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Time past, time future intricately connected in the brain: study

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Human memory, the ability to recall vivid mental images of past experiences, has been studied extensively for more than a hundred years. But until recently, there's been surprisingly little research into cognitive processes underlying another form of mental time travel -- the ability to clearly imagine or "see" oneself participating in a future event.

Now, researchers from Washington University in St. Louis have used advanced brain imaging techniques to show that remembering the past and envisioning the future may go hand-in-hand, with each process sparking strikingly similar patterns of activity within precisely the same broad network of brain regions.

"In our daily lives, we probably spend more time envisioning what we're going to do tomorrow or later on in the day than we do remembering, but not much is known about how we go about forming these mental images of the future," says Karl Szpunar, lead author of the study and a psychology doctoral student in Arts & Sciences at Washington University.

"Our findings provide compelling support for the idea that memory and future thought are highly interrelated and help explain why future thought may be impossible without memories."

Scheduled for advance online publication Jan. 1 in Proceedings of the National Academy of Sciences, the study sheds new light on how the human mind relies on the vivid recollection of past experiences to

prepare itself for future challenges, suggesting that envisioning the future may be a critical prerequisite for many higher-level planning processes.

Other study co-authors are Jason M. Watson, a Washington University doctoral graduate now assistant professor of psychology at the University of Utah; and Kathleen McDermott, an associate professor of psychology in Arts & Sciences and of radiology in the School of Medicine at Washington University.

McDermott, principal investigator for the University's Memory and Cognition Lab, where the research is based, suggests that the findings are notable for two reasons.

First, the study clearly demonstrates that the neural network underlying future thought is not isolated in the brain's frontal cortex, as some have speculated. Although the frontal lobes play a well-documented role in carrying out future-oriented executive operations, such as anticipation, planning and monitoring, the spark for these activities may well be the very process of envisioning oneself in a specific future event, an activity based within and reliant upon the same neurally distributed network used to retrieve autobiographical memories.

Second, within this neural network, patterns of activity suggest that the visual and spatial context for our imagined future often is pieced together using our past experiences, including memories of specific body movements and visual perspective changes – data stored as we navigated through similar settings in the past.

These findings, McDermott suggests, offer strong support for a relatively recent theory of memory, which posits that remembering the past and envisioning the future draw upon many of the same neural mechanisms. Previous speculation has been based largely on the

anecdotal observation of very young children, cases of severe depression and brain damaged persons with amnesia.

"There's a little known and not that well investigated finding that if you have an amnesic person who can't remember the past, they're also not at all good about thinking about what they might be doing tomorrow or envisioning any kind of personal future," McDermott explains. They comprehend time and can consider the future in the abstract sense (e.g., that global warming is a concern for the future), but they cannot vividly envision themselves in a specific future scenario.

"The same is true with very small children -- they don't remember particularly what happened last month and they can't really tell you much of anything about what they envision happening next week. This is also the case with suicidally depressed people. So, there's this theory that it all goes hand-in-hand, but nobody has looked closely enough to explain exactly how or why this occurs."

In this study, researchers relied on functional magnetic resonance imaging (fMRI) to capture patterns of brain activation as college students were given 10 seconds to develop a vivid mental image of themselves or a famous celebrity participating in a range of common life experiences.

Presented with a series of memory cues, such as getting lost, spending time with a friend or attending a birthday party, participants were asked to recall a related event from their own past; to envision themselves experiencing such an event in their future life; or, to picture a famous celebrity -- specifically former U.S. President Bill Clinton -- participating in such an event.

The "Clinton-Imagine" task was introduced to help researchers establish a baseline level of brain activity for a cognitive event that was in many

ways similar to the other two tasks but did not involve the mental projection of oneself through time. Bill Clinton was chosen because pre-testing showed he was easy for participants to visualize in a variety of situations.

Comparing images of brain activity in response to the "self-remember" and "self-future" event cues, researchers found a surprisingly complete overlap among regions of the brain used for remembering the past and those used for envisioning the future – every region involved in recollecting the past was also used in envisioning the future.

During the experiment, participants were not required to describe details or explain the origin of mental images elicited by the memory cues, but in post-testing questionnaires most indicated that they tended to place future-oriented images in the context of familiar places (e.g. home, school) and familiar people (e.g. family, friends), which would require the reactivation of those images from neural networks responsible for the storage and retrieval of autobiographical memories.

Conversely, the neural networks associated with personal mental time travel showed significantly less activity when participants imagined scenarios involving Bill Clinton. The reason, researchers suggest, is that participants had no personal memories of direct interaction with Clinton, and thus, any images of him had to be derived from neural networks responsible for semantic memory – our context-free general knowledge of the world. In fact, participants later reported that their mental images of Clinton tended to be less vivid (e.g. "I see Bill Clinton at a party in the White House, alongside several faceless senators").

"Results of this study offer a tentative answer to a longstanding question regarding the evolutionary usefulness of memory," McDermott concludes. "It may just be that the reason we can recollect our past in vivid detail is that this set of processes is important for being able to

envision ourselves in future scenarios. This ability to envision the future has clear and compelling adaptive significance."

Source: Washington University in St. Louis