Using Virtual Reality to Assess Navigation and Spatial Memory in Nonhuman Primates*

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***Abstract*— The neural mechanisms of navigation, spatial memory, and decision making are topics of significant interest to the neuroscience community. Studying neural activity during the performance of these behaviors in nonhuman primates provide the best opportunity to understand the human brain. However, it is technically challenging to conduct these experiments with freely moving primates. Here, we describe our use of virtual reality with rhesus macaque monkeys to investigate neural signals for navigation and spatial memory.**

I. INTRODUCTION

Our lab is interested in understanding the neural mechanisms that support learning, memory and spatial navigation. Our primary technique involves recording from individual neurons and groups of neurons in deep brain structures as monkeys perform different tasks of learning and memory. Spatial navigation presents a particular problem for this work because it is technically challenging to perform neurophysiological recordings in freely moving and navigating monkeys. Accordingly, we have developed behavioral tasks of spatial navigation using virtual reality. The use of virtual reality will allow us to identify neural signals related to spatial navigation and learning in a variety of environments.

II. METHODS

We have trained monkeys to navigate a virtual environment via a joystick and perform both free-foraging and spatial memory tasks. The monkey uses a joystick to navigate in a courtyard with different colored walls and distinct external landmarks to provide cues for navigation.

III. TASK

A. Spatial Memory Task

In this task, the monkey is rewarded for remembering the location of the target stimulus (banana) within the courtyard. Each trial begins with a visible banana placed within the courtyard, and the monkey is rewarded for navigating to and colliding with the banana. The monkey is given at least two presentations with the banana visible during the encoding phase. Between each presentation of the banana, there is at least one presentation of cherries, positioned in a different location each time. This serves both to move the monkey away from the banana and to give the monkey a different perspective of the courtyard and the banana location. After the encoding phase, the courtyard is empty, and the monkey is rewarded for navigating to the remembered location of the banana. As soon as the monkey navigates within a predetermined radius of the target location, the banana becomes visible, and the monkey can collide with the banana to obtain reward.

B. Description of Video

On the bottom left is a video of the monkey using the joystick, and on the bottom right is a map of the monkey's movement through the environment. In this map, the banana is represented by a yellow circle, cherries by a red circle, the monkey's movements are drawn in white, and the movements while searching for the remembered location are drawn in cyan. When the banana is invisible, a yellow circle is drawn around the target location, which represents how close the monkey must come to the target location to trigger the appearance of the banana and the availability of reward. The monkeys eye position is tracked (ISCAN, Inc.) and the eye position location is shown in this video as a transparent circle overlaid on the environment. The inset videos and the eye movement on the screen are not shown to the monkey during the task.

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