fect, no evidence was provided for PVG endorphinergic involvement in this second circuit. It is not clear what neurotransmitter mediates PVG inhibition of septal-preoptic vocalizations, but serotonin is a likely candidate. For example, there is evidence for serotonin mediation of PVG analgesia (*13*), and administering a serotonin agonist (quipazine) dramatically decreases forebrain vocalizations in guinea pigs (*6*, *14*). Our data extend the observations of others indicating that PVG analgesia inhibits thalamic vocalizations as well as pain by stimulating some ascending endorphinergic system or systems and suggest that the neurotransmitters mediating some of the effects of PVG stimulation depend on the circuitry leading to the final forebrain sites of interaction.

We also found that stimulation of nonanalgesic sites immediately surrounding the PVG produced painlike screams and potentiated the frequency of thalamic and septal-preoptic distress vocalizations. Such stimulation may release some unidentified "distress neurotransmitter" that interacts with forebrain vocalization circuits. Aversive and analgesic loci are close to each other in this region of the mesencephalon, and these sites appear to modulate distant forebrain circuits.

Our results suggest brain circuits controlling distress vocalization and indicate that these circuits are under endorphinergic control. These pathways may participate in the modulation of social distress.

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10. As predicted, morphine decreased electrically stimulated distress vocalizations (*6*).
11. Separate saline control sessions were run for each of the manipulations depicted in Fig. 2. For trials with naloxone alone, a single saline session was run in a counterbalanced fashion. In all other cases, saline sessions surrounded each manipulation, and these values were averaged.
12. It is possible that a simple additive interaction between naloxone and PVG stimulation could explain data obtained for the analgesic thalamic animals (Fig. 2). We believe that such additivity is unlikely, however. For example, no evidence for naloxone blockade of analgesic PVG stimulation was obtained in the septum-preoptic group (Fig. 2), despite the fact that naloxone alone increases were larger than PVG decreases in vocalizations.
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Saliva as a Chemical Cue in the Development of Social Behavior

Abstract. *Throughout development, Mongolian gerbils engage in conspicuous naso-oral investigations of their social partners' mouth areas. The behavioral contribution of saliva-related stimuli in regulating oral-directed responses was studied during several important phases of the gerbil's social life. Weanlings were preferentially attracted to their mother's saliva, subadults at puberty preferred saliva of littermates to that of nonlittermates, and sexually experienced males preferred the saliva of estrous females to that of nonestrous females. The use of saliva as a discriminative cue during various developmental periods suggests that oral chemostimuli have a perennial role in regulating social interchanges.*

Major questions in developmental psychobiology include how social relationships are established and how much adult social behavior is influenced by early social experience. Adequate tests of theories and hypotheses related to these questions require a relatively complete profile of the behavioral processes and mechanisms underlying social interactions at several points during ontogeny and adulthood. We now provide evidence from Mongolian gerbils (social cricetid rodents) suggesting that a chemical communication mechanism mediated by saliva may help to establish and link social behaviors at three stages of the gerbil's life: filial interactions at weaning, sibling or peer interactions at puberty, and sociosexual behavior during adulthood.

Table 1. Investigation responses of sexually experienced male gerbils ($N = 7$) to anesthetized female targets. Abbreviation: AMN, atropine methyl nitrate.

Target condition	Mean duration of contacts to female body regions (seconds)		
	Face	Ventral gland	Anogenital region
Experiment 1 (10-minute test)			
Estrus	*42.8	*22.1	24.4
Nonestrus	29.6	4.6	23.8
Experiment 2 (5-minute test)			
Estrus + AMN	14.0	*12.2	18.6
Nonestrus + AMN	13.7	0.6	16.7

*Two-tailed t-test, $P < .05$.

While studying social interactions of developing gerbils living in nuclear family units, we recorded a mother-young interchange at weaning (21 to 29 days after birth). During nursing sessions, the pups often engaged in long bouts of licking and nuzzling of the mother's lower lip and chin and lateral mouth region. This filial interchange, also seen in other mammals (*1*), is termed "mouthing" or "mouth-licking." Bouts of mouthing (sometimes lasting 10 minutes or longer) peak during the fourth week after birth as maternal behavior wanes and pups increase their ingestion of solid foods; these bouts are primarily directed to the dam, rarely to the father (*2*).

To examine the relative attractiveness of the dam's facial area during the weaning period, we measured the preferences of 25- or 26-day-old pups to their par-

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ents' heads. Six families with five or six pups per litter were housed in glass aquariums under a 14:10 light-dark cycle, with rat pellets and water freely available. Pups were tested at the end of the light period. Two hours before testing, the parents were removed, and the pups were presented with an empty tube (19 cm long and 5 cm in diameter). Both parents were anesthetized with sodium pentobarbital, their ventrums were washed thoroughly, and they were placed into a tube in a supine position with only their heads exposed, one at each end of the tube. The weanlings were then confined to the nest area by a partition, and the empty tube was replaced by the one loaded with parental targets. Each pup was allowed 4 minutes with the loaded tube, and an observer recorded the amount of time the pup spent sniffing or contacting the head of each parent. Litter means were analyzed with two-tailed t-tests.

Weanlings spent more time investigating the dams' faces ($\bar{X}$ = 51.1 seconds) than the fathers' ($\bar{X}$ = 12.8 seconds) ($P < .001$). The contacts were almost exclusively directed to the dam's buccal area. Moreover, 14 of the 43 pups licked and sometimes bit the mouth area, and 10 of these 14 pups directed these mouthing responses to the dam only. To test the importance of maternal oral secretions in this differential responding, we examined the parental preferences of gerbil pups when the dam's secretions were eliminated by peripheral injections of atropine. Forty-three pups, 25 or 26 days old, from nine different litters were tested as in the previous experiment except that 15 minutes before the tests the dams were injected intraperitoneally with 0.5 mg of atropine methyl nitrate (AMN) per kilogram of body weight; this treatment substantially dried the mouth cavity (as indicated by visual inspection). Pups no longer preferred their mothers ($\bar{X}$ = 6.6 seconds), but spent more time sniffing and contacting their fathers' faces ($\bar{X}$ = 19.1 seconds) ($P < .001$) (*3*). No instances of licking or biting of either parent's mouth were recorded in this test.

Finally, in a more direct test of saliva's behavioral effectiveness, we measured the responses of an additional 22 weanling gerbils to extracts of parental saliva placed on the mouth area of anesthetized virgin females. Saliva samples were obtained by syringing 0.1 ml of distilled water into the parent's oral cavity and removing an equal amount of (diluted) saliva by pipette aspiration. A single drop of the dam's saliva was placed on the lower lip of one anesthetized target, and the father's saliva sample was deposited on the other. The 25- or 26-day-old gerbils found the dam's saliva extract highly attractive, even when encountered on an unfamiliar female face (Fig. 1A) (*4*). Moreover, the dam's saliva alone elicited licking and biting of the target's mouth area in a third of the weanlings. This series of experiments suggest that the selective mouthing of gerbil pups during the weaning period to their mother may depend, in part, upon the attractiveness of her saliva. While various physiological roles have been proposed for maternal saliva in the weaning process (*1*), our data indicated that saliva of dams has some behavioral effect on mother-young interchanges during this important transition in psychobiological bonds.

After weaning, juvenile and subadult rodents living in groups often engage in relatively brief buccal contact behaviors during social interchanges (*5*). The next experiment was conducted to examine

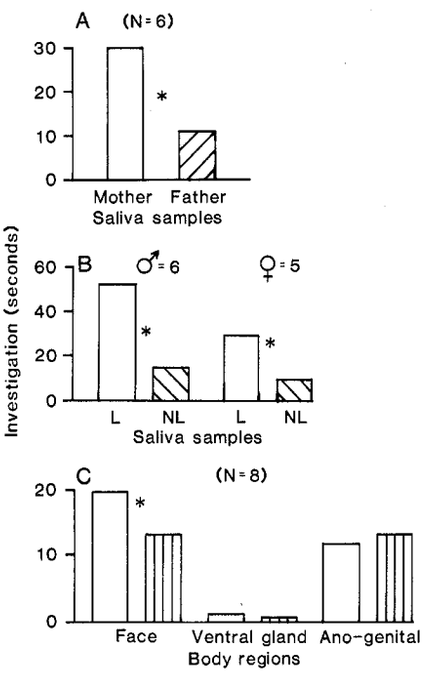

Fig. 1. Mean duration of investigatory responses to saliva samples deposited on the mouths of anesthetized virgin female targets treated with intraperitoneal injections of atropine methyl nitrate. Note that the ordinate scales differ. Asterisks indicate significant differences ($P < .05$). (A) Weanling pups (25 to 26 days old) responding to parents' saliva in a 4-minute preference test. Litter means were used in the data analysis; N refers to the number of litters. (B) Peripubertal littermates responding to littermate (L) and nonlittermate (NL) saliva in a 4-minute test. One nonresponsive female subject was dropped from the data analysis. (C) Sexually experienced males (mean age, 160 days) responding to saliva from either estrous (open bars) or nonestrous females (bars with grids) in a 5-minute test.

the effectiveness of saliva stimuli in regulating the social investigatory responses of subadult gerbils to peers. One male and one female from each of six litters selected randomly when they reached 65 to 71 days of age (*6*) were tested individually in a facial preference test to determine the relative attractiveness of littermate (familiar) and nonlittermate (unfamiliar) saliva. The targets, anesthetized and treated with AMN, were sisters unknown to the subjects. A saliva sample was taken from a female littermate of the subject and placed on one target's lip, and a second sample was drawn from a female nonlittermate and deposited on the other target. All subjects, targets, and saliva donors were approximately the same age.

Both female and male subjects spent significantly more time contacting targets carrying their littermates' saliva than those with nonlittermate saliva (Fig. 1B). The differential responding of these peripubertal gerbils suggests that oral secretions may convey information regarding group (litter) membership at a time when one would expect reproductive units to be forming. Whereas subadults of either sex are preferentially attracted to familiar saliva, females may be less attracted than males to the saliva of female littermates ($P < .05$, one-tailed t-test). This trend suggests that sex-related factors (of the subjects, or donors, or both) may affect the duration of investigatory bouts.

Mutual investigatory behavior directed toward the mouth area is also a regular part of adult sexual activity (*7*). Since these oral contacts may provide one mechanism by which the male could identify the female's reproductive status, we examined the possibility that saliva contributes to this identification process. In the first experiment, adult male gerbils were given access to anesthetized target females who were in either a nonestrous or estrous state (*8*). The frequency and duration of contacts to potential sources of chemical cues—the female's anogenital, ventral gland, and facial regions—were recorded.

The duration of contacts to the face and ventral gland regions was significantly affected by the reproductive state of the females (Table 1). (There were no differences between frequency measures.) When these males were retested with both nonestrous and estrous targets treated with AMN (*9*), differential responding to the ventral region, but not the face, remained (Table 1). A different group of eight sexually experienced males was tested with saliva samples that were drawn from estrous or nones-

trous females and placed on the lip of ovariectomized females treated with AMN. The males spent significantly more time contacting the facial regions of target females carrying the saliva from estrous females and, as expected, exhibited no difference in their contact times with ventral gland or anogenital regions (Fig. 1C). The results suggest that salivary stimuli may act as reproductive chemosignals, perhaps in parallel with ventral gland cues.

In developing gerbils, mouthing interchanges emerge relatively early in life and became most salient during weaning; they persist in a similar, species-typical form throughout the juvenile and adult phases of life. Our results suggest that all of these interchanges use a common source of chemical signals, arising from saliva of social partners. The type of information and functional role of the signal may vary with the age, sex, or experience (*10*). Further tests are needed to directly examine whether the saliva preferences reflect actual social partner preferences in normal interchanges.

Other investigators have established that saliva plays a role in the suckling behavior of neonatal rats and the aggressive behavior of adult mice (*11*). Our data extend these findings and provide evidence that saliva-related cues may act as chemosignals in all aspects of rodent social development. Using a common chemosignal source for various social interactions during development would provide a mechanism that not only maintains the structure of social investigations (naso-oral or oro-oral contacts), but also modifies or transforms the outcomes of social interchanges when the signal is altered by age and environment. Saliva-related stimuli may also contribute to the establishment of filial or juvenile interchanges and relationships that could have enduring effects on those adult social interactions that are also dependent on saliva cues. Although our study was not specifically designed to test these hypotheses, the data we have presented do provide an empirical base for more direct investigations of these questions (*12*).

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Auditory Brainstem Potentials in Chronic Alcoholics

Abstract. *Auditory brainstem potentials were recorded from abstinent chronic alcoholics and control subjects. The latencies of peaks II, III, IV, and V were significantly delayed in the alcoholic patients compared to control subjects. Brainstem transmission time was longer in alcoholics than in controls. This study provides systematic evidence that chronic alcohol abuse results in brainstem deficits suggesting possible demyelination of auditory tracts.*

Chronic alcoholism is known to result in aberrations of the central nervous system. At the structural level, these deficits have been studied with the use of neuropathological methods (*1*), pneumoencephalography (*2*), and computerized tomography (*3*). At the functional level, these changes have been examined with neuropsychological tests (*4*), electroencephalography (*5*), and cerebral blood flow studies (*6*). More recently, event-related potentials (*7*) have been used to assess the functional integrity of the brains of alcoholic patients. These electrophysiological studies have demonstrated functional deficits reflected in specific components of the event-related potential (ERP). The N1-P2 component of the ERP has been found to be depressed in chronic alcoholics, regardless of whether the response is to a relevant or irrelevant stimulus modality (*8*). Furthermore, abnormal P300 components have been reported in abstinent chronic alcoholics (*9*). Investigations of the structural (*1-3*) and functional (*4-9*) brain aberrations in alcoholics have produced consistent findings indicating that chronic alcohol abuse affects primarily the cerebral cortex and leaves relatively intact the primary sensory pathways.

Potentials generated in the auditory nerve and brainstem auditory pathway consist of seven positive waves occurring at specific latencies (*10*). Each peak is presumed to reflect the activity of different neural sites, with the first wave generated in the auditory nerve, the second in the cochlear nucleus, and the third in the region of the superior olivary complex. The fourth wave is postulated to emanate from the lateral lemniscus and the fifth peak from the inferior colliculus (*11, 12*). The neural sites responsible for the activity of the last two peaks are at present unknown. Investigators have reported that the time interval between peak I of the compound auditory nerve response and peak V of the inferior colliculus in the midbrain may prove valuable as a measure of brainstem transmission time (BTT) (*13*).

Several studies have demonstrated that a single dose of alcohol causes significant increases in the auditory BTT in rats (*14, 15*), cats (*15*), and man (*16*). However, functional brainstem deficits have not been reported in alcoholic patients practicing abstinence. We now report that transmission time in the auditory brainstem pathways of alcoholic patients is significantly slower than that in control subjects.

Seventeen hospitalized male alcoholic patients with a mean age of 38 ± 2.1 years (± standard deviation) were tested in this study. All patients met the Research Diagnostic Criteria (*17*) for alcoholism. Alcoholic patients with a history of hepatic encephalopathy, a history of

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