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Brain's internal compass also navigates during imagination

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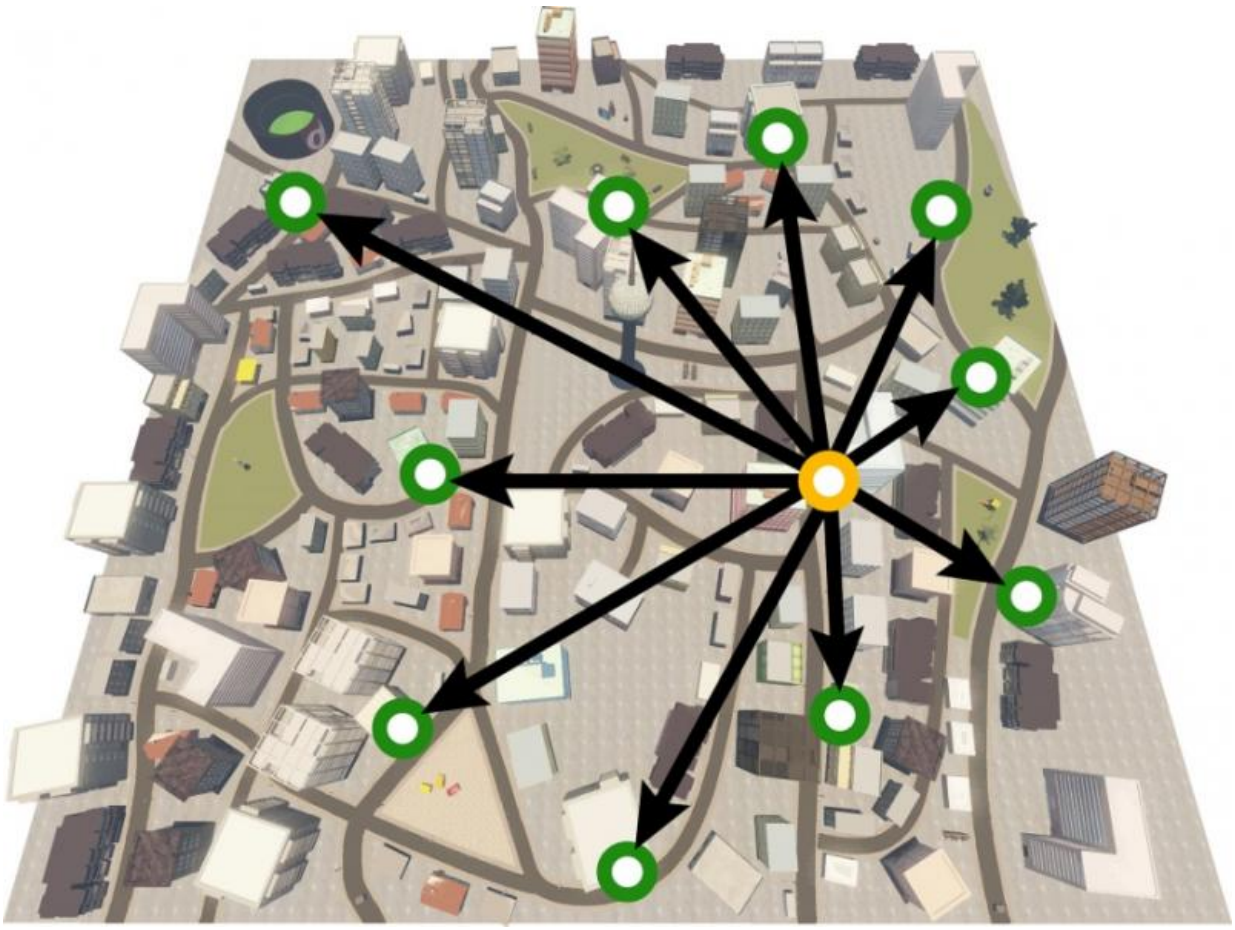

Figure 1. Imagine the view standing in front of the Clariant Corporation building (yellow circle), and looking towards the Spectrum Enterprises building (green circle in the top left). In total, each participant pictured 96 views in the fMRI scanner. Credit: Radboud University

When you try to find your way in a new place, your brain creates a spatial map that represents that environment. Neuroscientists from Radboud University's Donders Institute now show that the brain's 'navigation system' is not only active during actual or virtual movement, but also when imagining view directions. This suggests that the brain's spatial navigation system might also be important for cognitive functions such as imagination and memory. Scientific journal eLife published the results on August 30.

It took him four months to build, but now Donderstown – the virtual reality city that study participants had to navigate – consists of several neighborhoods: there is a banking district, a residential area, and even a market place. Jacob Bellmund, PhD candidate at Christian Doellers lab at the Donders Institute and first author of the study, explains: "In previous studies, our group showed that movement in a virtual environment activates the brain's navigation system; we observed patterns probably going back to grid cells and head direction cells, which are specialized in navigation. Now we wanted to take it a step further by testing if imagining view directions in a lifelike virtual environment, without imagining movement, can also activate these cells. And it did!"

The results are evidence for the idea that the brain's navigation system also plays a role in our capacity to imagine future events and construct them in our mind. "Grid cells encode your location in the world and calculate the vector from that location to another", says Bellmund. "They help us to move around, in real life but also in imagination."

He explains the study set-up: "First, participants had to study Donderstown for two days, on a regular computer. They learned the names, appearances and exact locations of eighteen buildings in the town and were tested repeatedly to check if they remembered correctly. After this training, they had to imagine view directions in Donderstown while lying in an fMRI scanner." For instance, "Imagine standing in front of

the Clariant Corporation building, and looking towards the Spectrum Enterprises building (Figure 1). What do you see?" Activity patterns in a specific brain region (the parahippocampal gyrus) were most similar when a participant imagined the same direction, showing the internal compass at work. Furthermore, patterns in a specific brain region called the entorhinal cortex indicated that the grid cell system was also active while participants were imagining these views.

"We are very excited about these results because they speak to the idea that the brain's spatial navigation system is also important for our imagination and the retrieval of memories", says Bellmund. "It is the first paper to show that spatially tuned cells are also active when we imagine ourselves being in a certain place, without moving."

More information: Jacob LS Bellmund et al. Grid-cell representations in mental simulation, *eLife* (2016). DOI: 10.7554/eLife.17089

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