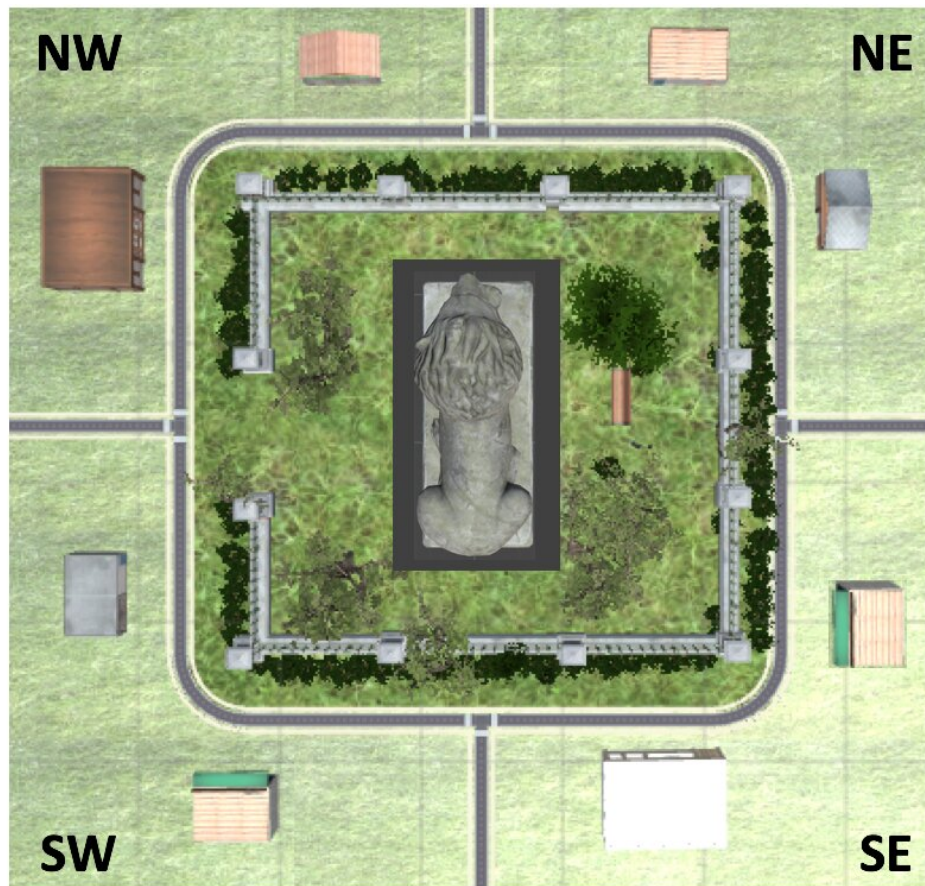


Navigating 'Neuralville': Virtual town helps map brain functions

October 7 2019, by Carol Clark



A bird's eye view of the virtual town, showing the park in the center and the four quadrants and buildings. Participants never saw this map-like presentation of the town, instead viewing it at a pedestrian level. Credit: Andrew Persichetti/Emory University

Psychologists at Emory University have found that the human brain uses three distinct systems to perceive our environment—one for recognizing a place, another for navigating through that place and a third for navigating from one place to another.

For a new paper, they designed experiments involving a simulated town and [functional magnetic resonance](#) imaging (fMRI) to gain new insights into such systems. Their results, published by the *Proceedings of the National Academy of Sciences (PNAS)*, have implications ranging from more precise guidance for surgeons who operate on the brain to better computer vision systems for self-driving cars.

"We're mapping the functions of the brain's cortex with respect to our ability to recognize and get around our world," says Daniel Dilks, Emory associate professor of psychology and senior author of the study. "The *PNAS* paper provides the last big piece in the puzzle."

The experiments showed that the brain's parahippocampal place area is involved in recognizing a particular kind of place in the virtual town, while the brain's retrosplenial complex is involved in mentally mapping the locations of particular places in the town.

These new results follow work published last year by the Emory researchers, showing that the brain's occipital place area is involved in navigating through a particular place.

Before, some researchers theorized that all three of these cortical scene-selective regions—abbreviated as the PPA, RSC and OPA—were involved generally in navigation. "Our work continues to provide strong evidence that this theory is just not true," Dilks says.

"We're showing that there are specialized systems in the brain that play different roles involved with recognizing places and navigating," adds

first author Andrew Persichetti, who did the work as an Emory graduate student in the Dilks lab. He has since received his Ph.D. in psychology and is now a post-doctoral fellow at the National Institute of Mental Health.

For the *PNAS* paper, Persichetti developed experiments based on a virtual town he created, called "Neuralville," and a simple video game. "One of my favorite things about being a scientist is getting to design experiments," he says. "It's fun to try to come up with a clever, yet simple, way to answer a complex question."

Neuralville consists of eight buildings, spread over four quadrants, or locations in the town, that surround a park. The categories of buildings are paired and include: Two [coffee shops](#), two dentists' offices, two hardware stores and two gyms. Each quadrant contains two buildings, but no quadrant contains two of the same category. And, although they can be paired by categories, location or facing direction, none of the eight buildings shares visual features, such as shape, size or texture.

Participants sat at a computer and became familiar with the town as they "walked" around the four quadrants by pressing the arrow keys on the keypad. They were then dropped into random locations of town and given tasks such as "Walk to Coffee Shop A." After about 15 minutes of this practice, they were shown images of each [building](#) and asked what type it was and which quadrant of the town it was located in.

Once a participant scored 100 percent on this quiz, they were then put into an fMRI scanner. As their brains were scanned, they were given a picture of one of the buildings, such as Coffee Shop B, and asked a question. For example: "If you're directly facing Coffee Shop B, would Dentist Office A be to your right or to your left?"

The participants repeated the task 10 times as the fMRI recorded activity

in the PPA and the RSC. The brain data was rendered in units called "voxels," which are similar to pixels, except they are three-dimensional.

The results showed that the pattern of responses in the RSC were more similar for buildings that shared the same location than for buildings of the same category. The opposite was true for the pattern of responses in the PPA.

"These multi-voxel patterns reveal a spatial representation of these buildings in the RSC, and a categorical representation in PPA," Persichetti says. "The RSC patterns basically puts them on a map in their proper locations, while the PPA pattern instead clusters them by their category."

Clinical applications for the research include better brain rehabilitation methods for those with problems related to scene recognition and navigation.

The research may also prove beneficial to improving computer vision systems, such as those for self-driving cars. "Through evolution, the brain has figured out the optimal solution to recognizing scenes and navigating around them," Dilks says. "And that solution appears to be one of specializing the different functions involved."

Dilks is a leader in mapping how the visual cortex is functionally organized. In 2013, he led the discovery of the OPA. In 2018, Dilks and Persichetti demonstrated that the OPA specializes in navigating through a particular [place](#).

"While it's incredible that we can show that different parts of the cortex are responsible for different functions, it's only the tip of the iceberg," Dilks says. "Now that we understand what these regions of the brain are doing we want to know precisely how they're doing it and why they're

organized in this way."

More information: Andrew S. Persichetti et al. Distinct representations of spatial and categorical relationships across human scene-selective cortex, *Proceedings of the National Academy of Sciences* (2019). [DOI: 10.1073/pnas.1903057116](https://doi.org/10.1073/pnas.1903057116)

Provided by Emory University

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