Module:
Psychological Foundations of Mental Health

Week 2
Cognitive processes and representations

Topic 3
Memory – Part 1 of 2

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Lecture transcript

Slide 3
Imagine you're involved in a conversation with a group of friends about a film you've watched. You have some strong opinions and points that you'd like to get across, and you're just about to make one point which disagrees with someone, but another friend comes in with their own point, slightly changing the discussion. Throughout this simple, everyday exchange, you must keep your points in mind, pay attention to the conversation, monitor what's going on, possibly modulate or add to the argument that you have in your own head.

It appears straightforward, and we do it all the time. But you're not only keeping this point you want to make in a simple, short-term memory store. This store is accessing your memories about the film from your long-term memory, using attention, and crucially, manipulating and organising your thoughts online. This is a cognitively demanding, active process. And these features of our short-term memory store-- what we now call working memory-- were not always well accounted for by theories within early cognitive psychology.

Slide 4
Before I outline the early theory about short-term memory and why it was incorrect, let's give you an idea about the kind of time period working memory works within. If you remember from last week, you learned about Sternberg's memory scanning paradigm. Digits were presented on screen, and then people were cued with a particular digit afterwards and asked whether it was present in the sequence. In this task, you maintain the digits in verbal working memory during the course of a trial.

But another quick and very common way to measure this type of working memory is to assess someone's digit span. This test is carried out in neuropsychology clinics the world over. Digit sequences of increasing length are presented, and people either repeat the sequence back or, more challengingly, repeat it back in reverse order, which is known as backwards digit span. When people get two sequences of the same length incorrect, the test is stopped, and their digit span is calculated as being the previously presented length. So for example, if they get five in a row correct and then make an error with both sequences of six, they have a digit span of five.

Let's try to do this now, and I'll read out the following sequences. Do it first forwards, i.e., repeating what I've said in the same order. And then rewind it, and do it backwards, so that if I say 3, 4, you would say, 4, 3.

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OK let's start. 2, 5. 7, 3. 3, 8, 5. 2, 1, 4. 5, 4, 7, 9. 1, 4, 2, 8. 9, 3, 2, 7, 5. 3, 8, 2, 6, 4. 6, 8, 2, 1, 5, 7. 4, 9, 3, 8, 2, 1. 9, 5, 3, 4, 2, 7, 1. 6, 2, 8, 1, 9, 3, 4. 8, 1, 7, 9, 3, 6, 2, 5. 2, 6, 1, 9, 4, 3, 8, 7.

I'll stop there at a sequence of eight. And well-done if you got to eight perfectly, particularly in the backwards condition.

Now, there are very large individual differences in digits span ability. And to do it well, it depends on many things, such as how tired you are, as well. But many people have associated the length of digit span with IQ. However, it's unlikely that this is a very straightforward relationship, particularly, as I've just said, it will vary according to many things, such as being tired. However, keeping in mind a large set of material and manipulating it effectively-- for example, producing it backwards-- is a very challenging and extremely useful cognitive skill.

Slide 5

Let's have a look now at the concept of a short-term memory store that existed before working memory was proposed. This is known as the modal model of memory and was devised by Atkinson and Shiffrin. This was seen as the definitive description of how the roles of short-term memory and long-term memory were parcellated for a long time. And the figure shows you how these roles were described. Items from the different senses enter sensory-specific stores for a brief time before entering the short-term store, where these elements might be rehearsed. And we transfer them into long-term memory, or we lose them or perhaps fail to rehearse them enough, and they're displaced.

Once in the long-term store, these items are in a permanent memory that can be returned to short-term store if needed for a current goal or task. Importantly, in this model, the route to the long-term memory is always through the short-term memory.

However, a simple study on just one neurological patient by Tim Shallice and Elizabeth Warrington showed that, as other people had suspected, too, the route to long-term memory was not necessarily through rehearsal in a short-term store. And therefore, the relationship between these two types of memory was not as described in the modal model. The patient in this study showed a severe short-term memory impairment in a variety of verbal tasks. But this was despite having no impairment at all in verbal long-term memory.

Shallice and Warrington argue two things-- first, that this means that short-term memory and long-term memory do not use the same neural structures as each other, as whichever structure was damaged in the patient, it did not impair his long-term memory; and secondly, that there can't be a sequential route from short-term memory to long-term memory, as otherwise, any impairment in short-term memory would prevent somebody possessing a normal long-term memory store.

Slide 6

It's not only the sequential nature of the modal model that did not fit the data. There also appeared to be separate short-term stores for different types of information. Baddeley and Hitch in 1974 showed this very nicely. Participants had to keep in mind a string of digits of varying length. And while they did this, they were presented with a spatial reasoning task. For example, in this reasoning task, they might see the letters C, G, and then the statement, "C is before G; true or false," which they'd have to answer.

The figure showed on the slide here shows that, although the time to compute the reasoning task went up as the size of the digit span to be recalled rose, the number of errors made did not go up. This means that keeping the digits in mind successfully-- these data are only from trials in which participants correctly recalled the digit string-- did not modulate reasoning accuracy. And so these two tasks that both need some kind of short-term memory store-- one, a verbal string of digits and one a reasoning rule-- presumably are not relying on the same resources. Otherwise, they wouldn't be able to be completed successfully.

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From this and related studies, Baddeley and Hitch developed the hugely influential model of working memory. And this has effectively replaced the idea of short-term memory.

Slide 7
Have a look at the slide at Baddeley and Hitch's first model of working memory. So working memory does not have as a function a route into long-term memory in the way the modal model did. But it is our mechanism by which we maintain online items from long-term memory that are relevant for our current task.

This storage is not passive and enables manipulations of this material; for example, the backwards digit span. We don't just repeat what's been said in that task, but transform it into the opposite order. And the addition of a central executive in this model is what enables this online manipulation.

But related to the study I was just talking about in the previous slide, the other important addition is having two independent short-term stores, one for verbal information, the phonological store or loop; one for visual-spatial information, the visuo-spatial sketch pad. So in a dual-task study, participants can maintain the digits in the phonological store, while the material in the visuo-spatial sketch pad can assess the relationship between the letters for the reasoning task. The central executive facilitates the process by organising the correct type of material into the correct store.

Some key assumptions of this model are first, if two tasks use the same parts of the working memory, they cannot be carried out well at the same time. And secondly, if the two tasks are using different parts, they should be successfully completed accurately.

Slide 8
Let's start by looking at the phonological store. The Paulesu et al. study from 1993 used PET to assess where in the brain might be important for this aspect of working memory. Note that nowadays, using our phonological store is often called verbal working memory, or VWM. What the authors here reasoned is that they thought English-speaking participants would use the phonological store for keeping in mind six English letters, but would use a different type of store for recalling Korean characters, as these are not verbally rehearsible if you can't speak Korean.

They isolated recall of the English letters and not the Korean characters to the two areas of the left hemisphere, which you can see circled on the slide here. One, circled in green, is more frontal. And one, circled in blue, is more parietal.

Slide 9
They then wanted to find out if these two areas differed in their roles for memory storage or in rehearsal for the sounds of the letters. If you think of Baddeley and Hitch's model, what they're looking at here is the phonological store compared to the articulatory loop.

So they added another task to the previous memory-- and remember, that was holding in mind six letters-- and added a rhyming task. So for example, they were asked, does the letter that you're currently holding in mind rhyme with B. This task is assessing online rehearsal of the letter sounds rather than storage.

Slide 10
Here, you can see a graph showing the difference in the use of these two areas, the frontal area, and the parietal area, in these two tasks. Memory refers to the first task that we talked about, which was storing in mind six letters. Rhyming refers to the second task we talked about, where they were asked what they have in mind rhymes with B. And you can see here, there's much more frontal activity when judging rhyming.

However, in the parietal area, activity during the rhyming task does not even reach baseline level.

So it seems that in the left parietal cortex, it might be more specific for a verbal working memory store, like the phonological store of Baddeley and Hitch's model. And the left frontal region might represent a neural correlate of the articulatory loop in Baddeley and Hitch's model. Interestingly, this left frontal area overlaps somewhat with Broca's area, which is a region we know to be involved in speech production.

Slide 11

Turning to the visuo-spatial sketch pad, this is used for creating a visual mental image of new items or items from long-term memory that you need online. To use your spatial working memory, which is the name for the type of working memory you use in the visuo-spatial sketch pad, just imagine your kitchen now and think of how you would go from your kettle to your fridge.

Navigating around this type of visuo-spatial mental image is one key task of spatial working memory. For us to be able to do this, we must hold in mind accurate spatial relationships of the items.

The study presented here by Possl assessed the neural areas involved in holding this type of spatial information in mind; i.e., in spatial working memory. They got participants to perform a simple task in the functional MRI scanner. The task started by participants being presented with an initial fixation screen, then a target item that appeared on the right or the left of a central fixation cross.

This disappeared, and they were required to hold this in mind over a delay period. In the delay period, while they looked at the fixation cross, black-and-white checkerboard patterns were presented bilaterally. These checkerboards were used as they're known to stimulate V1 very effectively.

After this period, fixation cross was still present. And two probe items were presented. Participants' task was to respond as to whether the target they had seen before the delay period was to the left or to the right or in the same position as where the probe items were now presented. So in order to do this effectively, they had to maintain the position of the target item in their spatial working memory over the delay period.

Slide 12

What they examined in the results was visual cortical activity in V1 to the checkerboards in the delay period. And what they showed was that holding a location in spatial working memory during the delay period enhanced early visual activity on the same side of space as that of the target. So here, it's on the right of the brain for the left target that you saw on the slides.

That means that keeping something in spatial working memory involves priming visual activity in the parts of the cortex that correspond to the item's location in the world. So there's some overlap here with the attention process, as I talked about in the last topic. This also spatially primes responses. Think of the exogenous queuing paradigm, for example. And indeed, it appears likely that similar right-hemisphere parietal regions are required for spatial working memory, just as they are for spatial attention. And in fact, the Neglect patients we talked about in the previous topic have a severely impaired spatial working memory as well, which suggests that, whereas left parietal regions are involved in verbal working memory, right-sided parietal regions are involved in spatial working memory.

Slide 13

You can see in our video of the patient from the attention topic completing the cancellation task that this time, without being able to see where he's cancelled or the Cs that he's clicked on already-- and you'll see that when he has to keep the locations in mind, which adds an additional spatial working memory element to the task, he's actually much worse than when he could see where he'd cancelled already.

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Slide 14

On the slide here, I've outlined very briefly some of the principal functions of the central executive, as proposed by Baddeley and Hitch. Firstly, it would describe what information should go into the stores, which store the information should go into, and it can inspect, transform, manipulate all of this information from the different stores. But what I'm going to do now is leave working memory here for now, as what the central executive is and how it works are all pivotal to the next topic this week-- that is, control processes or, in other words, executive functions. And we'll move on now to long-term memory.

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