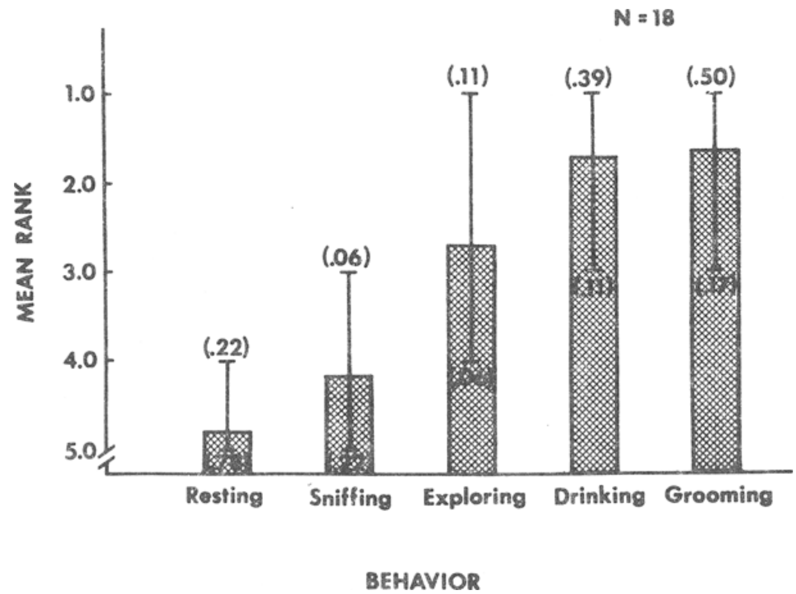

Fig. 2. Mean ranks of "integrated" multiple-unit activity for all sessions (vertical bars); the greatest amount of MUA received a rank of "1," etc. The vertical lines denote the range of ranks found for each behavior, and the numbers in parentheses indicate the proportion of times that these extreme ranks were reached.

underlying cause of the relationship seen here, it is clear that MUA level in the auditory system is not independent of ongoing behavior in the waking state. An important implication of this finding is that investigations of behavioral processes (e.g., learning) that employ MUA may confound a performance correlate with a presumed "process" correlate (e.g., "learning") unless the effect of ambient behavior itself is controlled or taken into account.

REFERENCES

WEINBERGER, N. M., GOODMAN, D. A., & KITZES, L. M. Is behavioral habituation a function of peripheral auditory system blockade? Communications in Behavioral Biology, 1969, 3, 111-116.

PODVALL, E. M., & GOODMAN, S. J. Averaged neural electrical activity and arousal. Science, 1967, 155, 223-225.

WINTERS, W. D., MORI, K., SPOONER, C. E., & KADO, R. T. Correlation of reticular and cochlear multiple unit activity with auditory evoked responses during wakefulness and sleep: I. Electroencephalography & Clinical Neurophysiology, 1967, 23, 539-545.

NOTES

1. Supported by Research Grant MH 11250 from the National Institute of Mental Health to N. M. Weinberger.

2. Trainee supported by Grant No. 11095 from the National Institute of Mental Health.

3. Weinberger, N. M., & Imig, T. J. Auditory system evoked activity during habituation of orientation in the rat. In preparation.

4. Ranking, rather than conventional analysis of variance, was used because the voltage output of the integrator while being monotonically related to spike rate was not linearly related across the entire range of unit activity.

Roughness discrimination with sandpaper surfaces: An olfactory confounding

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Enucleated rats were tested for acquisition of a rough-smooth discrimination in which the front and back surfaces of a piece of sandpaper served as discriminanda. Either lesions or experimental manipulations were used to reduce the possibility of animals following potential somesthetic and/or olfactory cues from the abrasive surfaces. Results showed an olfactory-somesthetic confounding common to some earlier experiments.

Abrasive papers have frequently been used as discriminanda to study learning and perception in normal animals (Cross & Rankin, 1962) as well as to study somatosensory discriminative capacities of lesioned animals (Benjamin & Thompson, 1959; Finger & Frommer, 1968a; Lovett, 1935; Semmes & Mishkin, 1965; Smith, 1939; Zubek, 1952). Sometimes, the abrasive discriminandum was paired with the surface of some other material (e.g., cardboard). In other experiments, the coarse side of the sandpaper was paired with the smooth, back surface of the same material in an attempt to eliminate the differential olfactory cues that would be present if two different materials served as discriminanda. In the present study, it is shown that even this procedure is inadequate to eliminate such olfactory confounding, at least in rats.

EXPERIMENT 1

Methods

Six naive male rats, weighing 225-325 g, served as Ss in the first experiment. All animals were enucleated under pentobarbital sodium (Nembutal) and were adapted to a 23-h food-deprivation schedule 2 weeks prior to the start of testing.

Apparatus and testing procedure were the same as those described previously (Finger & Frommer, 1968a). Briefly, a T-maze was used for discriminative testing. Front and back sides of a relatively coarse paper (Grade 360A aluminum oxide paper, Carborundum Co.), running on the floor of the maze from the choice point to the foodcups, served as rough-smooth discriminanda. Three Ss were assigned to be rewarded for choosing the rough surface, while the remaining rats received food for choosing the smooth surface. During testing (five trials/day), the tactile surfaces were shifted in the maze according to a semirandom procedure, so that the same stimulus did not appear more than three times in a row on a given side. Although both wings of the maze contained food, a screen prevented animals from eating after an incorrect choice.

After 150 trials of the initial task, a series of changes in the discriminanda was instituted to assess the roles of tactile and olfactory cues in guiding behavior. For blocks of 25 trials, one, or the other, or both possible discriminative cues were reduced. In the first manipulation, aluminum window screening was placed over both pieces of sandpaper so that tactile cues from the abrasive surfaces, but not olfactory cues, were diminished. Next, a deodorizer spray (Wizard) was applied to the sandpaper, and the screening was put over it, so that both tactile and potential olfactory cues were diminished. In the following block, the mesh was removed, and only spray was applied to the sandpaper. The original conditions were then reinstated to test whether or not disruptions in performance could be attributed to stimulus change.

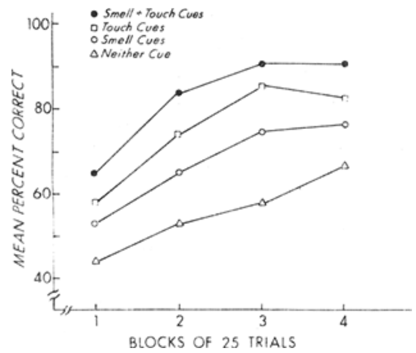

Fig. 1. Mean per cent correct for four groups as a function of blocks of 25 trials.

Results

The rats were 96% correct on the last 25 trials of the initial 150 trials of the rough-smooth discrimination (both tactile and olfactory cues available) and at 92% when this condition was reinstated at the end of the experiment. The first of a series of sign tests revealed that this difference was not significant ($p > .05$). The group mean was 91% without touch cues and 88% without smell cues, and this was not significant ($p > .05$). However, scores were lower with only tactile cues than they were on the last 25 trials of the original problem ($p < .05$). A sign test could not be applied to compare the olfactory cues condition with the original rough-smooth discrimination since two of six scores were tied, but the remaining rats showed lower scores when tactile cues were eliminated. Removing both cues dropped the group mean to 67%, and examination of individual scores revealed that all animals performed below, or just at, the chance level under this condition. Scores were significantly lower without tactile and olfactory cues than when one or both cues were present (all $p < .05$).

EXPERIMENT 2

Methods

Twenty-two naive male rats were used in the second experiment. The animals were assigned to one of two surgical groups. A scalpel blade was used to section the olfactory bulbs approximately 1.0 mm anterior to the frontal poles of 12 animals in the first group, making them anosmic. For 10 rats in the sham-operated second group, bone overlying the olfactory bulbs was exposed. All rats were blinded by enucleation. Two weeks were permitted for recovery.

For four normal and six anosmic rats, differential somatic cues were diminished by placing a fine wire screen over the rough and smooth sandpaper surfaces. These animals were tested in the T-maze as one squad. The remaining six anosmic and six normal rats were tested on sandpaper surfaces without screen as a second squad. The procedure was identical to that used in the first experiment, except that animals were sacrificed after 100 trials to confirm olfactory lesions by visual inspection.

Results

Acquisition curves for animals under the four experimental conditions are presented in Fig. 1. Animals whose behavior could be guided by both somatic and olfactory cues showed most rapid learning, and rats for whom both cues were diminished did least well. The accelerated learning curve exhibited by the latter group reflects the high scores of one animal with a severe, but incomplete, lesion. Most animals in this group performed at chance throughout testing. Rats for whom only tactile cues were available performed somewhat better than did rats for whom behavior could be guided by olfactory cues alone, and all animals in these groups performed above chance on Trials 76-100.

An analysis of variance on total errors proved significant at the .001 level. Duncan's multiple-range tests showed that animals whose behavior could be guided by smell and touch differed from animals presented neither cue at the .01 level, and that animals using smell did not differ from animals using touch ($p > .05$). Rats for whom two cues were available did better than animals for whom one cue was diminished ($p < .05$).

DISCUSSION

Results suggest that the front and back surfaces of a piece of sandpaper emit differential olfactory cues, possibly due to glue or print. They also show that most rats learned to attend to both somatic and olfactory cues when available, since removing one or the other cue marginally depressed performance, while removing both cues dropped the scores of most animals to chance. An olfactory confounding may, in part, account for the finding in an earlier report (Finger & Frommer, 1968a) in which some rats with large lesions in the somatosensory projections to the thalamus and cortex learned simple roughness discriminations as rapidly as did controls. A more recent study (Finger & Frommer, 1968b) has shown that rats with larger and better localized lesions, tested with discriminanda that eliminated olfactory confouding (milled aluminum plates), had severe deficits in acquiring tactile discriminations. The findings reported in studies with abrasive discriminanda comparable to those used in the present investigation must be re-evaluated, and future research should be conducted with plastic or metallic plates inscribed with different tactile features.

REFERENCES

BENJAMIN, R. M., & THOMPSON, R. F. Differential effects of cortical lesions in infant and adult cats on roughness discrimination. Experimental Neurology, 1959, 1, 305-321.

CROSS, H., & RANKIN, R. J. Tactile generalization in the rat. Psychological Reports, 1962, 11, 343-346.

FINGER, S., & FROMMER, G. P. Effects of somatosensory thalamic and cortical lesions on roughness discrimination in the albino rat. Physiology & Behavior, 1968a, 3, 83-89.

FINGER, S., & FROMMER, G. P. Effects of cortical lesions on tactile discriminations graded in difficulty. Life Sciences, 1968b, 7, 897-904.

LOVETT, D. Spinal mechanisms involved in solving problems in sensory discrimination: III. The ability of rats with spinal cord lesions to discriminate runways differing in tactual discrimination. Psychological Bulletin, 1935, 32, 540 (Abstract).

SEMMES, J., & MISHKIN, M. Somatosensory loss in monkeys after ipsilateral cortical ablation. Journal of Neurophysiology, 1965, 28, 473-486.

SMITH, D. E. Cerebral localization in somesthetic discrimination in the rat. Journal of Comparative Psychology, 1939, 28, 161-188.

ZUBEK, J. P. Studies in somesthesis: II. Role of somatic areas 1 and 2 in roughness discrimination in the cat. Journal of Neurophysiology, 1952, 15, 401-408.

NOTE

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