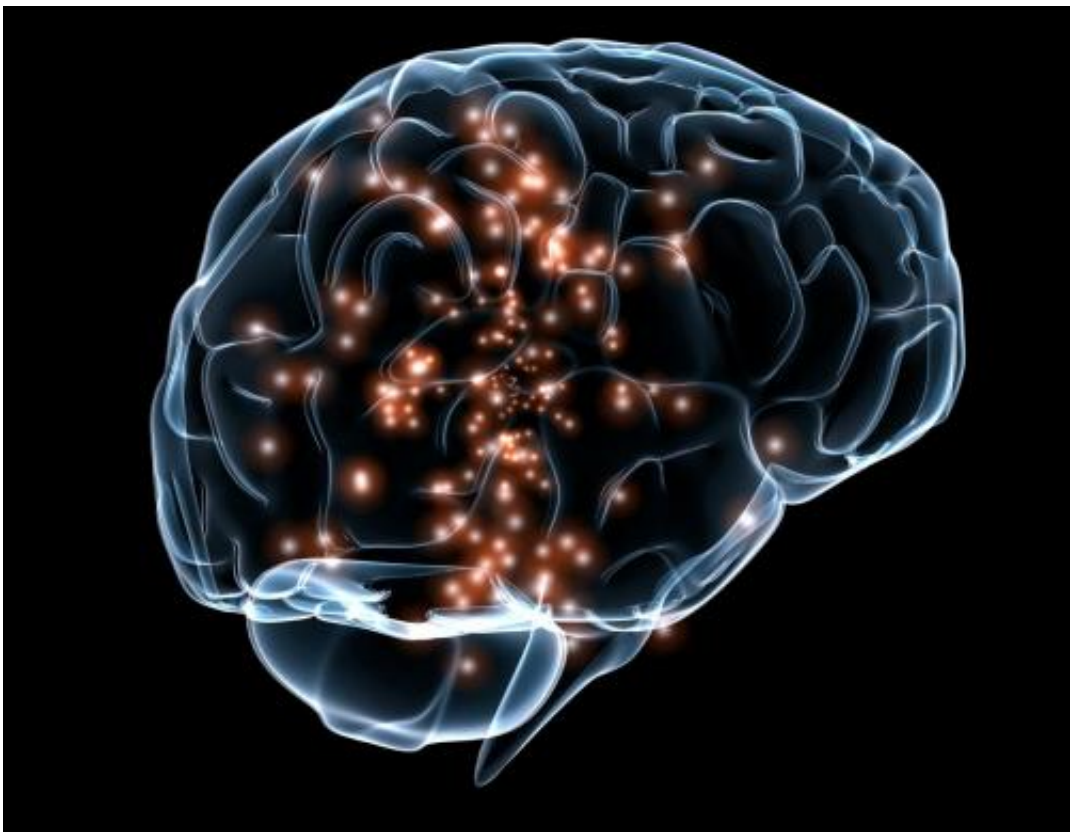
Study suggests the mind flexibly joins the meanings of individual words to form structured thoughts

August 25 2015, by Bob Yirka



Credit: Wikimedia Commons

(Medical Xpress)—A pair of researchers with Harvard University has found evidence that supports the idea that the human mind flexibly merges the meanings of single words to form or compose structured

thoughts. In their paper published in *Proceedings of the National Academy of Sciences*, Steven Frankland and Joshua Greene describe the study they conducted and why they believe what they learned helps in understanding how the human thought process works.

It has often been noted that human languages allow people to create and envision an infinite number of ideas using a finite number of words. But how we do that is still, of course, a mystery. In this new effort, Frankland and Greene conducted some MRI tests on volunteers to see if they could learn more about how the process works.

The research duo ran two types of tests, first 18 volunteers were asked to undergo MRI scans as they read short sentences that could be interpreted in either passive or active voice, or which could be arranged to have an opposite meaning, such as "the cat scratched the girl," versus "the girl scratched the cat." Next 34 other volunteers were asked to undergo MRI scans while reading sentences made up of just four nouns (dog, cat, girl and man) and five verbs (approached, chased, blocked, scratched and bumped) along with a connector, e.g. "the girl approached the man."

By examining a part of the brain known as the left mid-superior temporal cortex, as the volunteers read their sentences, the researchers were able to note that neurons fired differently depending on context, which they suggest corresponded to the mind separating contextual ideas into different types of meaningfulness, such as "Who did something?" and "Who was it done to?" This, they conclude, suggests the mind works in a way similar to computers processing information—with distinctions being made between information that is held in variables versus the variables themselves. They liken thought interpretation in the brain to usage of slots, with different types of contextual information being routed to the correct slot for processing.

The researchers also note that they are not suggesting that all language

and idea processing is done in the left mid-superior temporal cortex—only that it appears to play a central role.

More information: An architecture for encoding sentence meaning in left mid-superior temporal cortex, Steven M. Frankland, DOI: 10.1073/pnas.1421236112

Abstract
Human brains flexibly combine the meanings of words to compose structured thoughts. For example, by combining the meanings of "bite," "dog," and "man," we can think about a dog biting a man, or a man biting a dog. Here, in two functional magnetic resonance imaging (fMRI) experiments using multivoxel pattern analysis (MVPA), we identify a region of left mid-superior temporal cortex (lmSTC) that flexibly encodes "who did what to whom" in visually presented sentences. We find that lmSTC represents the current values of abstract semantic variables ("Who did it?" and "To whom was it done?") in distinct subregions. Experiment 1 first identifies a broad region of lmSTC whose activity patterns (i) facilitate decoding of structure-dependent sentence meaning ("Who did what to whom?") and (ii) predict affect-related amygdala responses that depend on this information (e.g., "the baby kicked the grandfather" vs. "the grandfather kicked the baby"). Experiment 2 then identifies distinct, but neighboring, subregions of lmSTC whose activity patterns carry information about the identity of the current "agent" ("Who did it?") and the current "patient" ("To whom was it done?"). These neighboring subregions lie along the upper bank of the superior temporal sulcus and the lateral bank of the superior temporal gyrus, respectively. At a high level, these regions may function like topographically defined data registers, encoding the fluctuating values of abstract semantic variables. This functional architecture, which in key respects resembles that of a classical computer, may play a critical role in enabling humans to flexibly generate complex thoughts.