end, inserted through the length of the solid artificial nipple. The open end of each sensing nipple was connected via PE-50 tubing to a custom-made pressure transducer (Lighton, 1988), which was capable of measuring changes in pressure on the nipple. The analog output from the pressure transducer was amplified and printed on a chart recorder (DASH-IV, Astro-Med Inc., West Warwick, RI). Both the open and closed systems were calibrated by attachment to a Scholander water manometer, which permitted measurement of pressure changes (reported as mm Hg).

Behavioral Observation

To provide a detailed description of the grasping response and other fetal behaviors during presentation of the artificial nipple, fetuses on E21 were videotaped for later motion analysis. A video camera (Panasonic, model AF-X8) was positioned vertically over the subject fetus and the session recorded (VHS format, 33.35 mm/s recording speed). The subject was illuminated from two sides with cool light directed from fiber-optic lightguides (Schott KL1500-Z), but were not otherwise manipulated during the session. Videotaped records of 16 fetuses were time-stamped with a video timer (FOR-A, model VTG-33A) to uniquely label each video frame, and analyzed frame-by-frame on a video playback system (Sony SLV-676UC) (Robinson & Smotherman, 1991). Motion analysis focused on the fine structure of oral, head, and forelimb movements during presentation of the artificial nipple. Specifically, this analysis included frequency and duration measures of fetal grasping of the nipple, mouthing activity, licking directed at the nipple, forelimb treadling (alternating flexion and extension of the forelimbs not in contact with the face), facial wiping (synchronous rostral movement of the forelimbs while in contact with the face), and head turning (lateral turning of the head to left or right away from the nipple). The observation system provided high reliability ($r > .95$ on multiple scorings of the same videotaped session).

Because the amount of time that different subjects were exposed to the nipple varied, frequency and duration measurements were divided by the total time of exposure to the nipple to provide time-independent behavioral measures. The resulting frequency and duration scores were analyzed by nonparametric Mann-Whitney U-test. The incidence of fetuses grasping the nipple at different ages and the incidence of facial wiping to the nipple were compared by chi-square tests of independence.

Results

Experiment 1: Description of Fetal Responses to the Artificial Nipple

The artificial nipple was presented to a total of 155 fetuses at five gestational ages (*N*s: E17 = 15; E18 = 30; E19 = 30; E20 = 30; E21 = 50). Across the range

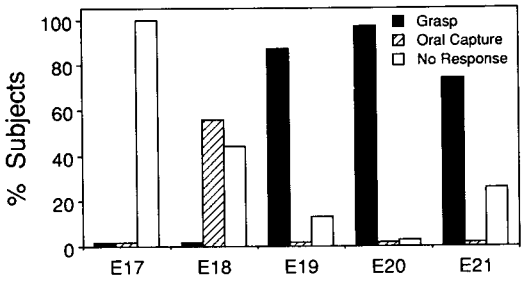

Fig. 1. Percentage of fetal subjects exhibiting oral capture or grasping response to artificial nipple at various gestational ages.

of subjects tested, the capacity of rat fetuses to bring the artificial nipple within the mouth varied with gestational age. On E17, fetuses failed to capture the artificial nipple. In fact, E17 fetuses showed no evidence of any kind of behavioral response upon presentation of the artificial nipple. More than half of the fetal subjects tested on E18 (56%) responded to the nipple by opening the mouth and repeatedly moving the head from side-to-side. These lateral head movements eventually resulted in the tip of the nipple falling within the oral cavity (oral capture), after which head movements ceased. This method of oral capture was unique to this age and differed qualitatively from the grasping response expressed by older fetuses. On E19–E21, a majority of fetuses (83%) expressed a grasping response to the artificial nipple (Figure 1). This grasping response consisted of an active movement of the head and mouth toward the nipple that resulted in the nipple entering the oral cavity and the mouth closing around the tip. Successful grasping was verified when, upon gentle withdrawal of the nipple, the fetus was pulled toward the experimenter.

Overall, the tendency for fetuses to exhibit either oral capture or grasping varied significantly with fetal age, $\chi^2 = 50.3$, $df = 3$, $p < .001$. Focal comparisons of fetal ages indicated significant increases in fetal responsiveness to the nipple from E17 to E18, $\chi^2 = 13.7$, $df = 1$, $p < .001$, and from E18 to E19, $\chi^2 = 5.1$, $df = 1$, $p < .05$. A significant decrease in the incidence of grasping was apparent from E20 to E21, $\chi^2 = 6.7$, $df = 1$, $p < .01$. These data indicate that rat fetuses can express specific behavioral responses to the tactile stimulation provided by an artificial nipple, and that these responses emerge relatively early during fetal development (E18-E19).

Experiment 2: Oral Pressure Changes Associated With Nipple Grasping

The grasping response of older fetuses was accompanied by pressure exerted on the artificial nipple, as evidenced by the resistance to remove the nipple from the fetus's mouth. To further document that rat fetuses exerted force in grasping the nipple, two pressure-sensing nipples were designed to measure compression pressure and negative pressure (sucking). Multiple compression pressure measurements were collected from ten E21 rat fetuses in three separate pregnancies using a closed, thin-walled, pressure-sensing nipple. An increase in compression pressure, rising to a peak of approximately 0.9–1.0 mm Hg, was observed in every subject

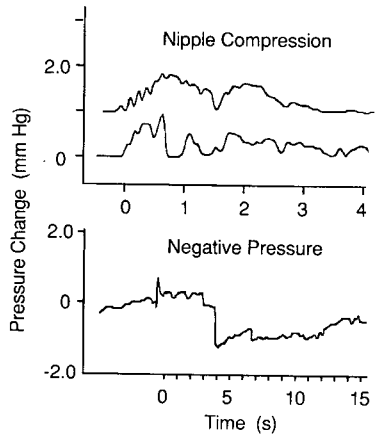

Fig. 2. Changes in compression pressure (top) and negative pressure (bottom) exerted on artificial nipple during grasping response by E21 rat fetuses.

during the first second after the onset of the grasp response. Two typical examples of the change in compression pressure associated with nipple grasping are shown in the upper panel of Figure 2. The increase in pressure occurred in a series of stages, creating a scalloped shape to the pressure graphs that is clearly evident in the upper tracing, and to a lesser extent in the lower record. Additional, smaller magnitude changes in compression pressure could be detected as the fetus performed mouthing movements while grasping the nipple, but pressure generally returned to baseline levels within a few seconds after the onset of a grasp response.

Negative pressure measurements were collected from five E21 fetuses in three separate pregnancies using an open-tube, pressure-sensing nipple. As shown in the lower panel of Figure 2, a brief increase in pressure was recorded as the fetus made oral contact with the nipple and initiated the grasp response. Changes in negative pressure, amounting to 0.5–1.5 mm Hg, were exerted on the nipple several seconds after the grasping response, while the fetus remained on the nipple. Changes in negative pressure were not evident after all grasping responses, but were observed in most subjects.

Experiment 3: Videotape Analysis of Nipple Grasping Response

To obtain a more detailed profile of behavioral responses to the artificial nipple, fetal subjects were exposed to the nipple and their behavior videotaped for later frame-by-frame analysis on E21. Examination of the videotape records focused on responses involving the head, mouth, and forelimbs. A graphic representation of the observation session and all fetal responses was constructed for all fetal subjects, as illustrated in Figure 3. This initial overview of fetal responses suggested that E21 fetuses exhibited several different motor patterns during presentation of the nipple. Initial responses typically consisted of small amplitude mouthing movements and occasional licking of the nipple. These were followed by the fetus actually grasping the nipple, and other behaviors such as alternated forelimb movements (treadling) were performed before oral contact with the nipple ceased.

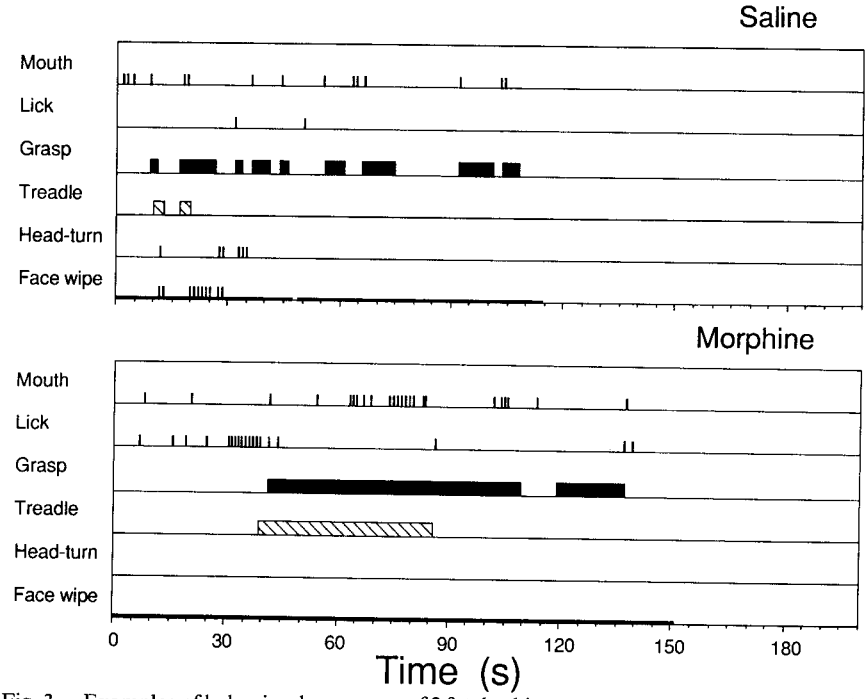

Fig. 3. Examples of behavioral responses of 2 fetal subjects to presentation of an artificial nipple. Fetuses were pretreated by ip injection of saline (top) or morphine (bottom). Six categories of fetal behavior are portrayed: instances of mouth, lick, head-turn, and facial wipe responses, and the duration of grasp and forelimb treadle responses. The period of time that each subject was exposed to the nipple is shown as the heavy line along the abscissa.

During each observation session, most fetuses exhibited several cycles of incipient mouthing activity, grasping, and termination of oral contact. In general, these patterns of fetal response resembled behavior expressed by rat pups during suckling at the nipple, and appeared to constitute appetitive or approach responses. E21 fetuses also exhibited other patterns of response to the nipple, consisting of facial wiping and head turning away from the nipple, that were similar to postnatal components of aversion reactions. Facial wiping and head turning often occurred after the initial grasping of the nipple, and sometimes were associated with termination of oral contact with the nipple. Avoidance responses such as facial wiping and head turning also tended to diminish in frequency with repeated episodes of grasping (Fig. 3, top).

Experiment 4: Opioid Effects on Fetal Responses to the Artificial Nipple

The expression of licking, nipple grasping, and facial wiping, among other behavior, suggested that presentation of the artificial nipple evoked ambivalent responses from E21 rat fetuses. Although such ambivalent reactions are not commonly expressed by pups at the nipple, intraoral infusion of milk to newborn rats consistently evokes components of both consummatory and aversive behavior.

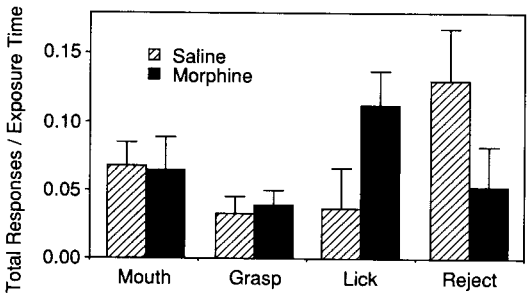

Fig. 4. Fetal responsiveness to the artificial nipple for four categories of fetal behavior in saline- and morphine-injected subjects. Bars show mean responsiveness (expressed as the number of responses divided by total time of exposure to the nipple); vertical lines show *SEM*.

The responses evoked by milk infusion are modulated by endogenous opioid activity; pretreatment of pups with the opioid antagonist naloxone increases the incidence of facial wiping after milk infusion, while administration of morphine suppresses aversion responses and promotes acceptance of milk (Smotherman & Robinson, 1992b). Because postnatal responsiveness to contexts associated with suckling, such as availability of milk, may be influenced by opioid activity, opioid manipulation also may affect fetal responsiveness to an artificial nipple.

In this experiment, E21 fetuses were injected with morphine or isotonic saline to assess opioid effects on responses elicited by the artificial nipple. A total of 16 fetuses, from 8 separate pregnancies, served as subjects. Half of the subjects received an ip injection of 5.0 mg/kg morphine sulfate (Sigma Chemical Co., St. Louis, MO) in isotonic saline (total injection volume = 50 μl), while the other half were injected with the saline carrier alone. Beginning 5 min after injection, each fetus was presented with the artificial nipple and its responses recorded on videotape. The actual time of exposure of each subject to the nipple was determined by measuring the duration of physical contact of the nipple with the perioral area of the fetus. The time of exposure did not differ between morphine and saline groups (overall mean = 106 $\pm$ 10 s), but varied among subjects. To compensate for interindividual variation in exposure time, the frequency of each measure of fetal responsiveness was divided by the total time of exposure to the nipple separately for each subject, providing a relative measure of response.

Fetuses treated with 5.0 mg/kg morphine did not show any evidence of reduced motor activity. This is consistent with previous studies that have reported no effect of morphine on motor activity when administered directly to perinatal subjects (Smotherman & Robinson, 1992a). Morphine-treated fetuses were active and exhibited incipient mouthing movements, licking, grasping of the nipple, and forelimb treadling movements, but showed a sharply reduced incidence of facial wiping and head turning. A typical timeline of behavioral responses by a morphine-treated fetal subject is shown in Figure 3 (bottom).

Comparison of saline- and morphine-injected fetuses indicated no difference in the incidence of mouthing activity (Fig. 4), the total duration of forelimb treadling activity (Fig. 5), or the number of grasping responses directed at the artificial nipple (Fig. 4), p values > 0.05. However, licking movements directed toward the nipple were nearly three times more common among morphine-treated fetuses

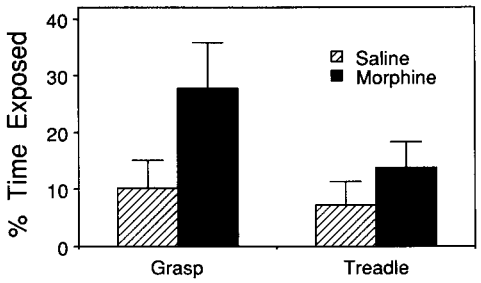

Fig. 5. Fetal grasping and treadling responses to the artificial nipple in saline- and morphine-injected subjects. Bars depict the percentage of the time exposed to the nipple devoted to each category of fetal response; vertical lines show *SEM*.

than saline-treated, U = 11, *n*s = 8, $p < .05$ (Fig. 4). The duration of each grasping response (i.e., time after grasp with the nipple in the mouth) was much greater in the morphine group, U = 6, *n*s = 8, $p < .01$ (Fig. 5). Conversely, saline-injected fetuses exhibited a much higher incidence of rejection responses (the sum of facial wiping and head-turning movements), U = 13.5, *n*s = 8, $p < .05$. Morphine administration reduced the percentage of fetal subjects that expressed facial wiping during the nipple presentation, $\chi^2 = 6.4$, $df = 1$, $p = .012$ (Fig. 6).

Experiment 5: Comparison to Neonatal Responses to Nipple

Although fetal rats on the last 3 days of gestation consistently exhibited grasping and other behavioral responses to the artificial nipple, it was not known how newborn rats would respond to the same stimulus. Responses of newborn rats to the artificial nipple were observed 1 hr following either vaginal delivery ($N = 8$), prior to any suckling experience, or after cesarean delivery ($N = 16$) following routine procedures in our laboratory (Blass, Jackson, & Smotherman, 1991). Pups were maintained in a temperature (32.5°C) and humidity-regulated incubator for 1 hr after delivery. Of the 24 neonates tested, only 1 (4%) exhibited a brief grasping response directed at the nipple. Other acceptance responses, such as mouthing, licking, and forelimb treadling, also were rarely expressed. Typically, newborn

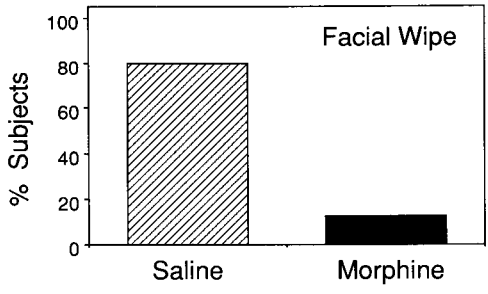

Fig. 6. Percentage of saline- and morphine-injected fetuses that exhibited facial wiping behavior during presentation of the artificial nipple.

rats failed to exhibit any motor response at all following presentation of the nipple, although a few subjects expressed brief rejection responses (head turning).

To further explore the lack of responsiveness of newborn rats to the nipple, three groups of cesarean-delivered pups received an ip injection (50 μl) of isotonic saline (n = 16), morphine (5.0 mg/kg; n = 10), or naloxone hydrochloride (1.0 mg/kg; n = 16; Sigma Chemical Co.). Subjects were maintained for 1 hr in the incubator and were presented with the artificial nipple 10 min after injection. None of the 42 subjects exhibited grasping or other acceptance responses to the artificial nipple. These findings, which are consistent with published reports that newborn rats will not suckle from surrogate nipples (Blass & Teicher, 1980; Hall & Rosenblatt, 1977; Hoshiba, 1986), stand in sharp contrast to the consistent grasping responses expressed by rat fetuses.

Discussion

This report provides the first evidence to our knowledge of behavioral responsiveness to a nipple-like tactile stimulus applied to the perioral region of the fetal rat. The prenatal development of responsiveness to an artificial nipple is noteworthy, because location and attachment to a nipple is one of the first critical behavioral patterns that the newborn rat must perform. The fetal grasping response comprises a number of salient attributes that resemble postnatal nipple attachment: (a) Fetuses exhibit resistance to physical withdrawal of the artificial nipple after grasping; (b) the grasping response is associated with an increase in compression pressure upon the nipple. The scalloped pattern of this compression may indicate that the fetus is adjusting the position of the nipple relative to the mouth and tongue; and (c) after the grasping response and the initial increase in compression, some pups exert negative pressure upon the nipple, which implies that a seal is formed between the mouth and nipple. All of these criteria are characteristic of attachment to the maternal teat in rat pups (Brake, Shair, & Hofer, 1988), suggesting that the grasping response of the rat fetus is developmentally related to nipple attachment behavior in the neonate.

Rat fetuses are clearly capable of expressing a grasping response to the artificial nipple as early as E19, about the same age or slightly earlier than fetuses exhibit other stereotypic action patterns (Robinson & Smotherman, in press). One day earlier, on E18, fetal rats are responsive to the nipple, but exhibit a transient pattern of behavior—involving side-to-side movements of the head and seemingly accidental oral capture of the nipple—which is outwardly similar to the rooting response of newborn human infants. The likelihood of fetuses grasping the nipple also declines significantly between E20, the peak in responsiveness, and E21. The apparent reduction in responsiveness at term parallels other changes in sensory-evoked behavior in the fetus, including stronger evidence for habituation to repeated stimulation on E21 (Smotherman & Robinson, 1992c), and a greater tendency for sensory responses to be masked or interrupted by contextual events (Smotherman & Robinson, 1989).

Although the artificial nipple evokes mouthing, licking, paw treadling, and grasping responses in the fetus, all of which may be characterized as acceptance reactions, it also elicits facial wiping and head turning away from the nipple, which resemble postnatal aversive or rejection responses (Berridge & Grill, 1983).

Rejection responses typically occurred after the fetus had grasped the nipple and appeared to be responsible for terminating oral contact with the nipple. Different forms of stimulation delivered to the perioral region, including application of a stiff bristle, other artificial nipples fashioned from less flexible material, or chemosensory infusion, consistently evoke aversion responses without accompanying mouthing, licking, or grasping. Moreover, the responsiveness of fetuses to punctate cutaneous stimuli is modulated by the endogenous opioid system (Smotherman & Robinson, 1992a). The results of the present study are consistent with previous studies of opioid effects on fetal aversion responses. Morphine reduces the expression of facial wiping and head-turning behavior following contact with the nipple. The effect of morphine to promote acceptance responses, such as increasing the duration of oral contact with the nipple, therefore may be attributed to the suppression of incompatible or competing rejection responses.

Increasingly, opioids have been implicated in modulating the motor activity (Smotherman & Robinson, in press), cutaneous and thermal responsiveness (Blass, Jackson, & Smotherman, 1991) social attachment (Blass, 1990), and expression of learning in perinatal animals and humans (Kehoe, 1988; Smotherman & Robinson, 1992b). Opioids of endogenous origin also may play an important role in modulating behavior during the newborn's first experiences at the nipple. Suckling behavior in the newborn comprises a sequence of events, the initial phases of which comprise location of the mother (approach), rooting and probing the mother's ventral surface (nipple search), and attachment to the nipple (grasping) (Hall, 1990). These behavioral responses appear to be controlled by a series of sensory cues provided by the mother. The findings of Experiment 4 in the present study provide a clue to the point in the suckling sequence where endogenous opioid activity may exert a regulatory influence on neonatal behavior. Morphine did not increase the probability that a fetal subject would grasp the nipple. Rather, morphine suppressed rejection responses to the nipple after grasping. Because rejection responses appeared to lead to termination of nipple contact in control subjects, activation of the fetal opioid system resulted in increased durations of attachment to the nipple. Similarly, presentation of another stimulus associated with suckling—delivery of milk into the mouth—evokes initial fetal responses (e.g., mouthing) that are not affected by opioid activity, but promoting or suppressing opioid activity with agonist or antagonist drugs dramatically alters delayed responses to milk infusion (e.g., changes in motor organization and expression of the stretch response) (Smotherman & Robinson, in press). Endogenous opioid activity thus appears to play a role in modulating changes in behavior subsequent to initial responses evoked by suckling stimuli, such as the nipple and milk.

The study of suckling behavior in newborn rats attached to the maternal teat has a major drawback that only limited control can be exerted over this environment. Furthermore, the act of observation itself is difficult, often requiring anesthesia of the dam that may, in an uncontrollable fashion, influence the behavioral responses of the newborn. Under such experimental conditions, it is difficult to identify subsystems that influence the development of early suckling behavior. This caveat may be illustrated by the lack of response of newborn rats to an artificial nipple. Pups tested within 1 hr of delivery do not exhibit a mouthing, licking, treadling, or grasping response to the artificial nipple. This agrees with reports from numerous other laboratories that newborn rats will not attach to or

feed from artificial nipples. An exception to this rule is the description of an automatic feeding apparatus where infant rats suckled from artificial nipples (Hoshiba, 1986). It should be noted, however, that pups in this report suckled from their mother for the first 3 days after birth. The existence of a fetal grasping response demonstrates that the lack of response of newborn rats to the tactile cues provided by an artificial nipple are not due to the inability of pups to detect or respond to this stimulus. Understanding why rat fetuses do and pups do not express a grasping response may provide a model for identifying factors that contribute to the reduced responsiveness of preterm human infants in suckling or feeding situations.

Notes

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