Bandage-backfall reaction: Occurs in infancy, hypothalamic damage, and catalepsy

(aphagia/catecholamines/development/recovery)

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ABSTRACT In cataleptic clinging, produced either by catecholamine-blocking drugs or lateral hypothalamic damage in adult cats, rats, or monkeys, bandaging the face and neck causes the head to fall backwards. Early in development, a similar reaction can be seen in normal undrugged infants.

Cats that become aphagic after lateral hypothalamic damage often are also cataleptic (1, 2). During the first postoperative week or so, though such an animal does not eat, drink, walk, or orient to sensory stimuli, it will cling reflexively with its forelimbs for long periods when placed on the back of a chair, supporting some of its weight also on its hind legs and keeping its head up right (Fig. 1, top left). Similar cataleptic clinging (Fig. 1, bottom left) is produced by bulbocapnine (3), an alkaloid that antagonizes catecholamine systems in the caudate nucleus (4). To discover whether vision is important in allowing a cat to keep its head erect during bulbocapnine-induced clinging, Van Harreveld and Bogen (3) covered the eyes by bandaging the entire head and neck. The animal's head then fell slowly backwards (see Fig. 1, bottom right), eventually becoming extremely dorsiflexed. At this occurred, the forelimbs extended and the forepaws gradually released their grasp, causing the animal to fall backwards off the chair.

Van Harreveld and Bogen called this the backfall reaction. In further analysis, they showed that, contrary to their original belief, lack of vision does not cause the reaction. In darkness, cataleptic animals still cling, keeping head erect. If head and neck are bandaged without covering the eyes, the backfall reaction still occurs. However, if the ophthalmic, mandibular, and maxillary branches of the trigeminal nerve are sectioned bilaterally, along with the dorsal rami of the first three cervical nerves, thus diminishing the effect of pressure on sensory fields in face, scalp, and neck, the bandage-backfall reaction does not occur (3).

As mentioned above, in our studies of aphagia and adipsia produced by lateral hypothalamic damage in cats, we also found cataleptic clinging. As will be described below, when we bandaged the head and neck of such cataleptic aphagic cats the backfall reaction occurred (2). In the present paper, we further explore the generality of this interesting reaction: (a) we repeated some of Van Harreveld and Bogen's observations in bulbocapninized cats and extended them to rats and monkeys; (b) to further assess its dependence on catecholamine systems in the brain, we determined whether the reaction would appear during the catalepsy produced by haloperidol or pimozide; and (c) because of a previously demonstrated parallel between stages of recovery from aphagia in adult hypothalamic-damaged rats and stages of development of the regulation of feeding and drinking in infancy (5, 6), we tested for the backfall reaction

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in normal infant animals. As will be described below, we were successful in demonstrating the bandage-backfall reaction in all these circumstances.

MATERIALS AND METHODS

Because different numbers of animals were used in the various experiments, we will cite the number used at the appropriate point in the presentation of the results. When adult cats are specified, they were female, weighing approximately 2.5-3.5 kg, supplied by Sleepy Hollow Cattery, Mundelein, Ill. The rats used were male, weighing between 237 and 416 g. They were either brown rats of the ACI/Cox strain (Laboratory Supply Company, Indianapolis, Ind.) or hooded rats of the Long-Evans strain (Blue Spruce Farms, Alamont, N.Y.). One male rhesus monkey, weighing approximately 5 kg, was also tested. All adult animals were housed individually in the animal colony of the Psychology Department of the University of Illinois. Infant kittens from one litter, reared in the colony at Illinois, and a second litter, home-reared, were also tested. Infant New Zealand white rabbits, all from one litter, and a litter of home-reared, mongrel puppies were also tested. Infant primates were reared and tested at the Illinois Institute for Developmental Disabilities, Chicago, Ill.

For stereotaxic surgery, cats were anesthetized with Nembutal, 35 mg/kg intraperitoneally. The head was shaved, and the scalp was cleaned with 70% alcohol. The animals were placed in a Kopf stereotaxic instrument, and under sterile surgical conditions, the scalp was incised, the skull was opened, and electrolytic lesions were produced bilaterally in the lateral hypothalamus (A 11.0, L 3.0, H −4.0 in the coordinates of ref. 7). With a stainless steel anodal electrode, 0.5 mm in diameter, insulated with Formvar except for 1.5 mm at the conically ground tip, direct current of 3 mA was passed for 90 sec at each lesion site. A rectal cathode served as the indifferent electrode.

Eventually, after behavioral testing, all animals subjected to brain damage were sacrificed. After intracardiac perfusion with saline followed by 10% formalin, the brain was removed and preserved in 10% formalin. After embedding in egg-yolk medium, the brain was frozen and sectioned at 40 μm. The sections were mounted and stained with cresyl violet. The extent of damage was evaluated by camera lucida tracings which were compared to corresponding sections from a stereotaxic atlas of the cat brain (7).

To assess cataleptic clinging, each cat was placed on the back of a chair (see Fig. 1, top left). If they clung with their forelimbs for several minutes at a time, supporting their weight partially with hind limbs, while keeping head and neck erect, they were judged to be cataleptic. A similar test was applied to the monkey. Cataleptic rats were placed on two 3.2 mm diameter stainless steel bars, 19 cm long, mounted horizontally in Plexi-
RESULTS AND DISCUSSION

Histology

The brains of five cataleptic aphagic cats have so far been analyzed histologically. (Photomicrographs and histology on all 10 animals will be presented in a later, more detailed paper.)

The largest lesions extended from the anterior hypothalamus to the posterior portion of the mamillary bodies. The lesions generally extended laterally to involve the medial margin of the internal capsule and dorsally to the ventral border of the thalamus. Ventrally, the extent of damage was more variable, sometimes approaching the base of the brain. In all these animals the nigrostriatal bundle (traversing the dorsal lateral aspect of the lateral hypothalamus) and the medial forebrain bundle were extensively damaged bilaterally.

Behavioral effect of bandaging the head and neck

In Lateral Hypothalamic Cats. Like the bulbocapnine-intact cats reported by Van Harreveld and Bogen (3), undrugged lateral hypothalamic cataleptic-aphagic cats (n = 10) also slowly fall backwards from a clinging position, when the head and neck have been wrapped in a bandage (Fig. 1, top right). After a few days (range 1 to 12), as the animals recover and begin to walk spontaneously, clinging and backfall no

FIG. 1.  Top left: Undrugged adult cat, 2 days after bilateral lateral hypothalamic damage, clinging cataleptically. Top right: bandaging the head and neck produces the backfall reaction. Bottom left and right: from van Harreveld and Bogen (3). Left: bulbocapnine-induced cataleptic clinging in intact adult cat. Right: bandage-backfall in bulbocapnine catalepsy.
FIG. 2. Top left: Newborn kitten (24 hr old) clings to the experimenter's hand, keeping head and neck erect. Top right: the bandage-backfall reaction in the newborn kitten. Middle left: 2-week-old normal puppy. Middle right: bandage-backfall reaction in the puppy. Bottom left: a 2-week-old baboon clings to the experimenter's fingers, keeping head and neck erect. Bottom right: bandage-backfall reaction in the infant baboon.

longer occur. Instead, like normal animals, they climb upwards over the back of the chair or turn to the side and jump down to the floor.

In Drug-Induced Catalepsy. We verified Van Harreveld and Bogen's findings: bulbocapnine hydrochloride in three cats (20–40 mg/kg intraperitoneally) produced cataleptic clinging and the bandage-backfall reaction. Similar clinging and backfall were seen in one adult male rhesus monkey (50 mg/kg intraperitoneally) and five hooded rats (80 mg/kg intraperitoneally). Catecholamine-blocking agents, such as haloperidol (25 rats, (5 brown, 20 hooded), 5 mg/kg) or pimozide (5 hooded rats, 10 mg/kg) also produced catalepsy and backfall. Thus, the bandage-backfall appears when brain catecholamine (perhaps merely dopamine) systems are inactivated.

In Normal Infancy. Our earlier work had shown that the sequence of stages of recovery of eating and drinking seen in the adult lateral hypothalamic rat parallels the development of feeding and drinking in infancy (5, 6). The bandage-backfall reaction in the lateral hypothalamic-damaged cat is present only during the initial, cataleptic-aphagic, stage of the syndrome. As recovery proceeds, it disappears (2). If some aspects of the recovery–development parallel hold for catalepsy as they do for feeding and drinking, the bandage-backfall reaction should appear in very young normal infants. Then, as encephalization proceeds with age (9), it should disappear.

The normal newborn kitten clings and holds its head erect (Fig. 2, top, left). When its head is bandaged (Fig. 2, top, right), the head falls backward, the grasp is inhibited, and the kitten will fall backward if allowed. This was seen in all 10 kittens from two litters, tested as early as 24 hr after birth. [If a kitten
is activated by an excessively tight bandage, it will struggle vigorously, and the backfall does not appear. Similarly, in an adult drugged or brain-damaged animal, activation by painful tail-pinch can counteract cataleptic clinging (2). The backfall was present for as long as 3 months, although towards the end of that period sideways rolling and jerking movements modify it as neck muscle control appears to develop further. Eight mongrel puppies (see Fig. 2, middle left and right; 2 weeks old, all from one litter) and seven baby rabbits (1 litter, 11 days of age) also showed the backfall reaction when bandaged.

We also tested some infant primates. In Fig. 2, bottom left, a 2-week-old baboon (Papio hamadryas) clings vigorously, holding its head erect. When bandaged snugly, the head falls backward to a position of extreme dorsiflexion. (Fig. 2, bottom right) Four crab-eater infant monkeys (Macaca fascicularis) ranging in age from 1 to 12 weeks also clung with head erect, but when bandaged showed the backfall. If the animals are bandaged loosely, the backfall does not appear in kittens (n = 5), infant monkeys (n = 2), or rabbits (n = 7); therefore the pressure of the bandage, not its weight (7–15 g) appears essential in such infants. Because the bandage-backfall reaction appears in primates, we sought it in humans. In work to be described in further publication, we have demonstrated it in severe human parkinsonism and in normal human infants.

Other postural systems also appear susceptible to inhibition by bandaging. We have found that bandaging a normal adult cat tightly around the lower abdomen causes its hind legs to become ataxic or to crumple altogether (n = 4). Activation, by tail pinch, or merely the sight of a mouse, can counteract the effect of the bandage, as it does some other cataleptic phenomena (2, 10). Grasping the skin of an adult cat's back tightly over the shoulders will cause its forelegs to crumple; over the pelvis, the hind legs collapse (n = 2). Similar phenomena have been described by Roberts (11), and may be related to techniques used in the handling and restraint of cattle (12).

In summary, the adaptive value of the bandage-backfall reaction and the neurophysiological mechanisms underlying it are still not fully understood. Observed earlier by Van Harreveld and Bogen (3) in bulboepiparnized adult cats, it is clear from the present work that the reaction is a normal infantile behavior pattern that occurs in several species, including primates. Soon after a normal infant is able to hold up its head, the bandage reaction can be demonstrated. Later, it disappears. A possible explanation is that infantile inhibitory pathways (from bandaged receptors) are themselves inhibited by later developing catecholaminergic brain systems. In adults, lateral hypothalamic (perhaps merely nigrostriatal) damage or drugs that antagonize catecholamine systems can produce catalepsy. In that state, the primitive inhibitory system appears to be released, and, as in normal infancy, a bandage around the head and neck will once again cause the backfall reaction.

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