Mental Processes and Memories

Introduction

In the last chapter I introduced the idea that we have different kinds of memories, including explicit/ declarative memories (memories of things we can explicitly describe or 'declare', like remembering the day you first went to college or remembering that Columbus reached the Americas in 1492), and procedural memories (memories that we would find hard to describe like remembering how to shift your weight when cycling a bicycle around a bend). In this chapter I will build on this distinction towards what it sometimes referred to as a 'dual process' model of reasoning.

First I will look at the type of dual process model that has been proposed in recent years for understanding how people come to judgement. This is obviously important in learning because, when we seek to learn something we first make a judgement about what we need to do in order to learn. Second I will then look at the different types of memories that are identified by social and behavioural researchers. This cuts to the heart of what it means to learn – when we learn we make memories; therefore an understanding of learning requires understanding the different types of memories we can form.

But first, coming to judgement.

Powerful intuitions and rational thinking

Here is a problem which forms part of a Cognitive Reflection Test, developed by Shane Frederick of Massachusetts Institute of Technology:

A bat and a ball costs $1.10.
The bat costs one dollar more than the ball.
How much does the ball cost?

The question is a powerful one because it gives rise to an intuitive answer (10c) which is incorrect. It is relatively easy to work out the correct answer (5c) but, when faced with questions like this, many people appear not to work out the correct answer. Instead, they "follow their gut", that is, they give the intuitive but wrong answer. Frederick (2005) has reported that, when 3,428 people from a wide range of settings including elite universities were asked three questions of this type, only 17% answered all three correctly. The percentage answering correctly ranged from 48% in MIT, though 20% in Harvard and as few as 5% in the University of Toledo. (Our 2013 sample from EPFL included only Masters' students which may explain why it fared a bit better: of 57 people who took the test, 54% answered all three of Frederick's questions correctly).

Frederick's test nicely illustrates what may be an uncomfortable reality: we are perhaps not as rational as we would like to think. Certainly we have the *capacity* for rationality, but we also appear to have an instinct not to use it all that much…

In recent years, social scientists have paid increasing attention to the non-rational aspects of human thinking. In sociology this is known as practice theory (which we will return to in a later chapter). In psychology, some have conceptualised human thinking as involving two systems or two types of

processes (see for example the recent book by Nobel Prize winning Economist and Psychologist Daniel Kahneman called *Thinking, Fast and Slow* [2012]*)*.

For Kahneman System 1 (or Type 1 processes) operates fast and automatically, requiring little or no voluntary control.

- When you cycle a bicycle along a bumpy road, it is system 1 which adjusts your balance and positioning of the handlebars. If you had to take the time to think about how to adjust your balance you would probably not be able to do so quick enough and would fall off.
- If you see the word 'banana', an image of a long, slightly bent, yellow fruit pops into your mind. You do not have to search for the meaning of the word 'banana', in fact it would probably take an effort to stop yourself from thinking about the fruit when you see the word. System 1 is again at work.
- If you are standing in your kitchen and suddenly, from the corner of your eye, you spot a large-bodied spider scurrying across the floor, you will in all likelihood, feel some degree of fear or disgust. Again, you do not search your memory to identify the creature and to work out if it is dangerous to humans or not. In fact, if you live in most of Western Europe it is very unlikely that the spider in question is of any danger to you. Nonetheless, without ever going through any conscious reasoning process to identify the creature, your body tenses, your adrenaline starts to pump, and you become primed move. Once more it is system 1 at work.

In the terms of Kahneman's book, all of these are examples of fast thinking or fast judgements. You will note, if you look back at the examples I have given, that System 1 is involved in physical movement (riding a bike), cognitive tasks (assigning meaning to words) and emotional reactions (seeing a spider). It covers a wide range of human judgements and activities.

Not everything is done quickly and effortlessly by System 1, however. There are some things that do require you to pay attention, and can involve mental effort. Take the following question:

Apples cost 32 cent and oranges 45 cent.
You have €3.97.
You buy 6 apples.
How many oranges can you buy?

Getting the answer to this question requires you to work it out – to perform a number of different mental activities at the same time. You have to multiply the cost of the apples by six. You have to remember the result and then subtract it from €3.97. You have to remember this result and then divide the answer by 45. Then you have to remember that you are buying apples and so the answer must be a whole number. At the same time as doing this, you have to manage the mental process – work out the steps of the procedure, remember which step you are on and which step comes next. Doing all of this takes time and requires an effort. It is not easy to do, and it would be even harder to do if you were trying to do something else at the same time (driving in town, listening to someone explaining directions to you, and so on). Here System 2 is at work.

System 2 involves mental effort and attention even if not always as much as in the question above.

- If you are not a psychologist but have studied the first six chapters of these notes, then you will probably be able to remember the names of the five factors that make up the Big-5 personality model. It may take a little effort and you may need to use some mnemonic device to help remember ('O-C-E-A-N'), or you may need to try to visualise yourself in the class and looking at the slide show during that lecture, but, with a little effort and a little searching, they will usually come to mind. Searching your memory in this way is also the work of System 2.
- System 2 can also play a role in some physical activities. If you need to walk quicker than usual to get home before the rain arrives, you may find that it takes some of your attention to keep up a faster than usual pace. If your attention slips, you may find yourself slowing down to a more typical speed again.
- When you learn to drive a car for the first time your conscious systems also play a role. You may find yourself speaking to yourself, reminding yourself to press on the accelerator a little more before lifting off the clutch. When you were learning to drive you probably needed to turn off the car radio to prevent it from distracting you (and, as we will see in the next chapter, if you did not do so, you probably drove more dangerously). Later however, these driving processes no longer require your attention; they become automatic and are taken over by System 1. However, when you are still learning, they are the remit of System 2.

In Kahneman's terms these are all examples of slow thinking.

It should be evident that both fast and slow systems have benefits and costs. One benefit of System 1 is seen in the example of riding a bicycle: if you had to think through and consciously control each action when riding a bicycle, you would almost certainly fall off. Conscious thought is often not quick enough to respond to situations. A second benefit is perhaps seen in the example of learning to drive: when you are still learning to drive, driving takes all your attention. However, once driving becomes more automatic you can think about other things or (maybe) listen to the radio while driving. Because driving no longer requires so much conscious attention, the space is freed for other thinking activities. In problem-solving the term *heuristic* is used to refer to a strategy which is relatively quick, uses relatively few resources, and which often – but not always – works. System 1 operates heuristics which allows you to come to quick judgement without carefully considering all the evidence or following a structured reasoning process.

On the other side of the coin, Frederick's bat and ball test shows the downside with system 1 heuristics and the benefit with system 2. While our automatic processes and our intuitive responses will often be good enough, sometimes they will fail. Indeed, much of the work of researchers like Kahneman has been in exploring predictable failures which arise from intuitive (System 1) thinking. When we want to make sure we have the best possible answer, we need system 2. In learning terms, if we want to ensure that we maximise our learning in any given situation, we need system 2 to be involved in making the decisions as to how to proceed.

As the examples above suggest, system 2 is, in a sense, 'the controller'. If we take the example of going for a walk, our automatic systems will manage the walking for us, allowing us to keep our minds free for other tasks. If we want to speed up our walk however, System 2 can take control and push us to walk faster. Similarly, in learning situations, we can take control of what we are doing and we can chose to monitor and control our own learning.

But, if System 2 is 'the controller', in the words of Daniel Kahneman it is 'the lazy controller': System 2 seems to avoid kicking-in when possible, and will take a break and let System 1 take over if it can. So, while we are capable of doing "slow" thinking, our tendency is to rely on our fast intuitions. This means that System 1 is hugely powerful – all day, every day, it is busily making judgements and decisions below the surface of our own awareness.

Jonathan Haidt from the University of Virginia, who has looked at the role of emotion and intuition in moral judgements, describes it as follows: for him, our intuition (System 1) is like an elephant with our capacity for rational thought and control (System 2) being the rider on the elephant's back. The rider feels that it is in control of the elephant, but, at the same time, if the elephant shifts to the left then the riders' attention will shift to the left too. As a consequence, what the rider sees (what our conscious self perceives) is typically what the intuitive self directs us towards: what we tend to see is that which confirms the direction in which our intuition is taking us. I noted above that recognising how much we rely on System 1 would probably be uncomfortable given that we are used to thinking ourselves as 'rational' beings. In fact Haidt argues that one of the functions of System 2 is that it uses it rational capacity to justify judgements made by System 1; in other words, we often make the judgement intuitively and then afterwards come up with reasons as to why the judgement was correct. Part of the value of Haidt's metaphor is that it directs us to where the power lies in our thinking processes: we may see our System 2 as being 'the controller', but in reality the elephant will go where it wants, while the would-be-controller spends much of its time in a PR role, coming up with reasons after the decision as to why a particular judgement was a good one.

Implicit and Explicit Memories

In the last chapter I distinguished between explicit/declarative memories (ones we were conscious of holding) and procedural memories (ones which were automatic and could not be easily consciously described). It is probably obvious by now that procedural memories are closely tied to System 1, while declarative memories have some links to System 2. In this section I will provide more detail on the different forms of memory that fall under these two broad headings.

Try to remember, if possible, when you learned to cycle a bicycle (if you never learned to cycle a bicycle then think of some other activity you learned – skiing, swimming, riding a horse, roller skating etc.). When I do this, the memory that comes to mind is of being outside my family's house as a child on a bright day. My father had been helping me learn to cycle by holding the bicycle upright while I turned the pedals and moved forward. He kept letting go and each time I noticed he had let go I lost confidence and lost my balance. Now he was taking a break and talking to a neighbour while I got increasingly impatient and kept trying to drag him away, telling him I wanted to try again. Eventually I decided to try without him holding the bike. So, as he chatted, I pointed the bicycle downhill and set off, and managed – to my enormous surprise – to keep the bike upright while I pedalled. I was so surprised, I jumped off the saddle and pushed the bike back up the hill to ask my father if he had seen – I had done it! The excitement still comes back to me now, over a space of decades.

This sort of memory – a memory of an episode or personal story – is called an *episodic memory*. It is a memory that I can consciously describe and recall – it is one of two types of explicit or declarative memories.

The other type of declarative memory is also evident in this story. As you read the story, you knew the meaning of the words 'house', 'pedal', 'bike/bicycle', 'father', 'saddle' and 'hill'. If English is a native language – or if you are relatively fluent – you may not have had to search your memory to recall the meaning. For non-native speakers a memory search may have been necessary. These kinds of memories – memories of meanings, of facts or general knowledge – are called *semantic memories* (the word 'semantic' means 'related to signification or meaning'). Other types of semantic memory involve being able to explain what is meant by 'one-quarter', being able to explain Maxwell's equations, being able to describe something about the political context in which Shakespeare wrote his play '*Henry V*', or remembering in what year the French Revolution took place. Very often it is semantic memories that are the focus of learning and assessment in schools, and universities.

The key element of both semantic and episodic memories is that we can relatively easily describe what it is that we remember. For that reason they both types of 'explicit' or 'declarative' memories.

Although I have a reasonably clear memory of the day I finally managed to stay upright on my bicycle, there are lots of other days that I tried and failed, and which I don't remember. Along the way of all those trials and errors, I learned to cycle a bike. If you break what I learned down into its component parts, it turns out that it is a fiendishly difficult thing to describe. Turning the pedals alone involves:

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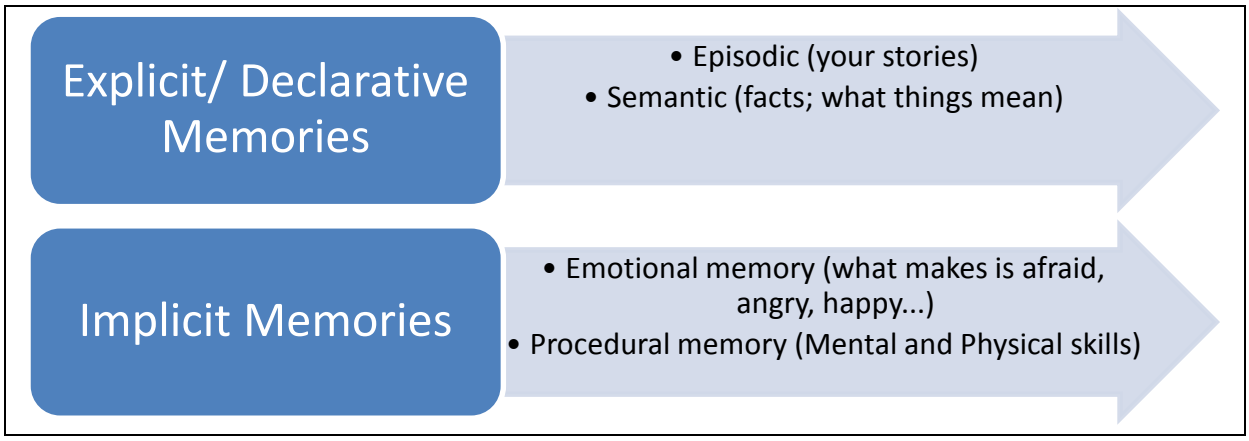
(a) Pressing both forward and down on the left pedal
(b) Shifting the weight and the angle of the foot to press downwards on the left
(c) Keeping enough pressure on the right foot to stop it slipping off the pedal without putting so much pressure that it hampers the downward progress of the left pedal
(d) Shifting the weight and the ankle to push backwards on the left pedal at the bottom of the cycle
(e) At the same time, shifting the right ankle to push forwards and to put weigh on the right pedal while simultaneously lifting some (but not all) weight off the left pedal
(f) Pressing both forward and down on the right pedal
(g) …and so on

And this involves just moving the pedals, and doesn't even fully explain that (I have left the knee and hips out of this account entirely) (!) At the same time as doing all this, I am maintaining balance, shifting the handlebars, looking where I am going, and half a dozen other things. Writing it out like this makes it seem incredibly complex and, indeed, it is incredibly complex: that is why it takes so long to learn. When I first learned to stay upright on the bike I could not have done so while turning the handlebars. I regularly bumped into things because I could not find the brake while focussing on my balance and staying upright. Now, however, it has become so fluent and easy that it is taken for granted and actually describing the process is incredibly difficult. If I was to add more elements to the process (how do I shift my weight when I turn a corner when cycling at speed, how do I move when the front wheel hits a bump?) it would be effectively impossible for me to describe what I do. Yet, at the same time, it is clear that *I have a memory which tells me what to do.* This knowledge is called a *procedural memory* (a memory of a procedure that I follow). Because it is hard or impossible to describe, it is called an implicit memory.

The example I have given here relates to motor skills (riding a bicycle) but if you remember the examples given about system 1 above, you will see that something similar can happen for emotions and for thinking processes: we learn them and they exist as memories without our being consciously aware of them:

- Procedures probably play a strong role in learning. When you have to learn from a text, you may well have a way of reading it that you begin automatically. It may be hard to describe what that is because it is so automatic (do you scan first to understand the general argument before reading, do you read each section carefully and afterwards try to stand back and see the big picture, do you read carefully but not stand back to see the big picture, do you keep going when you think you don't understand something, do you stop, walk away and try again, do you just walk away, and so on?). Learning in lectures, learning from completing exercises or projects is probably the same – you may well have a way of doing things which you begin automatically in a given situation and which you would find hard to describe to someone else. These too are examples of procedural memories.
- When faced with a particular social situation (if for example, when working on a group project, someone dismisses your ideas and insists on a different approach), you may not be able to describe how and where your emotions come from (you may get angry or feel embarrassment, or both) but nonetheless they appear to come automatically. Again this is an example of an implicit memory being activated.

Explicit and Implicit long term memories



Conclusion

When we learn we form memories. However, not all memories are of the same type of formed in the same way. As we saw in the last chapter – particularly from the studies on HM – forming long-term explicit memories involves the use of particular brain systems (such as the hippocampus). We also say from HM that learning implicit or procedural memories (like drawing the star in a mirror) did not implicate the hippocampus but instead relied on other brain systems.

Much of the focus of learning research over the years has been about how we form explicit semantic memories. This is understandable because it is often those kinds of memories that are deemed to be important in school and in university. It is possible that these kinds of memories have also been the focus of attention because we like to think of ourselves as conscious and rational beings. In the next two chapters we will pay more attention to the processes through which we form long term semantic memories.

However, it is hopefully also now evident that we probably tend to over-estimate the role of our conscious and rational selves. Like an iceberg, we focus on the rational and conscious part of our thinking which is above the water, and underestimate the importance of the vast among of mental processing which goes on unconsciously all the time drawing on our implicit and procedural memories. This is important to recognise and to pay attention to (a) because much of what we aim to learn are actually procedures (learning to use certain tools, but being able to recall things fluently and with ease) and (b) we learn though following learning procedures, often without really realising we are doing it and without being readily able to explain what they are. And, as Jonathan Haidt has suggested, even if we are asked to explain what we are doing, the rational rider, probably follows the lead of the intuitive elephant and so, rather than questioning what we are doing, we use of rational ability to justify it to ourselves.

So, it will be important to come back keep in mind and consider the way in which procedures play a role in our learning. First, however, we will turn our attention to semantic memories and to the key role of attention in learning them.

will now turn.