Module: Psychological Foundations of Mental Health

Week 2
Cognitive processes and representations

Topic 3
Memory – Part 2 of 2

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Lecture transcript

Slide 2
Turning to long-term memory, I'm going to start by fractionating this function into two quite different processes, one which forms the memories that we can consciously access and explain and which is known as explicit memory, and the other which we cannot describe or define, but nevertheless consists of long-term memories, which is known as implicit memory. For example, we have long-term implicit memories for skills we've learned, like catching a ball.

And priming is a good example of implicit memory. Within this phenomenon, exposure to some stimuli, for example, a list of words, might alter participants' responses to later stimuli, without them explicitly recalling the previous words or knowing that they are affecting their responses. Note that implicit memories are not accessed through any conscious recollection.

Two other terms used for these two types of memory are "declarative memory" for explicit-- that means memories we can declare or say out loud-- and "non-declarative memory" for implicit, i.e., we cannot describe them in words. In order to demonstrate this fractionation, I'm going to use evidence from patients with amnesia.

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When the term "amnesia" is used, it refers to a specific problem in long-term memory, without concurrent decline of any other cognitive function. So "retrograde amnesia" is the term for loss of memory before the event that caused amnesia. And this is perhaps what people think of when they imagine amnesia.

For example, someone in a film has a bump on their head, and they can't remember where they are or who the people are that they're with or even who they themselves are. But actually, this is extremely rare, and the brain injuries that lead to amnesia do not usually lead to any severe loss of previously acquired memories from long-term storage in isolation.

Much more common are anterograde impairments. And these cause a loss of the ability to acquire any new memories. And it's very debilitating, indeed. There's little evidence, remember, that focal retrograde amnesia, that means pure retrograde amnesia without the learning deficits of anterograde impairments, exist without there being a psychiatric origin.

OK, so what do you think the film might be that memory research has rated the best depiction of amnesia in the movies a few years ago?

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So in Finding Nemo, Dory always says that she has a short-term memory problem. But what she really demonstrates is a clear case of anterograde amnesia. She fails to learn new events or new characters.

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The distinction between implicit and explicit long-term memory was clearly shown for the first time by Brenda Milner in her study of the most famous neuropsychological patient, HM. He suffered from severe anterograde amnesia after removal of parts of his medial temporal lobes that you can see in the figure here and hippocampal formations on both sides of his brain, so bilaterally.

HM had had this operation to remove these parts, as he suffered from profound and life-changing epilepsy. He was having many serious fits a day. So operations of this type are performed successfully to this day, but much less of the medial temporal lobes are removed, and memory impairments are vastly reduced, if they're present at all.

However, for HM, after his operation, he could remember family, friends, and events from before he'd had the medial temporal lobe moved. And he suffered, in fact, only quite mild, minor retrograde amnesia, with estimates suggesting maybe an impairment for the two years before the operation. However, new people and new events that occurred after his operation were never remembered. Dr. Brenda Milner who worked with him for over 40 years had to introduce herself on each visit.

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Brenda Milner and her colleague Scoville carried out a detailed study of HM over many years. And they showed clearly that his working memory was in the normal range. And this was for both verbal working memory and spatial working memory. His digits span for working memory was six, which is well within the normal range. And his spatial working memory span, which was assessed with the Corsi blocks was five, also in the normal range.

Just briefly, in this task, if you look at the figure, the experimenter, rather than saying out loud digits, taps a sequence on the blocks. The patient on the opposite side of the blocks can't see the number that they're tapping. They just have to remember where they tapped.

So HM had a normal digit span and a normal spatial working memory span. But when Scoville and Milner modified these tasks to introduce a long-term memory element, simply by trying to help him learn one more item at a time to the sequence of digits or the taps in the Corsi blocks, he failed to progress either verbally or spatially. So in the digit span, he managed one more. Normally, people can get up to around 15. And in the Corsi block task, he never made it up to six at all.

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Milner next tried a different type of task altogether. This was the mirror drawing task, and it revealed fascinating results. When people are doing this, they must watch their hand in the mirror, while they try to draw around a star shape. This is very difficult to begin with, as you can see your hand moving in an opposite way to the expected movement that you've planned.

HM was presented with this task 10 times on three consecutive days. And each time Brenda Milner came in with the task, he had no recall of having done it before. But if you look at the graphs, you can see clearly that he shows a very good improvement, in fact, exactly at the same level you would expect a person with no brain injury to do. Certainly, he's learning the task very well, and he's perfect by day three. But remember, this was without him being able to consciously remember ever having completed the star drawing task.

This was the first evidence that although he was unable to learn new explicit knowledge and form new memories, he appeared able to retain brand new procedural skills, but without any awareness

of learning them at all.

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Scoville and Milner wanted to test this type of learning in another way, in order to extend it beyond a motor learning task or procedural memory, to see if he would also show an improvement in another domain.

And they chose a visual task, the fragmented pictures task shown here. You can see that the pictures shown in block one are extremely fragmented indeed and impossible to recognise. But they become more and more detailed as you go through the blocks. Exposure to the more complete ones, if you can have some kind of memory of them, will then improve your performance when you next see the extremely fragmented ones in block one.

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If we look now at HM's performance, you can see for block one, he's failing to recognise many of the images, as indeed I'm sure you couldn't. But he's learning as he goes through the blocks. The crucial thing here is that one hour later, when he's shown block one pictures, he makes very few errors, showing that he's learned something from the previous four blocks. But again, he has no recollection of performing this task before.

This performance is entirely within a normal range, so he's learning visual material too, albeit entirely implicitly. And these data from HM provide an excellent source of knowledge into the difference between explicit and implicit memory. Both of these are long-term memory processes, but one, explicit, is impaired in HM and one, which is implicit, is entirely unimpaired.

So we learn that the parts of the medial temporal lobes that have been removed in HM are not needed for implicit memory formation, but they're certainly necessary for explicit long-term memory. His lack of a dense retrograde impairment also tells us that those medial temporal lobe regions are unlikely to be the site of long-term storage of old memories.

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So we've seen that memory is fractionated into working memory and long-term memory, and then that long-term memory is fractionated itself into implicit and explicit memory processes. Now, we will stick with explicit memory and examine a further fractionation. And this is the distinction between episodic and semantic memory.

There's clear evidence for a difference in the way that we remember events that happened to us-- that's episodic-- and facts about the world around us. That's semantic. So episodic memory is our memory for our personal experiences or personally experienced events. Note that this doesn't have to mean that they're to do with emotional, autobiographical memories or particularly things that are very special to you, although obviously they can be, and there's evidence that these might be consolidated more powerfully.

But you can have an episodic memory just for when you think back to walking into your kitchen this morning or having dinner last night. By this, I mean the memory of the event of having dinner last night and not just a recall of the food you ate.

And this brings me to the three Ws of episodic memory, what, where, and when. To have an event memory, all these three elements must be there. So if you really have an episodic memory of last night's dinner, when you say what you ate and who you ate it with-- that's what-- you also form a mental image with spatial information of what the scene around you looked like during dinner, which is the where.

And then, you will correctly position this memory in time. And that's when. And I don't mean here the actual time you ate dinner at, for example eight o'clock, but the temporal order of the

event within your life. So that's that it was after lunch, that it's last night's dinner, which occurred yesterday, and that it was after dinner the night before that.

So semantic memory is also part of explicit memory. But these are our memories of general knowledge, what we learned at school, university, what characteristics belong to different animals, which countries are in Europe. And very differently from episodic memory, they are context free.

So they're not stamped with that spatial and temporal information, the what, where, and when of episodic memory. You don't need to remember where you heard it first, whether you learned the features of a rabbit before or after you learned the features of a mouse. They don't contain these three Ws.

So there's evidence that episodic and semantic memory are functionally distinct and also that the brain networks that they require might be different too. For example, evidence does suggest that episodic memory is much more affected by medial temporal lobe and hippocampal damage than semantic memory.

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Endel Tulving, who was the person who coined the phrase "episodic" and "semantic memory," studied a patient known as KC. After sustaining damage to his medial temporal lobes bilaterally in a motorbike accident, he had severe anterograde and retrograde amnesia, but it was confined to episodic memory. Note also that HM's deficits were thought to be much more episodic than semantic.

Evidence that the deficit shown in KC was specific to episodic includes the fact that he took a mechanics course after his injury and during this managed to learn new semantic terms, for example, spiral mandrel, but without explicitly recalling people from the course or any episodic events during the same period. Any memories he seemed to make, in fact, of episodic type events, like family weddings, were, in fact, very factual in nature and didn't include a sense that he had personally experienced them at all.

In the top panel on the slide, you can see coronal slice through KC's brain, with the arrows pointing to medial temporal lobes and hippocampus, which you can see are extremely damaged, particularly if you compare them to the lower panel, where the arrows point to the same areas of a healthy brain.

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However, some research has argued that the differences shown in episodic and semantic memory might simply be down to the way in which we learn episodic memories compared to semantic.

So an event in our life can be experienced only one time. However, when we learn facts or read news stories, we often see the same material presented again and again, sometimes over a period of years. People thought that perhaps the less frequent exposure we have to episodic type information might be a possible reason why this is more susceptible to loss by brain damage than semantic information.

With this in mind, Varga-Khadem and her colleagues sought to test people who had suffered hippocampal damage at a very young age. The thinking was that if these patients showed an episodic-semantic distinction, this would be unlikely to be due to the time over which something had been learned, but rather something qualitatively different between episodic and semantic information.

So the researchers were interested in whether the young people can learn semantic knowledge, without these medial temporal lobe and hippocampal brain regions and despite any episodic impairment. In the brain scans shown here, the left panel is the coronal cross-section of a healthy

medial temporal lobe region, including hippocampi.

And on the right are the same sections from one of the patients participating in this study. The arrows point out the areas that are particularly debilitated. You can see they are much smaller and less dense. Three patients took part in this study, all of whom had suffered from hippocampal and medial temporal lobe damage at a very young age.

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These are the results from some of the episodic tests that Varga-Khadem and her colleagues performed on the three young patients. On the left are the results from word list recall, the black columns representing immediate recall and the lighter ones recall after just a short gap. You can see that the patients, Beth, John, and Kate, compared to a group of normal healthy controls, which were matched for age and labelled NC in the figure, forget almost all of the words after a short period.

On the right is the Rey complex figure task. And in the first panel, participants have copied this figure. And in the second panel, you can see their versions in a surprise memory test for the figure after just 20 minutes. The example from the healthy controls shows a reasonable amount has been retained.

However, the versions from the young medial temporal lobe patients is striking. They have really remembered very little at all from the image. These types of formal task were supported by self-reports from the patients and interviews with their families. In daily life, they demonstrate dense problems in remembering events that have happened to them, people they meet, and so forth.

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However, despite these episodic deficits, these children attended mainstream school, and they had IQs and knowledge within the normal range for their age group. Look here on the slide for some examples from the semantic testing that Varga-Khadem carried out. For example, here, John is asked, what is a sanctuary? And he replies, safe haven, a place of safety everyone can go to.

Or Kate is asked, why do some people prefer to borrow money from a bank, rather than from a friend? And she answers, because they can pay back the money in their own time. A friend might pester them.

So you can see there's really no semantic impairment here in these children. And the results from the patients show a clear episodic-semantic distinction. They were impaired in every episodic task, but at normal range in semantic tasks.

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Now we've seen the difference between episodic and semantic memory. Let's think a little about episodic memory itself. It's crucial to our sense of ourselves that we have a sense of re-experiencing the events that we recall. Indeed, the loss of episodic memory that is frequently among the first symptoms of dementia is exceptionally upsetting and unsettling for patients.

The significance of our personal memories to us makes it all the more surprising to learn how remembering is very much a reconstructive process. Rather than being analogous to an accurate snapshot or a video of an event, our memories are biassed by our expectations. They change over time or are susceptible to influence by false pieces of information. Thus, the re-experiencing aspect of episodic memory-- think again for a moment of having dinner last night-- often is not producing a veridical representation of the event that occurred.

One reason for the loss of accuracy with time can be due to rehearsing the memory in company and incorporating recollections of others the next time you recall the event. In fact, episodic memories can be inaccurate from the first recall. In the classic work by Loftus on the susceptibility

of eyewitnesses to falsely recall details of a crime scene when the wording of the questions was altered is an excellent example of that.

You heard last week from Richard some examples of false memories. These were episodic memories, and they were produced in experimental participants biassed by their prior expectations regarding what would be present in a particular room, for example, in an office.

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Wade and colleagues examined the extent that people were susceptible to falsely recall an episodic memory, by altering real childhood photographs that they had obtained of participants from their families. They put the photographs into new images, for example shown here, into a hot air balloon trip. And they knew that the participants had not, in fact, experienced the event that they were creating.

Despite this, when they were shown the image of themselves as a child in a hot air balloon, many participants, over 50%, in fact, produced rich and detailed recall of this entirely fictitious event, inspired to do so by the evidence they'd been presented.

Related to this evidence for the reconstructive nature of episodic memories is recent work by Demis Hassabis and Eleanor Maguire on the constructive nature of recall. And they've shown that the same network of brain regions, including medial temporal lobe and hippocampal structures, which we use when we recall real episodic memories, are also used when participants in a functional MRI scanner create an imaginary event.

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In this topic, I've introduced you to some of the principal aspects of human memory. I started with outlining what working memory is and in which ways it's different from the previous conception of short-term memory. I then introduced long-term memory, and we looked at the difference between implicit and explicit long-term memory, a distinction that was first shown by Brenda Milner's study of the famous patient HM.

And I went on to discuss how explicit long-term memory can be fractionated into episodic and semantic aspects. We looked at evidence for these being genuinely dissociable both functionally and structurally, as damage to medial temporal regions affects episodic memory, but not semantic memory or semantic knowledge.

Finally, I introduced some important aspects of episodic memory. This reconstructive nature of this type of memory renders it fallible. But as you'll see next week, it can also be harnessed into some forms of psychological therapy.