marked only that ". . . neither the writer nor the editor . . . thought it necessary" [reference 2 in (*1*)] to make such a specification. Now he castigates us for using an inappropriate background, but it was one we settled on for good reason; a large background elicits inappropriate behavior that interferes with reaching. In his new experiment a background was used which is different from ours and, presumably, different from the one used in (*2*), although that is still uncertain. Why the original background was not specified, or why in (*1*) a background of different size from ours was used, when Bower *et al*. were trying to replicate aspects of our experiment, remains a mystery. Nevertheless, Bower *et al*. have a point; possibly our background was perceived by the infants as an object. In order to assess this possibility, we reanalyzed the videotapes of our second experiment to see if infants (i) made more reaches to the background edge than to its center, and (ii) made more reaches to the object than to the picture. To reach the center of the background in our experiment, reaches had to be made toward the midline; to reach the background edge, they had to be outside a line sagittal to the shoulder. Infants of this age do not normally manifest midline activity (*4*), so any reaches to the central target would strongly indicate visually triggered behavior. In fact our infants made more reaches to the background edge (57 percent) than to the center (43 percent), but the latter were not differentially distributed between object and picture, a result directly contradictory to that of Bower *et al*. (*1*).

Perhaps this contradiction is due to the apparent absence of a background in (*1*), when the real object was presented, in contrast to the settings reported in (*2*) and (*3*). On the other hand it may be because a "small metal bell was attached to its [the object's] underside" (*1*, p. 1138). Especially in view of recent reports of reliable orienting to sound in neonates (*5*) it is inappropriate to draw conclusions about visual recognition of objects from such an investigation.

In their new experiment (*1*) Bower *et al*. used a 3-minute observation period, ". . . that which we have found to be both practical and efficient in eliciting neonatal reaching. The first reach may be slow to appear but is frequently followed by a burst of reaching; a shorter presentation period fails to exploit these characteristics of early reaching" (*1*, p. 1138).. However, we used the period (2 minutes) used in Bower's original experiment, with which he earlier reported reaching. In the reanalysis of our videotapes (*4*), we detected no difference in the mean reaching rates between the first and second periods of observation under a given condition, nor any evidence for the type of delay followed by bursts of reaches which Bower *et al*. have now claimed to be typical. In addition, they have now suggested that 3 minutes is the best period of observation to use, yet have reported without comment an average rate of reaching to the object in the 3-minute period (approximately one reach per 24 seconds) which is about *six times slower* than the rate reported earlier for the 2-minute period (approximately one reach per $4^1/_2$ seconds).

The main conclusion to be drawn from this controversy is that it is vital to specify experimental conditions well enough to ensure that no similar dispute can recur. We are not alone in failing to replicate results from Bower's laboratory (*6*) and have here illustrated some of the reasons why this might be so. Since babies are highly variable in their behavior, investigators must at least specify their selection criteria, the proportion of subjects rejected, how state changes were manipulated or controlled, and what the range of individual variation in behavior was in the experiment, as well as give a full and clear description of how the investigation was conducted.

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## Primate Olfactory Behavior

Goldfoot *et al*. (*1*) purportedly made three male rhesus monkeys permanently anosmic in order to test whether olfactory cues are necessary in the sexual attractiveness of females. However, the olfactory discrimination task described in their reference 6 does not confirm "that a completely anosmic condition had been achieved." It seems inappropriate to infer that since the animal fails to recognize anise-scented monkey chow it cannot possibly recognize olfactory cues indicative of female sexual status. Recognition of olfactory cues associated with the fertile phase of the ovarian cycle would be an adaptively significant response to a biologically important stimulus. If small areas of olfactory epithelium remained intact after the ablation procedure, one might expect the animal to be unable to recognize normally unimportant olfactory stimuli, such as anise. However, one might expect recognition of biologically significant olfactory cues indicative of the fertile phase of the ovarian cycle.

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Goldfoot *et al*. (*1*) claim that intranasal application of cotton pledgets soaked in 10 percent formalin made their experimental rhesus monkeys permanently anosmic. Their evidence for anosmia was inability of the treated subjects to use the odor of anisole in a simple discrimination task. The conclusion that these subjects were anosmic may be unwarranted for several reasons. First, it has not been established that intranasal application of formalin will completely destroy nasal epithelial tissue or prevent the regeneration of olfactory receptor cells in areas of the olfactory epithelium coagulated by contact with formalin. There do exist detailed morphological and behavioral studies on effects of coagulation necrosis produced by intranasal syringing with zinc sulfate (*2*). Histological studies demonstrate that small pockets of olfactory epithelium are spared by the zinc sulfate treatment. This sparing may be due to air bubbles or mucus trapped in the ethmoturbinals. Regeneration of sensory cells occurs within about 10 days after treatment even after extensive irrigation of the nasal vault. Recovery of odor discrimination behavior occurs within 3 to 4 days after treatment. Treatment with formalin pledgets as described by Goldfoot *et al*. might be more effective than nasal irrigation with zinc sulfate, particularly if formalin vapors penetrated mucus barriers and coagulated tissue to the depth of the basement membrane. However, without histological confirmation, the assumption that the intranasal formalin treatment resulted in complete and permanent ablation of the olfactory sensory cells is unwarranted.

A second reservation concerns the behavioral evidence for anosmia. Animals were judged to be completely anosmic because of a "continued inability to perform an olfactory discrimination task . . ." (*3*). Anosmia means the loss of the sense of smell. The failure to perform on a single olfactory discrimination task is no more prima facie evidence for anosmia than failure to perform a visual discrimination is evidence for blindness. While performance failures may indicate the loss of a sensory capacity, it is essential to ensure that other factors such as changes in motivation, changes in response strategies, inadequate sampling of stimuli, increases in sensory threshold, and so forth do not account for discrimination failures. Behavioral studies of olfactory deficits should control for such factors and provide psychophysical measures of sensory capacity. As in research on visual, auditory, or other sensory functions, there appear to be no shortcuts for assessing adequately the effects of experimental treatments on olfaction.

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Hennessy and Slotnick express doubts as to the adequacy of our assessment of olfactory deficits, which we induced in adult male rhesus monkeys by inserting for 10 to 12 minutes cotton pledgets soaked with 10 percent formalin high into the nares where contact with olfactory epithelium was possible (*1*). We agree that additional confirmatory assessments of the olfactory disability would have been advantageous, particularly histological studies. Nonetheless, the dysfunction that we measured following our ablation procedure was so drastic that we remain confident that the males were anosmic throughout the course of the experiment.

The males were initially taught to reject biscuits with anise odors to avoid a noxious flavor of quinine. The task was acquired within 2 to 3 days of testing (12 presentations of each stimulus type per session) and was maintained at 85 to 90 percent correct performance 5 days per week for 3 to 5 weeks before formalin exposure. Testing continued two to three times per week after the anosmia procedure for the duration of the experiment (4 to 8 weeks) and was characterized by an abrupt fall in performance to chance levels, with no evidence of recovery. Additional concomitant performance changes (such as increases in sniffing food and threat displays and cage shaking after mistakes) suggested that motivation continued to be high to avoid the quinine taste.

In contrast, males exposed to zinc sulfate during pilot work were still capable of performing this task at above chance levels, with full recovery in approximately 2 weeks. Thus, our experience is in agreement with Slotnick's. Of course, the argument concerning this agent is spurious to the extent that we did not use zinc sulfate in the study reported in *Science*, nor did we use nasal syringing. Moreover, the olfactory system of the rhesus monkey presents an entirely different anatomical situation from that of small rodents to which Slotnick refers. Contrasted with rodents, rhesus monkeys have a much more restricted distribution of olfactory epithelium, no vomeronasal system whatsoever, and much less convoluted turbinates in which to trap air bubbles; all of these factors increase the chances that peripheral anosmia can be accomplished.

J. H. Brandenburg, head of the department of otolaryngology at the University of Wisconsin Hospitals, helped us develop the pledget technique and recommended formalin as the ablative agent since the vapors alone are caustic to epithelial tissue and could reach olfactory areas not brought in direct contact with the pledget. Brandenburg has seen two patients who suffered irreversible (greater than 2 years) anosmia after accidentally inhaling formalin fumes, and is aware of others with similar experiences (*2*). Thus, in humans formalin fumes alone are capable of destroying basal cells of the olfactory epithelium, without which regeneration of bipolar (sensory) cells is impossible.

Regarding the questions of using biologically relevant material and threshold psychophysics, there is no anatomical or physiological evidence of any regional distribution at the cellular level of different types of olfactory receptor cells in mammals, exclusive of the vomeronasal system, nor is there evidence to suggest that one type of receptor cell is more protected from formalin assault than any other. We assumed, therefore, that when our males could not use an odor cue to avoid the obviously noxious qualities of quinine-flavored food, our efforts had been successful. Psychophysical experiments would have been an elegant way of additionally assessing the effects of formalin, but no study to our knowledge has adapted the methodology of olfactory threshold psychophysics to Old World primates, and the specialized equipment and time to develop this technique were not available to us.

Our findings do not imply that rhesus monkeys never attend to odor to regulate sexual activity, but do show olfaction as unnecessary for detecting periovulatory periods.

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