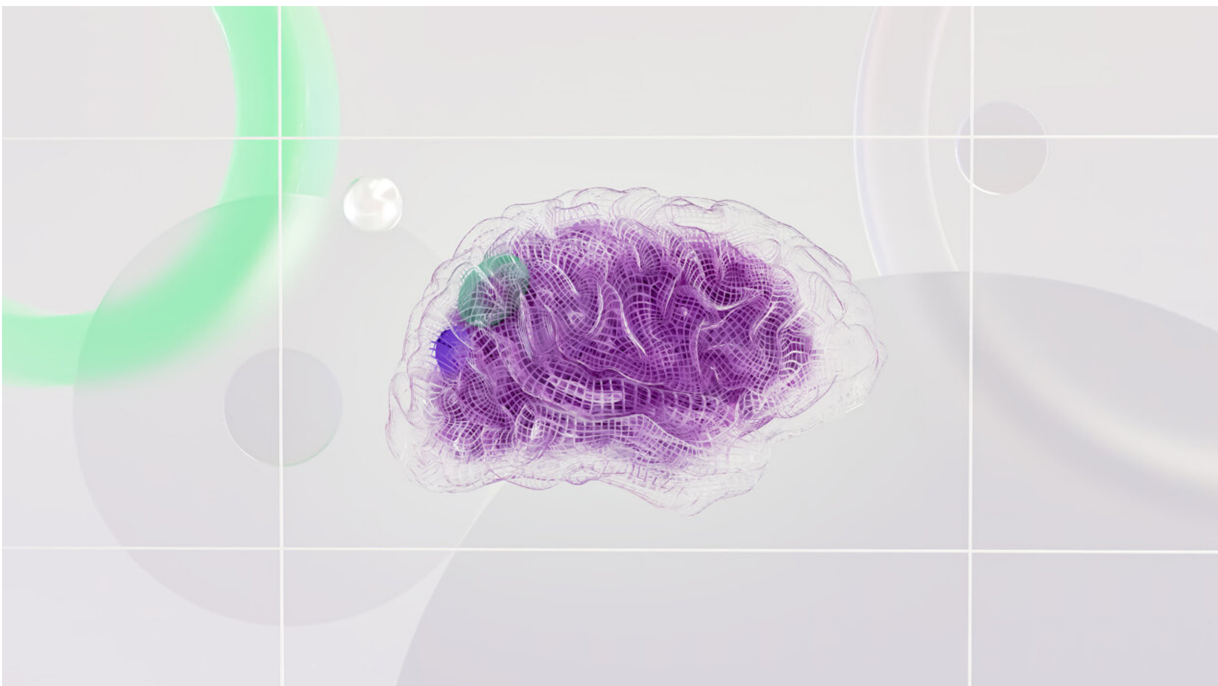
Medical Xpress

How we discovered that brain connections shape memories

July 10 2017, by Carl J Hodgetts



Credit: Google DeepMind from Pexels

Reliving and sharing our personal past is part of what makes us human. It creates a sense of who we are, allows us to plan for the future and helps us form relationships. But we don't all remember our past in the same way. In fact, the nature and quality of memory differs considerably between people.

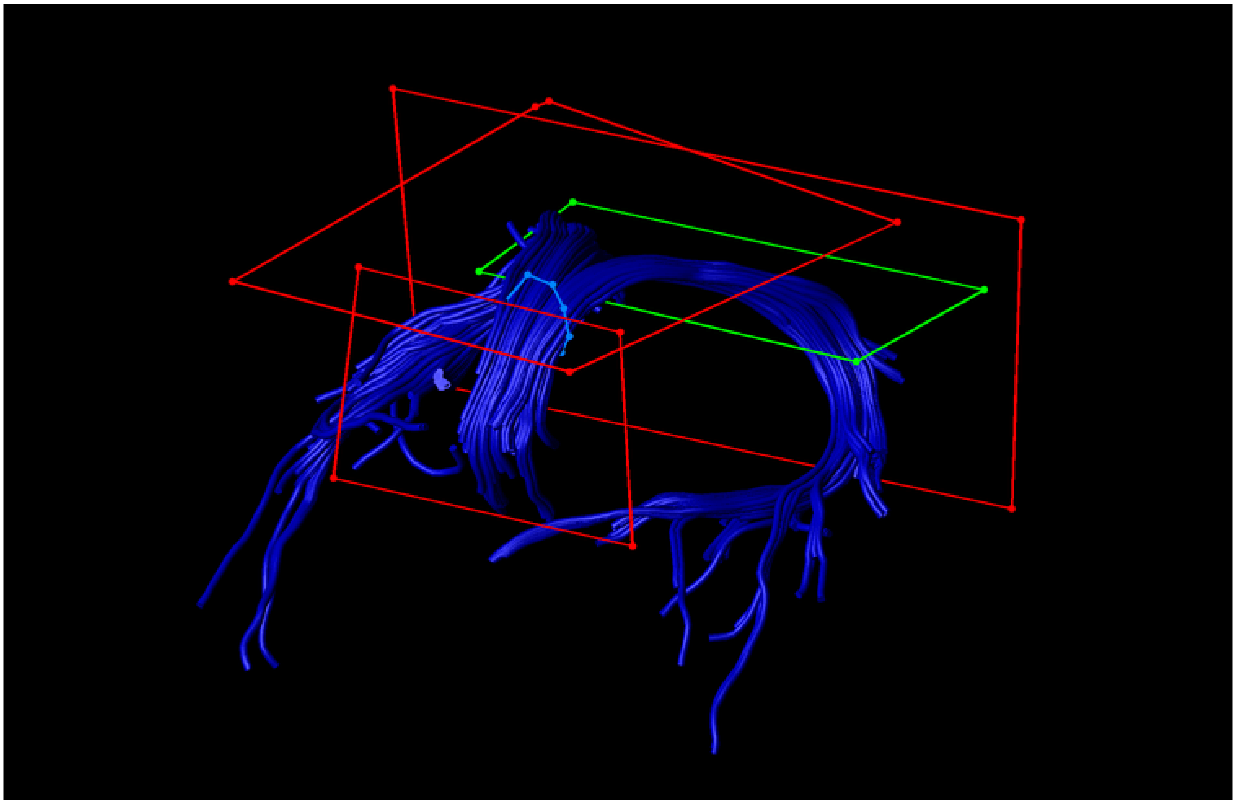
For instance, when asked to remember something about a party, one person might describe vividly their sixth birthday: how the gifts were laid out, the sweet, chocolatey taste of the hedgehog cake and going to bed really late. Another person might not recall this precise detail, but remember that their aunt despised parties and that hedgehog cakes were massive in the 80s.

So, our personal memories contain different types of information. Some of this is very specific about when and where things happened – and what it felt like. This collection of personal experiences is known as "episodic memory". Other bits are general facts about the world, ourselves and the people we know. This is called "semantic memory". A big question in neuroscience is whether these two memory types involve distinct parts of the brain.

Individuals who have suffered damage to a region called the hippocampus (involved in memory, learning and emotion) have been found to remember facts about their lives but lack the high-resolution, episodic detail. On the other hand, patients with a rare form of dementia, known as semantic dementia, can remember episodic information, but not the facts that glue it all together. Intriguingly, these individuals show early degeneration of another part of the brain called the anterior temporal lobe (thought to be critical for semantic memory).

Networks versus areas

But can we see a similar distinction in the healthy brain? As reflecting on our past is highly complex, it seems likely that different brain regions must work together to achieve it. And studies using functional MRI have shown that personal memories activate large networks in the brain.



Virtually dissecting white matter connections. Credit: Carl Hodgetts/Cardiff University

So it appears that memory cannot be boiled down to one or two particular brain areas. We have to think more widely than that. The brain itself is made up of both grey and white tissue. The white part, known as "white matter", contains fibres that allow information to travel between different areas of the brain. So could these connections themselves predict *how* we remember?

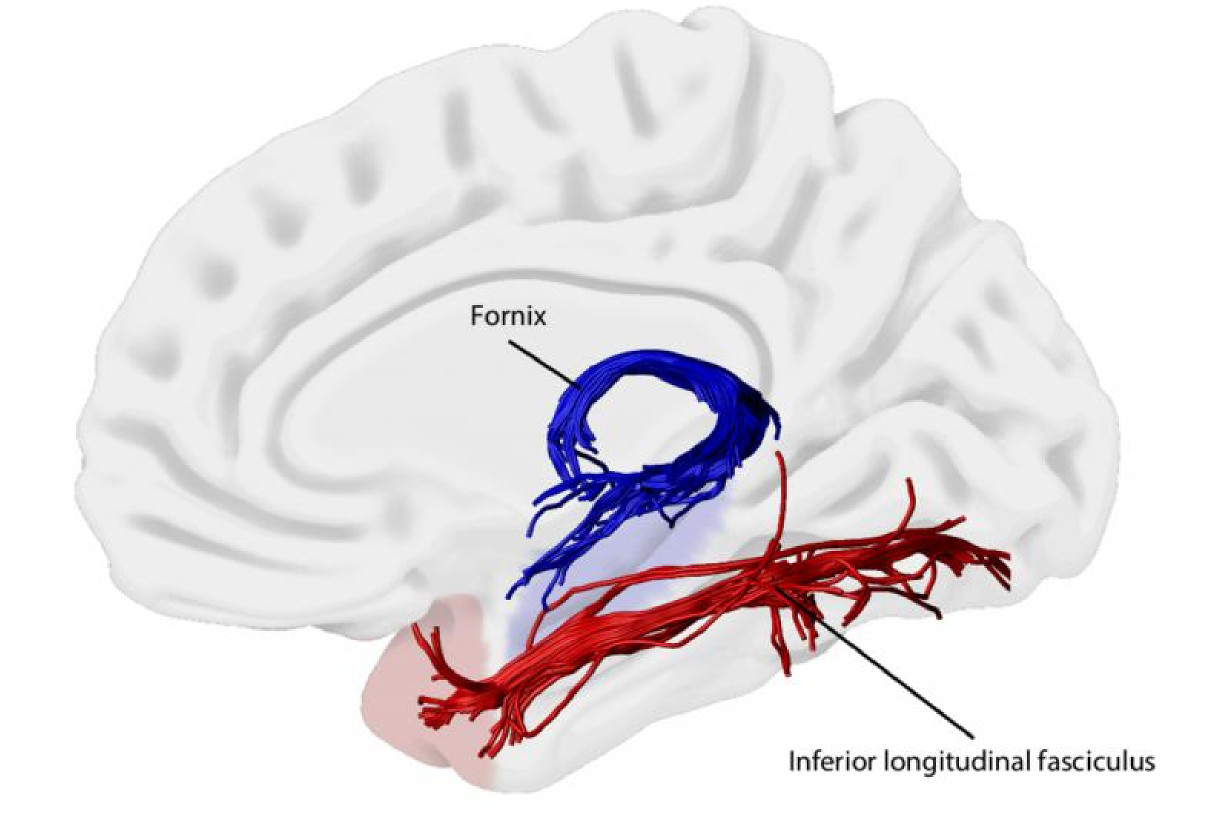
In our latest study, published in the journal Cortex, we explored this question by using a brain scanning technique known as diffusion MRI. This method uses the movement of water molecules to map out the brain's white matter pathways.

We asked 27 college-aged volunteers to lie still in the scanner as we collected images of their brains. Using these images we could identify specific pathways and pull out measures their structure – indicating how efficiently information can travel between connected regions.

Outside the scanner, each volunteer was asked to describe memories from their past in response to cue words, such as "party" or "holiday". By going through and painstakingly coding each memory, we could work out how "episodic" and "semantic" each person's memory was. For instance, precise spatial statements would count toward the episodic score ("The Eiffel Tower was directly behind us"), and facts would count toward the semantic score ("Paris is my sister's favourite city").

We found that the amount of rich, episodic detail that volunteers remembered was related to the connectivity of an arch-shaped white matter pathway called the fornix, which links to the hippocampus. So, the more efficiently the fornix can relay information from the hippocampus to surrounding regions, the more episodic someone's memory is.

A different white matter pathway – catchily named the inferior longitudinal fasciculus – strongly predicted how semantic people's memories were. Interestingly, this long bundle of white matter is the major route from visual parts of the brain to the anterior temporal lobe – the same region that is affected in cases of semantic dementia.



Pathways to personal memory. Credit: Carl Hodgetts/Cardiff University

Wired for memory

These findings suggest that differences in how we each remember our past are reflected in how our brains are wired. Historically, neuroscience has tended to see brain regions as singletons, working alone. These results suggest the alternative: that links between regions – and the networks they form – are critical for how we think and behave.

Our finding also supports the idea that there are separate memory "systems" in the brain. One for reliving time and place and another for pulling in general knowledge and personal facts.

Could these findings help people with memory problems? Not yet, but working out how memory works in healthy people may eventually help us understand exactly what goes wrong in the brain when we get diseases like Alzheimer's – and help us treat it. For instance, people with damage to the "episodic" network, such as those with early Alzheimer's disease, may benefit from semantic memory strategies to compensate. A recent study found that cuing memories with physical objects led to better episodic memory in people with Alzheimer's.

There's plenty we still don't know about the brain's white matter. A number of properties can affect how information travels along it, such as the density of fibres. In the future, we can use new and powerful scanning techniques to uncover the parts of white matter that drive these fascinating effects.

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