Effect of lesions to the posterior parietal or medial prefrontal cortices on navigation based on distal or proximal orienting cues in the rat

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Despite the long-lasting research on rodent spatial memory, we are still unable to specify the particular roles of various cortical structures in a satisfactory manner. Here we examined the impact of lesions to the Posterior Parietal (PPC) and Medial Prefrontal (MPFC) cortices on two variants of rat place avoidance task, based on distal or proximal orienting cues.

Generally [1,2], the place avoidance apparatus consists of a smooth metallic rotatable circular arena (80 cm in diameter) enclosed with a 30 cm high transparent Plexiglas wall and elevated 1 m above the floor. The rat placed on the arena is wearing a light latex harness, to which an infrared light-emitting diode (LED) is attached between the rat's shoulders. Its position is tracked every 40 ms by overhead camera and recorded onto a computer track file, allowing subsequent reconstruction of the track with an off-line analysis program (TrackAnalysis, Biosignal Group Corp., USA). Second LED is attached to the outer part of arena circumference serving as a referencing point when monitoring position of the animal within rotating arena frame. Thus, the system allows to store and analyze animals' tracks both in arena and room frame coordinates. Animals are trained in daily 20 min sessions to avoid entering a directly imperceptible 60-degrees sector of the arena, defined either in room or arena reference frame (see below). Whenever a rat enters the shock sector for more than 0.5 s, mild electric shocks (50 Hz, 0.5 s) are delivered at intervals of 1.5 s unless the rat leaves the shock sector for at least 0.5 s. The shocks are delivered through a thin subcutaneous low-impedance nichrome wire implant on the back of the rat standing on the grounded floor. The appropriate shock current (ranging between 0.2-0.7 mA) can be individualized for each rat to elicit a rapid escape reaction but to prevent freezing.

Here we present two variants of place avoidance task, differing in the spatial properties of the to-be-avoided sector. In the arena frame (AF) task, the sector is anchored to slowly rotating (1rpm clockwise) arena surface. Thus, rats have to remember position of the punished sector with respect to cues present on the arena surface (urine marks, etc.).To motivate rats to actively and homogenously explore the arena, they are run on a restricted diet schedule and left to search for peeled barley grains scattered at 10s intervals randomly over the arena from centrally placed overhead feeder. Since the arena is slowly rotating rats must abandon the use extramaze cues. On the contrary, in room frame (RF) task, the punished sector is anchored to reference frame of the room and therefore does not move with rotating arena. In this case, rats are required to use distal (extramaze) navigational cues such as doors, shelves, etc. and to abandon navigation based on proximal (intramaze) cues.

Following measurements were evaluated in our experiments: number of entrances into punished region (expressed learning rate), and total path during the session (expressed the overall locomotor activity). To eliminate possible confounding effect of variable locomotor activity during the AF task, number of entrances divided by path length was added. In RF task we also measured maximum time the animal was able to avoid entrance to the shock sector within a session. This variable is applicable only in RF design, where continuously rotating arena inevitably brings an animal sitting immobile to the punished region. The immobile animal sitting outside punished region in AF task is, however, undistinguishable from completely avoiding rat on the basis of max t evaluation, thus making max t uninformative. All variables were statistically analyzed using two-way ANOVA (lesion x sessions) design with days as repeated measures.

Rats with thermocoagulation lesion of the PPC (n=10) did not differ from matched group of sham-operated controls in their performance (number of entrances or overall locomotion) in AF nor in RF variant of the task. Preliminary experiments with MPFC lesioned rats led to the same results. These data suggest that PPC and MPFC are not crucial for navigation based neither on proximal nor distal orienting cues, at least at the level of precision given by the accuracy demands of the used behavioral paradigm.

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References

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