Changes in locomotor activity following basal forebrain lesions in the pigeon*

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Adult male pigeons (*Columba livia*) were used to study the effects of basal forebrain lesions upon a measure of responsiveness to the environment, locomotor activity. Daily activity as well as food and water intake and body weight were recorded for Ss through various experimental test phases. Significant reductions occurred in activity scores of all but one experimental S following lesioning, with no changes occurring in controls during comparable test periods. Intrasession analyses of activity showed a tendency for lesion-produced activity depression to affect initial period scores most severely. Small lesions were identified in the parolfactory lobe and paleostriatum or anterior (ventral) thalamic and hypothalamic areas. A possible neuroanatomical explanation for these results was discussed.

The forebrain has been found to be a focal point for the investigation of the control and regulation of a variety of behaviors; for example, lesions in basal forebrain areas in mammals have been reported to produce changes in activity (Gladfelter & Brobeck, 1962), feeding (Brobeck, 1960), or drinking (Anand & Dua, 1955), and, sometimes, rather complex multiple behavioral effects (Hetherington & Ranson, 1942).

Research which has systematically investigated the role of avian forebrain structures in such behaviors is less numerous and has yielded a less clear picture regarding the underlying neural mechanisms. Several studies involving widespread forebrain destruction in birds (Rogers, 1922; Tuge & Shima, 1959) have noted some reduction in "spontaneous" activity accompanied in some cases by abnormalities in one or more other reactions, e.g., sexual behavior, feeding, defensive conditioned reflex, and a variety of postures and movements. Ablation restricted to the dorsal forebrain, specifically hyperstriatum, has been shown by Zeigler (1963) to be effective in producing a reduction in locomotor activity, accompanied by a suggested lessening of responsiveness to stimulation; such lesions had no apparent effect upon feeding and drinking or normal postures and movements. Yet, changes in feeding have been demonstrated in birds with basal forebrain lesions (Zeigler, Green, & Karten, 1969), as have changes in drinking (Akerman, Fabricius, Larsson, & Steen, 1962); some incidental mention of changes in activity level, in some cases, has been

made (Feldman, Larsson, Dimick, & Lepkovsky, 1957).

The purpose of the present study was to investigate the effects upon activity of basal forebrain lesions, particularly in those areas known to maintain neural connections with dorsal forebrain structures which have been shown to affect locomotor behavior in the pigeon. Potentially, such measured behavior was seen to be of considerable importance in relation to the larger question regarding central control of the organism's tendency to sample and/or respond to its environment.

METHOD

Twelve male adult White Carneaux pigeons (*Columba livia*) were housed in individual cages under controlled lighting (12 h light/12 h dark) and temperature (70°F). Food (mixed grains), grit, and water were available on an ad lib schedule in the home cage.

Surgery was performed on Ss anesthetized with sodium pentobarbital (35 mg/kg, IP). Electrodes were chronically implanted bilaterally in the basal forebrain in an area extending from the anterior hypothalamus and the parolfactory lobe [AP 7.5-9.5, according to the Karten & Hodos atlas (1967)].

Activity was measured while individual Ss were in a brightly illuminated glass-fronted box, 32 x 17 x 23 in. The floor was divided into six equal parts by three positioned sets of photoelectric beams and cells within the box (3 in. above the floor). Locomotor activity (horizontal movement) producing photobeam interruptions were recorded by an event recorder.

All Ss were tested prior to surgery (Phase 1). Each pigeon was given 14 daily 45-min test sessions, during which activity was measured and direct observations made from an adjoining room through a one-way

glass. Animals were tested at the same time daily in order to minimize individual variability possibly related to circadian rhythms. When Phase 1 testing was completed, all Ss had electrodes implanted. Following recuperation, 14 more daily testing sessions were run (Phase 2). When this phase of testing was completed, experimental Ss were lesioned electrolytically via indwelling electrodes; 2-mA anodal dc current was applied for 10-15 sec. Following a 2-day interval, experimental and control (implanted but unlesioned) Ss were tested for 14 more consecutive days (Phase 3).

Following all testing, animals were sacrificed and perfused through the heart with normal saline followed by formal-saline. Frozen brain sections of 100 microns were stained for fiber and cell body identification (Wolfe & Yen, 1968).

RESULTS

Food and Water Intake and Body Weight

Neither the daily food, water, nor body weight measurements indicated a significant change over days. Only a slight disruption in all three measures resulted in 7 of the 12 Ss immediately following surgery. Changes in any individual's weight never exceeded 6% of its mean weight in the preceding phase. Food and water intake changes for any individual never exceeded 7% of the mean intake in the preceding phase.

Locomotor Activity Test

Locomotor activity was extremely variable among sessions, especially in Phase 1. Phase 1 and 2 activity scores were compared within the experimental and control groups; both groups showed similar effects, i.e., a

Fig. 1. Mean locomotor activity scores for 14 sessions each in Phases 2 and 3 for basal forebrain-lesioned Ss and unlesioned controls.

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would appear to be consistent with those obtained with rats (Gladfelter & Brobeck, 1962).

Interestingly, Zeigler (1963) produced locomotor activity reductions with lesions in the dorsal forebrain, the hyperstriatum, whereas basal forebrain lesions were employed in the present study. Neural fibers have been shown to leave the accessory hyperstriatum and dorsomedial hemisphere, combining to form part of the descending septomesencephalic tract in the avian forebrain (Adamo, 1967; Ariens-Kappers, Huber, & Crosby, 1967). Portions of this tract pass to the paleostriatum, preoptic, and anterolateral hypothalamic areas. As well, there is a variety of ventral forebrain fiber groupings connecting telecephalic (e.g., parolfactory lobe, paleostriatum) and diencephalic (e.g., thalamus, hypothalamus) structures (Ariens-Kappers, Huber, & Crosby, 1967). Perhaps such forebrain fibers of passage and/or termination, relating dorsal and ventral forebrain areas, were destroyed in the present study, thus possibly disrupting a functional neural circuit between these two areas.

The present study identifies only a part of the neural network involved in the control of locomotor activity, a system which may be critical for such behaviors as exploration and defense or in the control of the arousal under different levels of external stimulation. Further neuroanatomical and behavioral study is required to establish the basal and other forebrain structures which control the responsiveness of avians to their environment.

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- Eleftheriou, 1963; Thiessen, 1964; Bailey, 1966; Essman, 1966; Sigg et al, 1966; Louch & Higginbotham, 1967; Anton, 1969; Archer, 1969a, b). These experiments often differed with regard to the initial housing of the animals immediately prior to separation into experimental categories of different density. There are two likely explanations for the difference in adrenal function between isolated and grouped male mice. The classical one is that of Christian et al (1965), stating that the increasing density to which animals in larger groups are submitted leads to an increase in adrenocortical activity and to a depression in gonadal function. Another interpretation is the reverse of this argument, namely, that a decline in density leads to the activation of the pituitary-gonadal function, which, in the case of the male, results in an androgen mediated depression in adrenal size and function (androgens are known to depress adrenal weight). It was thought to be pertinent to attempt to determine if either of these two interpretations was true, and an experiment was devised in which both the initial and the subsequent housing of young male mice were varied and the consequent effects of these treatments on adrenal weight were described.

METHODS

Young male mice of the albino TT strain (originally obtained from A. Tuck & Sons, Ltd., Essex) utilized in this study were from breeding cycles which are described in more

The effect of prior housing on adrenal response to isolation grouping in male albino mice*

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An investigation was carried out to determine if immediately prior housing conditions had any effect on the subsequent adrenal response to isolation grouping in young albino male mice. It was found that previous isolation appeared to accentuate the response to pairing and that the decline in relative adrenal weight following isolation of initially paired mice was not so marked.

It has been previously shown that Tuck albino TT strain mice which are isolated differ from grouped animals with respect to a number of behavioral and physiological parameters. The single female has a heavier adrenal, a lower "basal" level of plasma corticosterone, a heavier ovary and hemiuterus, and is more likely to be in estrus than its grouped counterpart (Brain & Nowell, 1970c). The isolated male, on the other hand, has a lighter adrenal, lower plasma levels of corticosterone (both "basal" and "stressed"), a heavier ventral prostate (indicative of increased androgen production), and is more aggressive than its grouped counterpart (Brain & Nowell, 1969b, 1970b). In a study on the effects of differential grouping on mature males of this strain, these results were confirmed, but it was also found that paired mice exhibited a somewhat greater response to grouping in terms of increased adrenal weight, elevated levels of "basal" plasma corticosterone, and depressed ventral prostate weight than did some larger groups (Brain & Nowell, 1970a).

Many studies have been carried out on the effects of grouping on adrenal weights of male mice, often with conflicting results (e.g., Christian, 1955a, b; Southwick & Bland, 1959; Vandenberg, 1960; Welch & Klopfer, 1961; Thiessen et al, 1962; Bronson &

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