Simultaneous activations of main and accessory olfactory bulbs in mice by fMRI

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INTRODUCTION

The mammalian olfactory system consists of two major pathways: the main and accessory systems. It is generally believed that the functions of the two systems are distinct: the main system processes common odors and mediates the sense of smell, while the accessory system is more specific for pheromones and mediates specific behavioral and endocrine responses (1). A few studies provide preliminary evidence that this distinction may not be absolute (2-3). Here we systematically test the hypothesis that the two systems have a greater degree of complexity in their responses across odor space than is generally realized by measuring the activities in the main and accessory olfactory bulb (MOB and AOB) simultaneously with high resolution fMRI.

EXPERIMENTAL

Female C57BL under urethane anesthesia were stimulated with iso-amyl acetate, 2-heptanone, or urine from strains B6.AKR:H-2^k and .AKR:H-2^b in this study. All data were acquired on a modified 7T Bruker Biospec. Imaging experiments were performed using fast low-angle single-shot (FLASH) gradient-echo sequence. T_1-weighted FLASH anatomical images have resolution of 100x100x200 μm. Each fMRI experiment contained a series of 24 T_2^*-weighted FLASH images (resolution = 200x200x200 μm). The mean image of the pre-stimulation "baseline" images was subtracted from the "stimulation" images on a pixel-by-pixel basis to generate student *t*-maps, which were overlaid onto the corresponding anatomical images to locate the activated region in the laminar structures. The activity map of the entire glomerular layer was constructed from a collection of individual slices with computerized software [4]

RESULTS and DISCUSSION

The odorant 2-heptanone has a fruity odor quality and known pheromonal functions in the mouse. It activated both the MOB and the AOB (Fig. 1). In the dorso-lateral region of the MOB, a focus peaked at slice 2 (thin arrow) and in the dorso-medial region, another focus peaked at slice 4 (thick arrow). The two foci may correspond to the mirrored projection of the receptor neurons to the MOB. The activity in the AOB (white circle) was located in the anterio-dorsal region. Mouse urine contains hundreds of volatile compounds including pheromones, thus it activated the MOB (Fig. 2a). Unexpectedly, the activation was largely limited to the ventral regions glomerular layer, despite the wide variety of potential odor compounds present. This indicates that there are strong component interactions in the complex mixture of odorants. In the AOB, the activity is found mainly in the anterio-dorsal region, to which the V1R vomeronasal neurons project (Fig. 2b). It has been demonstrated that these neurons can be activated by mouse pheromones [5]. Therefore, the results correlated well with the peripheral studies. It is well known that urine odors carry important signals between conspecifics of different strains. The urine odors from two different strains give rise to different odor maps in both the MOB and the AOB (Fig. 2). In both structures, urine from strain B6.AKR:H-2^k showed a stronger activation pattern than that from C57BL6: H-2^b. The patterns and the relative intensity in the MOB correlated well with previous works [6]. In conclusion, this study demonstrates that the AOB and MOB can both respond to volatile odorants and to pheromones, suggesting a greater degree of overlap in their functions than previously appreciated.

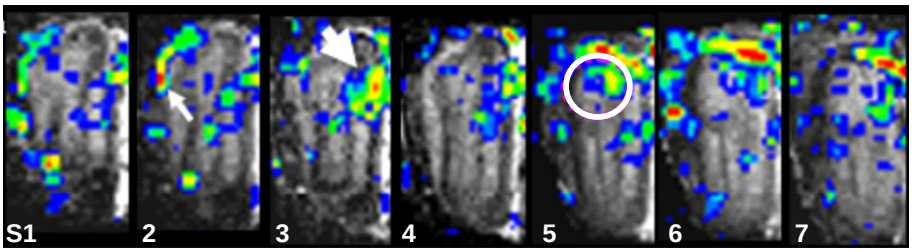
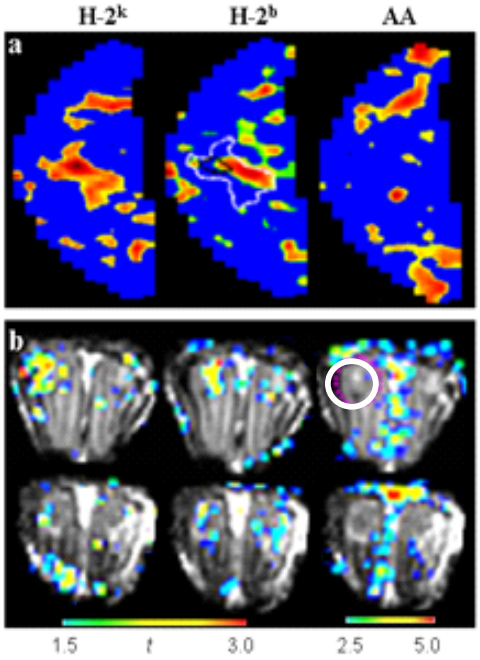


Fig. 1 The activity pattern of 2-heptanone. Concentration, 4 μM; duration, 1 minute.

Fig. 2 The activity patterns elicited by mouse urine in the MOB (**a**) and AOB (**b**). H-2^k and H-2^b are the mouse strains; AA, amyl acetate. AA concentration, 4 μM; urine, undiluted; duration, 2 minutes.



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