Forepaw food pellet grasping and consumption in rats following amygdaloid lesions

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Efficiency in grasping, manipulating, and consuming 45-mg food pellets by rats with preferred, nonpreferred, or either forepaw was tested before and after amygdaloid lesions or control procedures. Amygdaloid lesions did not alter forepaw preference but did significantly increase food wastage. The lesions also tended to decrease efficiency in grasping and manipulating food pellets when responses were restricted to a single paw. The results suggest that amygdaloid Ss may receive less effective reward than normal Ss in tasks which employ small food rewards and/or which place constraints on the manner in which delivered rewards are obtained.

Recently, Norton (1970) showed that amygdaloid lesions in rats produce a disruption in the temporal sequencing of response components in a leverpressing task. Since food rewards are quite frequently employed in investigations of amygdaloid function (e.g., Schwartzbaum, 1960; Thompson & Schwartzbaum, 1964; Kemble & Beckman, 1970) and since the grasping, manipulation, and consumption of food rewards is a response sequence required in such experiments, it seemed of interest to examine the effects of amygdaloid lesions on the efficiency with which food pellets are grasped and consumed. Secondarily, the experiment was designed to detect any possible lesion-induced changes in the forepaw preferred for grasping.

METHOD
Subjects
The Ss were 17 experimentally naive male albino rats (Holtzman Co.), weighing 216-241 g at the time of surgery. The data of two Ss was later discarded because of incomplete lesions.

Apparatus
Testing was conducted in an 18 x 6¾ x 10 in. chamber having ¼-in. plywood walls painted flat gray, a ceiling of clear Plexiglas, and a floor of ½-in. hardware cloth. One end wall contained two ½ x ¾ in. foodcups, placed ½ in. above the floor and flush with the side walls. The end wall was slotted to permit the insertion of adjustable 1/16-in.-thick aluminum barriers which made the right (only), left (only), or both foodcups available to S. During training the barriers were gradually extended to 15/16 in. beyond the end wall (and 7/15 in. beyond the foodcup), creating a 15/16 x 1/2 in. alcove which permitted access to the foodcup with the ipsilateral forepaw only. Trays placed beneath each foodcup were used to collect dropped pellets and food fragments dropped during consumption (wastage). Food pellets (45-mg Noyes) were delivered to each foodcup manually. Illumination was provided by a 40-W incandescent bulb, placed 8 in. above the ceiling of the apparatus, and extraneous sounds were attenuated by background white noise.

Procedure
All Ss' body weights were gradually reduced to 85% (±3%) of their ad lib value over a 5-day period by restricting daily food intake (Purina Lab Chow), with ad lib access to water throughout the experiment. During these initial 5 deprivation days, the Ss were trained to take 45-mg food pellets from both foodcups with the ipsilateral forepaw. This was accomplished by placing a barrier which permitted access to both foodcups flush with the end of the cups and gradually extending it to 15/16 in. by the fifth day. At this adjustment, Ss grasped and consumed food pellets rapidly and without any apparent difficulty (68-106 pellets in 10 min) but with access effectively restricted in all Ss to the ipsilateral forepaw. These training sessions were 15-30 min in duration and each S received 20 45-mg Noyes food pellets from each foodcup at each training session. The Ss received the remainder of their daily food ration 5-10 min after each session. When the Ss' body weights were stabilized at 85% (±3%) and training was completed (5 days), Ss were given 6 days of preoperative baseline tests. During the first 2 days, the Ss were allowed to grasp and consume pellets from both foodcups (two-paw test) for 10 min per day. On Days 3 and 4, Ss were permitted to grasp and consume food pellets for 10 min with their left forepaw only and during Days 5 and 6 with the right forepaw only. During these tests, the total number of pellets grasped with each paw, the number of pellets dropped with each paw, and the weight of food crumbs and fragments (wastage) was recorded. Baseline was considered the mean of each 2-day test. At the conclusion of baseline testing, Ss were deprived of food and water and received the appropriate surgical treatment 18 h later. Following surgical treatment, Ss were given ad lib access to food and water for 8 days. At the end of this time, all Ss exceeded their preoperative body weights and there were no significant weight differences between brain-damaged and control Ss. Next, Ss were again reduced to 85% (±3%) of ad lib body weight (2 days). The Ss were then given 1 day of two-paw access to food pellets, followed by 6 days of testing conducted exactly as preoperatively (two paw, left paw, right paw).

Surgery and Histology
All surgery employed pentobarbital anesthesia (40 mg/kg) supplemented by local application of Xylocaine. Amygdaloid lesions (N = 8) were produced by passing 2.0-mA anodal dc through the uninsulated tip of a stainless steel insect pin, which was stereotactically positioned 2.0 mm posterior to the bregma, 4.25 mm lateral to the midline, and 8.25 mm ventral to the cortical surface (head horizontal). To assess the possible contribution of the brain damage produced by electrode insertion into the amygdala, three operated control Ss were prepared exactly as amygdaloid Ss, except that a blunted 20-ga hypodermic needle was lowered 7.0 mm and withdrawn without passage of current. The remaining (N = 6) Ss received anesthesia and scalp incisions only (sham control Ss).

At the conclusion of testing, all amygdaloid and operated control Ss were intracardially perfused with isotonic saline and formalin solution while deeply anesthetized. During removal, each brain was carefully examined for damage to the trigeminal nerves. The brains were frozen and sectioned at 24 microns in the frontal plane. Every third section through the lesion area was stained with cresyl violet for histological examination.

Histological Results
A representative amygdaloid lesion and electrode track from an operated control S are depicted in Fig. 1. Six Ss sustained bilateral amygdaloid damage, with consistent damage in the area of the lateral, basal, cortical, and central nuclei as well as
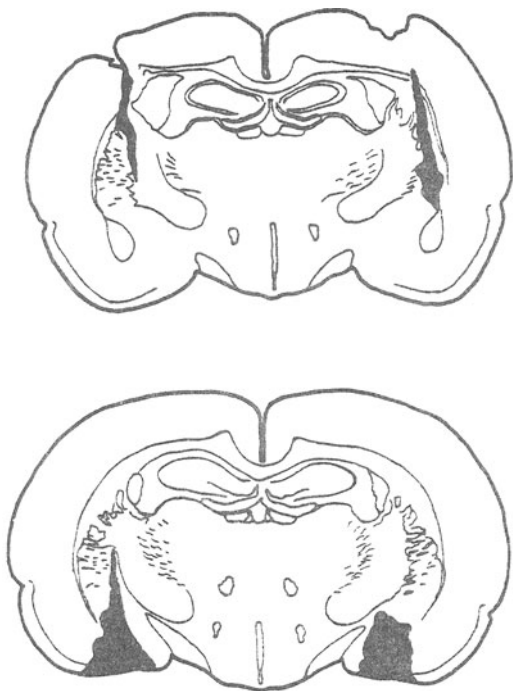
Fig. 1. Representative coronal section of operated control S (upper section) and amygdaloid S.

pyriform cortex. The medial amygdala optic tracts and trigeminal nerves were consistently spared. There was no obvious relationship between lesion size and behavioral deficit. Two Ss sustained unilateral amygdaloid damage paired with damage to the trigeminal nerve lying ventral to the contralateral amygdala. It is interesting to note that the performance of these Ss was well within control values. As can be seen in Fig. 1, the blunted 20-ga needle lowered in operated control Ss produced a large electrode track which produced greater damage to structures lying dorsal to the amygdala than was noticed in amygdaloid Ss.

RESULTS AND DISCUSSION

Initial analyses failed to reveal any reliable differences between operated control and sham control Ss either pre- or postoperatively (ps > .10). The data for these two groups was pooled for further analyses. Paw preference was determined by calculating the percentage of total responses made with each paw during the two-paw tests. Preoperatively, both amygdaloid and control Ss showed considerable variability in paw preference (amygdaloid, 51.8%-100.0%, $\bar{X}$ = 61.7%; control, 54.6%-89.2%, $\bar{X}$ = 61.5%). The postoperative performance of these groups was also quite variable (amygdaloid, 46.4%-100.0%, $\bar{X}$ = 55.1%; control, 7.2%-99.0%, $\bar{X}$ = 61.1%), with one amygdaloid S and three control Ss showing a change in the preferred paw. There was no suggestion of a consistent preference change in either group, however (ps > .10).

The amygdaloid and control Ss did not differ preoperatively in the number of pellets dropped or total responses (number of pellets grasped) made with two paws, preferred paw, or nonpreferred paw (ps > .10). Also, there was no difference in food wastage (p > .10). Therefore, postoperative performance was expressed as a percentage of preoperative (baseline) performance. The postoperative performance of amygdaloid and control Ss is summarized in Table 1. It can be seen that the amygdaloid Ss did not show any reliable decline in efficiency when allowed to use either forepaw (ps > .10). When the amygdaloid Ss were restricted to their nonpreferred paw, however, they tended to make fewer responses than control Ss (U = 12, p < .10) and dropped more pellets (U = 9, p < .05). When responses were restricted to the preferred paw, amygdaloid Ss made fewer responses (U = 6, p < .02) but did not differ from control Ss in the number of pellets dropped (p > .10). The amygdaloid Ss also showed significantly greater postoperative food wastage than did control Ss (amygdaloid, 108.6%-844.3%, $\bar{X}$ = 271.1%; control, 41.7%-198%, $\bar{X}$ = 96.5%; U = 6, p < .02).

The increased food wastage noted in this experiment indicates that amygdaloid lesions reduce the efficiency of consumption of small food rewards. This result is quite consistent with repeated informal observations of

Table 1
Postoperative Performance of Amygdaloid and Control Groups Expressed as a Percent of Baseline (Preoperative) Performance Level

Condition	Group	Percent Baseline	Range	p
Total Responses				
Two-Paw	Amygdaloid	92.3	78.9-117.6	n.s.
	Control	100.7	90.3-120.7	
Preferred Paw	Amygdaloid	95.6	89.4-110.2	< .02
	Control	108.7	95.6-127.4	
Nonpreferred Paw	Amygdaloid	87.1	40.0-108.3	.05 < p < .10
	Control	104.2	96.7-116.6	
Pellets Dropped				
Two-Paw	Amygdaloid	94.5	48.5-128.6	n.s.
	Control	83.3	50.9-116.3	
Preferred Paw	Amygdaloid	116.3	59.7-169.0	n.s.
	Control	84.4	40.2-165.0	
Nonpreferred Paw	Amygdaloid	119.8	66.6-137.6	< .05
	Control	80.2	39.0-155.0	

large amounts of food wastage by amygdaloid Ss in our laboratory. The experiment also indicates that amygdaloid Ss experience difficulty in efficiently grasping, manipulating, and consuming small food pellets when they are restricted to use of a single forepaw. This deficiency, when combined with increased food wastage, may significantly lower the effective rewards obtained by amygdaloid Ss in tasks which employ small food rewards (e.g., single 45-mg food pellets) and which place constraints on the manner in which the food may be grasped and consumed. Clearly, the size and kind of food reward employed and the manner in which it is obtained must be carefully considered in planning or interpreting the results of studies of amygdaloid function which employ food rewards.

The results of this experiment also suggest the need for a careful analysis of lesion-induced changes in response components which may be common to, or alter the results of, a variety of more molar behavioral tests. Such analysis is continuing in our laboratory.

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