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研究課題名（和文）The roles of distinct projection neurons in anterior cingulate cortex during spatial navigation

研究課題名（英文）The roles of distinct projection neurons in anterior cingulate cortex during spatial navigation

研究代表者

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交付決定額（研究期間全体）：（直接経費）　　1,100,000円

研究成果の概要（和文）：以前の実験により、前帯状皮質（ACC）から後脾臓皮質（RSC）ニューロンには、報酬の場所の周りで特異的に発火する場所細胞が含まれているのに対し、ACC-dmSTR ニューロンには、空間マップで順番に発火する場所細胞が含まれていることがわかりました。今年度には、報酬がない場合でもACC-RSC細胞が発火することを確認しました。 次に、報酬の場所が移動すると、これらの細胞の一部が新しい報酬の場所で発火し、新しいACC-RSC場所の細胞も新しい報酬の場所で形成されることがわかりました。 これらの発見は、脳内で空間マップがどのように形成されるかをよりよく理解するのに役立ちます。

研究成果の学術的意義や社会的意義
These studies will help us to better understand how memory is formed and stored in the brain. It will promote the medical treatment of amnesia disease like Alzheimer,and it can also promote the development of artificial intelligence.

研究成果の概要（英文）：In our previous experiments, we found that the anterior cingulate cortex (ACC) to retrosplenial cortex (RSC) neurons contain the place cells which preferentially fired around the reward location, whereas ACC-dmSTR neurons contain the place cells which fired in sequence in spatial map. In this year, we checked whether ACC-RSC place cells still firing when there is no water reward. We found that these cells still firing when the reward was removed. Next, we found that when the reward location shifted some of these cells fired in new reward location, and new ACC-RSC place cells also formed in new reward location. These findings will help us to better understand how spatial map is formed in the brain.

研究分野：neuroscience

キーワード：spatial memory　projection neuron　place cell

１．研究開始当初の背景

In mammal brain, memory is first stored in hippocampus, then important memory transfers to multiple brain regions, especially cortex regions. This process is termed as systems consolidation (Frankland et al., 2005). During the systems consolidation, various types of memories (e.g., spatial memory, semantic memory) are transferred. It is hypothesized that transferred memory is stored in multiple brain regions to form a network supporting memory recalling, but how do these regions connect is still unclear. Brain regions are connected to each other by projection neurons. **To better understand how memory is stored in cortex network, it is important to classify the cortex projection neurons by projection patterns and identify what kind of memory is stored in different projection neurons**. By using in vivo two-photon calcium imaging, I recorded the activities of ACC-dmSTR and ACC-RSC projection neurons while mouse was navigating in virtual linear maze. **I found that ACC-dmSTR projection neurons fired in sequence in whole maze, whereas ACC-RSC projection neurons fired preferentially around reward location**. Therefore, ACC-dmSTR and ACC-RSC projection neurons encode different information during spatial learning.

２．研究の目的

The purpose of this project is to figure out the roles of ACC-dmSTR and ACC-RSC projection neurons in spatial learning and memory formation.

３．研究の方法

Calcium imaging

AAV2-retro-CaMKII-GCaMP6f were injected into RSC or dmSTR in C57BL male mice. One month later, an imaging window attached with prism (1.5mm x 1.5mm) were inserted into the fissure and positioned 0.5 mm anterior to bregma. Activities of CaMKII-positive neurons were recorded by two-photon microscope (Fig.1).

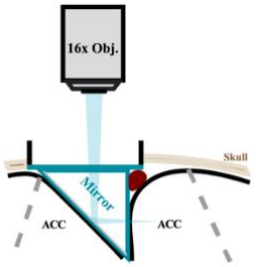

Fig.1 Imaging window attached with prism is inserted into opposite ACC.

Virtual reality (VR) system

To record cell activity during spatial navigation by the two-photon microscope, the head-fixed mouse was put on the styrene foam treadmill. A monitor in front of the mouse showed the bidirectional virtual linear track task. In this task, when mouse reached at the end of the track, the moving direction would rotate 180 degrees automatically (Fig.2 a). Mouse can get water only when it passed specific location in the forward direction (Fig.2 b).

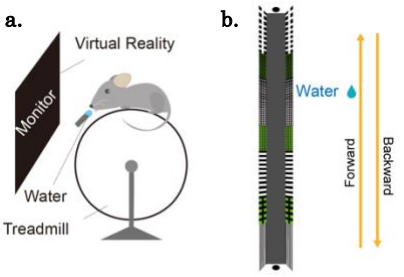

Fig.2 a. Apparatus used in virtual reality system. **b.** The wall pattern of linear track and reward position.

４．研究成果

In the previous studies, I found that ACC-RSC projection neurons fired preferentially around reward location. **To figure out whether these projection neurons firing around reward are encoding reward location or just respond to the reward itself,** I removed water reward in some trials during spatial learning and checked these ACC-RSC neurons firing rate in the water reward omission trials. I found that these neurons still fired in the non-water reward trials (Fig.3). It means that ACC-RSC neurons are encoding the reward location information.

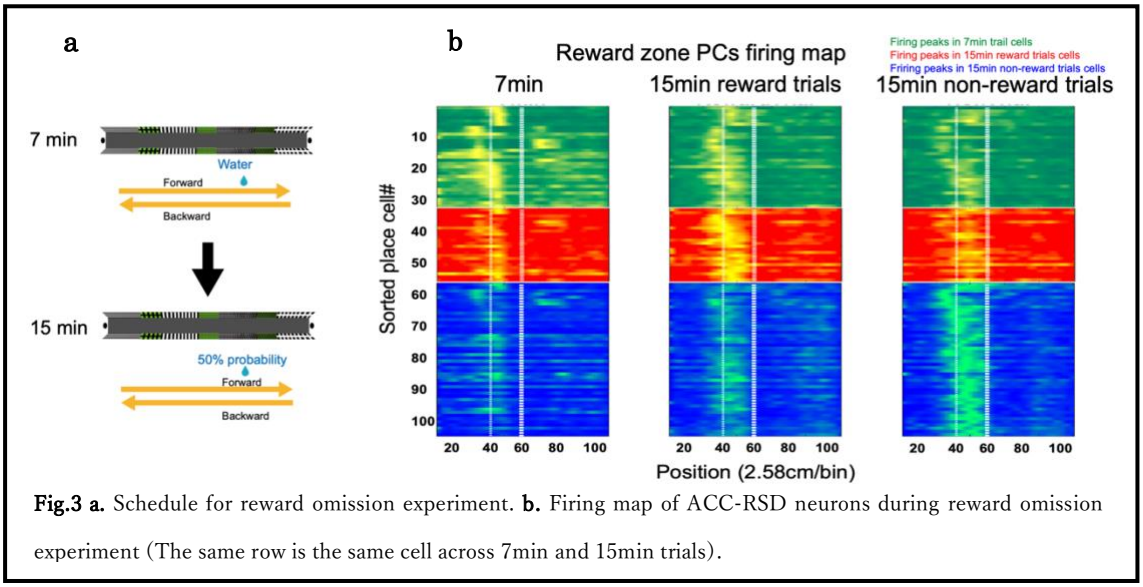

Fig.3 a. Schedule for reward omission experiment. **b.** Firing map of ACC-RSD neurons during reward omission experiment (The same row is the same cell across 7min and 15min trials).

Next, **in order to figure out whether ACC-RSC projection neurons firing around reward keep firing around the reward location when the reward moved to a new location,** I moved water reward to a new location. I find that ACC-RSC projection neurons firing around reward gradually stop firing, and other ACC-RSC projection neurons started firing around new reward location (Fig.4). It means that ACC-RSC encoding the distinct reward location with different population.

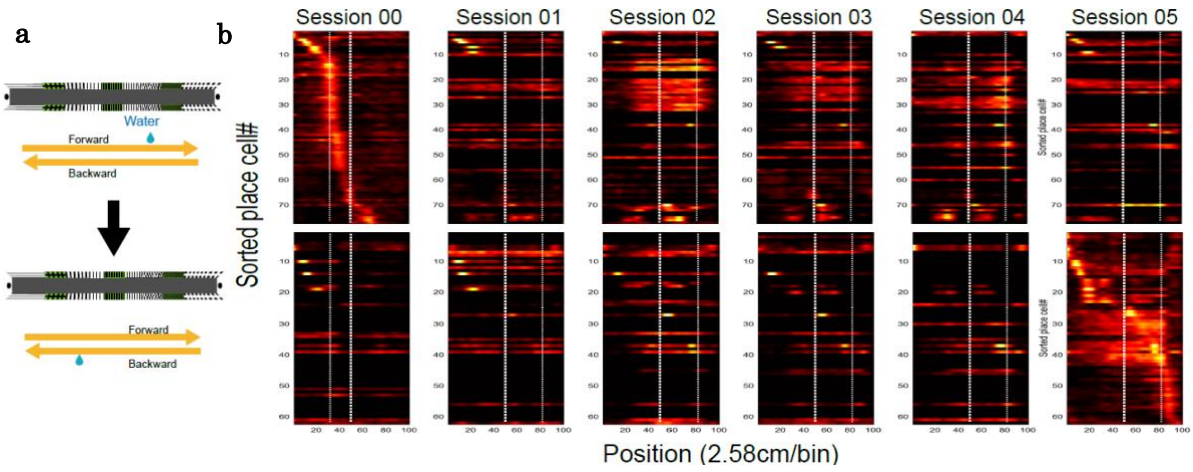

Fig.4 a. Schedule for reward moving experiment. **b.** Firing map of ACC-RSD neurons during reward moving experiment (The same row is the same cell across different sessions).

These results were presented in the "The 99th Annual Meeting of The Physiological Society of Japan" and "The 45th Annual Meeting of the Japan Neuroscience Society".

５．主な発表論文等

〔雑誌論文〕　計0件

〔学会発表〕　計2件（うち招待講演　0件／うち国際学会　0件）

１．発表者名 Yaolong Li
２．発表標題 Distinct classes of projection neurons in anterior cingulate cortex differently encode spatial and reward information
３．学会等名 The 99th Annual Meeting of The Physiological Society of Japan
４．発表年 2022年

１．発表者名 Yaolong Li
２．発表標題 The projection neurons in anterior cingulate cortex projection separate spatial and reward information during spatial navigation
３．学会等名 The 45th Annual Meeting of the Japan Neuroscience Society
４．発表年 2022年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関