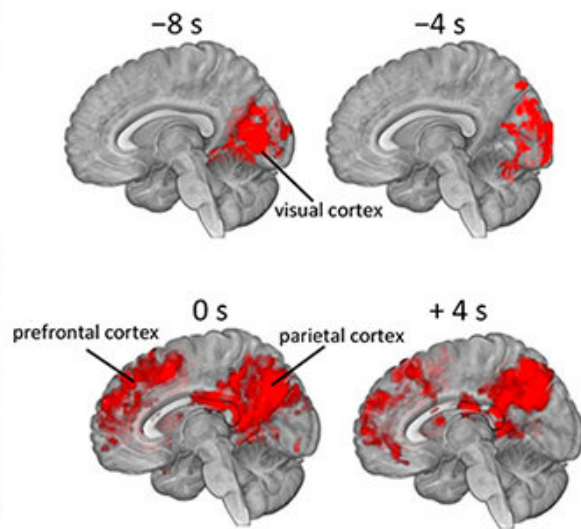


Nolan film 'Memento' reveals how the brain remembers and interprets events from clues

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Marked red are the brain regions which process the clue-providing key scenes, both before and while they occur. Anticipatory activity appears on the visual cortex up to eight seconds before the scene begins. During the scenes, there's fingerprint-like activity in the prefrontal lobe and parietal lobe, both believed to be connected to memory retrieval and reinterpretation of previously seen events. Credit: Memento poster detail (left), (c) Oy Nordisk Film Ab | Image (right): Iiro Jääskeläinen.

Key repeating moments in the film give viewers the information they need to understand the storyline. The scenes cause identical reactions in the viewer's brain. The results deepen our understanding of how the brain functions, how narratives work in film, and memory mechanisms are impaired by conditions such as Alzheimer's disease.

In an Aalto University film study combining art and neuroscience, viewers were shown Christopher Nolan's early classic *Memento* (2000). The protagonist is unable to retain new memories for longer than a few minutes. The events unfold in reverse chronological order. To provide the viewer with the means to piece together and understand the storyline, key scenes repeat at certain intervals throughout the film. These scenes work as clues—they give new information needed to understand the plot.

Every time they appear, the key moments make the same regions of the brain react in an identical fashion. Even the brains of different viewers show similar activity during the same vital scenes. "Normally, people make sense of a film's plot in their own individual ways. So far, it has been difficult to capture indications of simultaneous understanding in the brains of several viewers with brain imaging methods. We have now managed to identify brain activity connected to story reconstruction in the viewer's mind. The repeating key moments in *Memento* provide an opportunity to pinpoint viewers' cognitive activities: They react in a similar way to the information they get from the key moments," explains Professor Pia Tikka of Tallinn University, who leads the NeuroCine research group initially formed in Aalto University.

The research made use of functional magnetic resonance imaging (fMRI), which measures changes in the blood oxygen levels in the brain. The researchers used multivariate analysis when comparing the [brain activity](#) of different viewers. The brain was divided into three-dimensional data points called voxels. Using multivariate analysis, the researchers studied the activation patterns of the voxels. The key

moments in the film triggered similar and repeating patterns the researchers say are close to being "neural fingerprints."

"There is a total of 15 key moments in *Memento* that give the viewer opportunities to better understand the story—sort of "the butler did it" types of revelations. While the activation of the voxels varies randomly during other parts of the film, at each of the 15 key moments, certain voxels are in the same position for each viewer and form an identical fingerprint pattern," says Iiro Jääskeläinen, Aalto University professor in systems neuroscience.

The researchers observed the [fingerprint patterns](#) across large regions of the brain, especially in the prefrontal lobe and parietal lobe. "What is astounding is that the change in the viewer's brain, and especially in the visual cortex, starts to occur seconds before the key scene even begins. Clearly, there are some kinds of clues in the film communicating to the brain that something worth noting is about to happen. This speaks of the brain's ability to anticipate and predict," Jääskeläinen adds.

Viewers in the control group were shown the film's events in chronological order, where the key moments were not repeated. No fingerprint patterns emerged, and there was no anticipatory activity either. Unprecedented in the setup was that the test subjects freely viewed a feature-length, 105-minute film in its entirety in the brain scanner.

"In brain research, it is more common to show test subjects short sections of the same film or from different [films](#) and seek answers for strictly predefined questions. Such a setup, however, does not allow the film's dramaturgy and character development to play out properly. We have taken a step forward in understanding both the functioning of the brain and the process of understanding film narratives," says professor Tikka, also a filmmaker herself.

The results help researchers to comprehend how the brain remembers things based on received or obtained clues.

"*Memento* simulates what it feels like to be a person who has suffered damage to the hippocampus that has obliterated the formation of long-term memories. Even short-term memories last only for a couple of minutes before they are gone. The hippocampus also gets damaged—albeit to a lesser extent—in cases of severe and protracted stress as stress hormones gnaw the [brain](#). Our work also sheds more light on the neural basis of memory, which is of great help when we wish to understand dementias such as Alzheimer's disease," Jääskeläinen believes.

More information: Janne Kauttonen et al, Brain mechanisms underlying cue-based memorizing during free viewing of movie *Memento*, *NeuroImage* (2018). [DOI: 10.1016/j.neuroimage.2018.01.068](https://doi.org/10.1016/j.neuroimage.2018.01.068)

Provided by Aalto University

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