Thinking of prepositions turns brain 'on' in different ways

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Parts of the human brain think about the same word differently, at least when it comes to prepositions, according to new language research in stroke patients conducted by scientists at Purdue University and the University of Iowa.
People who speak English often use the same prepositions, words such as "on," "in," "around" and "through," to indicate time as well as location. For example, compare "I will meet you 'at' the store," to "I will meet you 'at' 3 p.m." These examples show how time may be thought of metaphorically in terms of space.

Just because it's the same word, however, doesn't mean the brain thinks about it the same way, said David Kemmerer, an assistant professor of psychological sciences and linguistics at Purdue's College of Liberal Arts.

"There has been a lot of cognitive neuroscience research about how the brain processes language pertaining to concrete things, such as animals or tools," said Kemmerer, who also is an adjunct faculty member at the University of Iowa's Department of Neurology, where this research was conducted. "This is the first cognitive neuroscience study to investigate brain regions for spatial and temporal relations – those involving time – used in language.

"I was interested in whether these spatial or temporal prepositions can be dissociated in individuals with brain damage. One might think that if a person's knowledge of the word 'at' to describe location is impaired, then

his or her ability to use that same preposition to describe time would be disrupted. But we found the words implying time are processed independently."

This research was conducted at the Benton Neuropsychology Laboratory in Iowa's Carver College of Medicine and was funded by the Purdue Research Foundation and the National Institute for Neurological Disease and Stroke. Kemmerer's paper is available online at Neuropsychologia.

"This study has potential implications for neurology," Kemmerer said. "A clinician could use information about how brain injuries in stroke patients affect specific speech components to develop therapies to help their patients."

The four patients in Kemmerer's study were used because of similar brain injuries, such as lesions from stroke, in the perisylvian region, which is responsible for language processing. Kemmerer found the stroke subjects who passed the language tests asking about prepositions relevant to time subsequently failed when these same words reflected spatial meanings. For example, the subjects were asked to choose the correct preposition for scenarios such as, "The baseball is 'on/in/against' the glove." Two subjects did not select "in" as the correct answer. However, they did select "in" as the correct preposition for "It happened 'through/on/in' 1859."

The other two subjects' test performances were the opposite.

Kemmerer's earlier research with Daniel Tranel, professor of neurology at Iowa's Carver College of Medicine, had confirmed that the left inferior prefrontal and left inferior parietal regions of the brain play a crucial role in processing spatial prepositions. The previous research with Tranel was published in October's Cognitive Neuropsychology.

This work, which has explored how different types of words are retrieved by different parts of the brain, is part of a larger-scale investigation being carried out by Tranel and his colleagues at the University of Iowa.

"For example, we have identified the anterior left temporal lobe as being critical for proper nouns, whereas the left inferior prefrontal/premotor region is important for verbs," Tranel said. "The collaboration between myself, a neuropsychologist, and professor Kemmerer, a neurolinguist, has yielded important breakthroughs in understanding how the brain operates language, due to the unique perspectives that these researchers bring to a common research agenda."

Three of the patients in Kemmerer's recent study also had damage to their brains' left hemispheres, in an area known as the parietal lobe, which houses the supramarginal gyrus. This area is involved in spatial meaning, and it is the part of the brain that guides action. For example, the supramarginal gyrus coordinates how a person moves his or her hand toward a glass of water. Previous research with normal brains identifies this area as important also in the knowledge and meaning of prepositions.

The patients with damage to the supramarginal gyrus did not score high on the tasks that evaluated their knowledge of prepositions that dealt with space. In comparison, the fourth patient, who did not have similar damage to this region of the brain, was able to demonstrate complete knowledge of spatial prepositions.

Kemmerer's next step will be looking at how the brain processes these prepositions in other languages.

"If this is true in English, then what about the 6,000 other known languages in the world? This time-and-space metaphor is used from

language to language, but how the metaphor is used does vary," he said.

In English, months of the year are treated as containers. People say "in January" or "in February." Other languages treat months as surfaces. For example, "on January" or "on February." Despite the difference, there is a metaphor at work, Kemmerer said.

"The cross-linguistic ubiquity of the metaphor suggests that people are naturally inclined to conceptualize time in terms of space," he said. "Nevertheless, the neuropsychological data suggest that people don't need to invoke the metaphor every time they use prepositions to talk about time. Just as the word 'breakfast' doesn't require one to think of a morning meal in terms of breaking a fast, so the sentence 'She arrived at 1:30' doesn't require one to think of time as a series of points on a line."

Source: Purdue University (by Amy Patterson-Neubert)