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Eye movements provide insight into amnesia

Our behaviour is continuously influenced by past experiences retained in our memories. These memories incorporate sensory details about our world and guide how we process new sensory input in the future. Because memory pervasively affects our behaviour, amnesia can have profound consequences for how an individual interacts with their environment. Yet, memory is not a unitary system: amnesia can affect some memory types more than others.

Twenty-five years ago, the kinds of memory that are lost or retained in amnesia was becoming a contentious topic, and in 2000 Jennifer Ryan and colleagues aimed to adjudicate among the prominent viewpoints prevalent at the time. One theory proposed that amnesia is a selective loss of explicit memory — memories of which we are consciously aware. According to this theory, implicit memories, which we can acquire and express without realizing it, are retained in amnesia. An alternative viewpoint held that amnesia impairs memories regarding relationships among elements of experience, whether those memories are explicit or implicit. Both theories agreed that explicit relational memories are impaired in amnesia, but they differed with respect to the fate of implicit relational memories. To determine which theory is correct, researchers can test implicit memory for relational information by assessing whether people detect that objects have been moved around in a scene, even if they don't realize their memory is being tested.

To accomplish this goal, Ryan et al. capitalized on eye movements as an implicit test of memory of visually presented scenes. Research participants included neurotypical individuals and individuals with amnesia due to head injury, anoxia or aneurysm. Participants viewed scene images while their eye movements were tracked. Their only task was to answer yes or no questions about each scene, which encouraged them to look at the relationships between objects in the scenes. Some scenes were repeated exactly as they were initially viewed. Other scenes were changed upon repetition: objects were added, removed or shifted. Researchers then examined how much participants looked at each scene and where they looked, depending on whether the scene was novel (viewed only once), repeated exactly as before or changed. Differences in how many eye fixations are made to repeated compared with novel scenes indicates overall familiarity with the image. Differences in where participants look within repeated compared with changed scenes indicates memory for relations among scene elements.

Neurotypical participants made fewer fixations with their eyes when viewing a repeated scene than a novel scene. They also made more eye movements to a scene region when it had changed compared to when that same region was novel or repeated exactly as before. Strikingly, increased viewing of changed scene regions was observed only when participants were unable to explicitly report what had changed, according to a post-test assessment. Thus, increased viewing of changed scene regions is an indicator of relational memory without awareness.

Individuals with amnesia also looked less at repeated scenes than novel scenes. Remarkably, however, their eye movements did not show any evidence of relational memory: they failed to look more at changed scene regions. Taken together with the finding that neurotypical individuals looked more at changed scene regions only when they were not consciously aware of what had changed, this finding suggested that relational memories can be lost in amnesia even if the memories are expressed unconsciously.

This work fascinated me during my PhD, and it continues to inspire my research into connections between memory systems, visual systems and eye movements. It motivated subsequent research that directly linked the brain's memory systems — most notably the hippocampus — to eye movement markers of relational memory without conscious awareness. It stimulated work that uncovered close connections between the brain's memory and oculomotor systems. Finally, it spurred research into how the representations that constitute memory matter more than whether a memory is expressed consciously or unconsciously. In summary, this elegant research highlighted how our eyes provide a window into our memory, even if we don't realize it.

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Competing interests
The author declares no competing interests.

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