Reinforcement Learning-Based Modeling of Alzheimer's Disease

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Navigation inflexibility is a symptom observed in approximately 50% of early Alzheimer's disease (AD). However, why and how this disorder occurs has remained unclear. Computational modeling of this impairment is expected to shed light on the crux of AD by visualizing and simplifying its complex mechanism while few studies have been conducted. Thus, this study aims to model AD's spatial disorder by blending two reinforcement learning methods. One is successor representation (SR) simulating the hippocampus-dependent place navigation system (PNS), and another is model-free reinforcement learning, SARSA, simulating striatal cue navigation system (CNS). PNS and CNS are responsible for navigation flexibility and efficiency, respectively. They are automatically integrated based on reward prediction errors. The AD model has time-dependent atrophy parameters in the learning rate and the prediction map. To observe the model's navigation flexibility, the navigation task is assigned with the maze environment where the position of start and goal are flipped after the onset of AD. The result shows that the model has remarkable inflexibility at the initial stage of AD when it has a significant loss in learning rate. The model also gets to take a detour when the prediction map is equalized. This indicates that the place cell's remapping malfunction could be the main cause of navigation inflexibility and breakdown of the cognitive map sets off disorder in efficient navigation. Moreover, clear transition in the model's behavioral patterns is confirmed from before the onset of AD. These findings may contribute to the early detection of AD.

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