Is the Medial Nucleus of the Amygdala Important for Mating in Male Mice?

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This research was supported by the Howard Hughes Medical Institute under Grant No. 52003071,
the National Science Foundation (NSF) Research Grant IBN-9974530 and the Center for Behavioral Neuroscience under NSF Grant #IBN-9876754.

Abstract:
Chemosensory perception through the olfactory system in mice and many other rodent species plays an important role in the mediation of a variety of social behaviors. The medial nucleus of the amygdala (MNA) receives converging chemosensory information from the main and vomeronasal olfactory systems, and is likely to be involved in the chemosensory regulation of certain social behaviors. The present study is designed to determine the effect of MNA lesions on mating in male mice. Although stereotaxic maps for the mouse can provide approximate brain coordinates for the MNA, mouse strain and age-related brain variation make it necessary to empirically determine lesion coordinates. Through inspection of stained brain slices of seven lesioned animals, we determined that the lesion electrode should be placed 1.1 mm behind Bregma, 2.25 mm to each side of midline, and 5.85 mm below the surface of the skull, with .8 mA current passed for one second. Using these parameters, sexually active males will receive either bilateral lesions of the MNA or will be sham-operated. After recovery from surgery males will be tested for mating behavior with receptive females. This study is a first step towards establishing the importance of the MNA for mating in the male mouse, and, has particular relevance for understanding the neural circuits involved in the chemosensory regulation of social behaviors in this species.

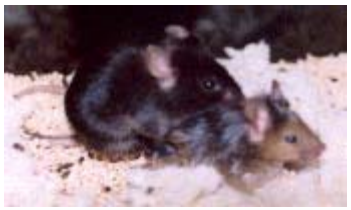
INTRODUCTION

The olfactory system in rodents (and probably most other mammalian species) consists of two anatomically distinct subsystems (see Figure 1). The main olfactory system originates in the olfactory epithelium of the nasal septum and projects neurons to the main olfactory bulbs. The epithelium of the vomeronasal organ at the base of the nasal septum projects neurons through the vomeronasal nerve to the accessory olfactory bulbs. Damage to both systems, either by removal of the olfactory bulbs or by damage to the mail olfactory epithelium combined with either removal of the vomeronasal organ or transection of the vomeronasal nerve, produces profound social behavioral deficits, including the elimination of:

- Maternal behavior
- Intermale aggression
- Male and female sexual behavior

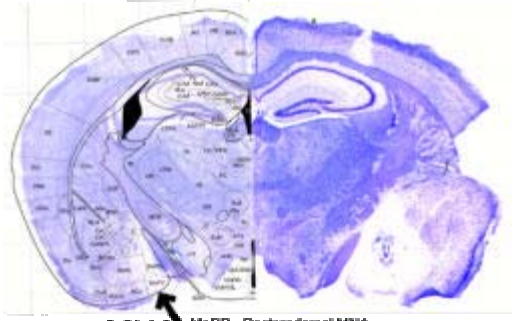
The medial nucleus of the amygdala (MNA) receives direct projections from the accessory olfactory bulb, and (via inputs from the cortical nucleus of the amygdala) receives input from the main olfactory bulb. Thus, the MNA represents the first point of neural convergence for chemosensory information from the main and vomeronasal olfactory systems, and is likely to be involved in the regulation of both intermale aggression and mating. Mehta & Edwards (1999, unpublished) showed that bilateral lesions of the MNA eliminate intermale aggression in mice. The present study was initiated to determine the effect of bilateral lesions of the MNA on mating behavior in the male mouse.

3a) Mice Mating - Intromission



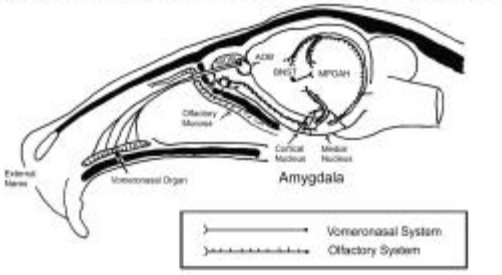
3b) Mice Mating - Ejaculation

1) Bilateral MNA Lesions



Lesions were made by passing .8 mA current through a 25mm electrode for 2 seconds; Shown, 50 uM brain slice, 1.34mm posterior to bregma. The lesions are in the right place, but very large. Note: the chip on the right side was made during histology to identify the right hemisphere.

2) Schematic Representation of Olfactory and Vomeronasal Pathways



Abbreviations: A/MOB, Accessory/Main Olfactory Bulb; BNST, bed nucleus of the stria terminalis; MPOAH, medial preoptic area; VP, ventral pathway from MNA to MPOAH.

* Redrawn from Behavioral Ecology, Becker et al. 1992

Methods:

Male and female retired breeders of the CrlːCFW (SW) BR strain were commercially obtained (Charles River). Although stereotaxic maps for the mouse can provide approximate brain coordinates for the MNA, mouse strain- and age-related brain variation made it necessary to empirically determine lesion coordinates for our males. To do this, using coordinates used by Mehta and Edwards (1999, unpublished) some males were lesioned (0.8ma anodal current for 1-3 seconds in each hemisphere) and sacrificed after 3-5 days by cervical dislocation. Killed mice were immediately perfused through the heart with 0.9% saline followed by 10% formalin. Brains were removed and preserved in formalin. Several days later frozen 50 um sections were taken throughout the extent of brain damage. Sections were subsequently stained with thionine and brain damage was traced onto histology sheets prepared from drawings in the Franklin and Paxinos stereotaxic atlas of the mouse brain (Figures 2 and 3). As determined from inspection of these drawings, to make lesions of the MNA for the males in our study the lesion electrode should be placed 1.1 mm behind Bregma, 2.25 mm to each side of midline, and 5.85 mm below the surface of the skull. Current should be passed at .8 mA for no more than 1.5 seconds.

Females were ovariectomized and, beginning one week later, were given estrogen and progesterone each week to induce sexual receptivity. Males were paired twice each week with receptive females for a one-hour test. Only males who mated to ejaculation will be used in the experiment proper.

Future Directions:

Males selected for the study will be randomly divided into two groups. Some males will be anesthetized and given bilateral lesions of the MNA using the coordinates detailed above. Remaining males (sham-operated controls) will be treated identically with the exception that no current will be passed to the electrode. Beginning about two weeks after surgery, lesioned and control males will be tested for mating behavior twice each week with receptive females for a total of four tests. The number of mounts, intromissions and ejaculations will be noted for each male for each test. If electrolytic lesions of the MNA decrease mating, a second study of the effect of excitotoxin (and thus axon-sparing) damage to the MNA will be performed. Taken together, studies of the effects of electrolytic and excitotoxin lesions of the MNA on male sexual behavior in the mouse can show the importance of neurons intrinsic to the MNA for the regulation of mating in this species. Given the olfactory connections of the MNA, these studies have particular relevance for understanding the neural circuits involved in the chemosensory regulation of mating and, perhaps, many other social behaviors in this species.