

Memory

Today's lecture will be on memory. We have all learned about Pi, 3.14..... How many numbers after the decimal point in Pi do you remember? 2? 3? In 1985, Rajan Mahadevan was the record holder for the number of digits after the decimal point in Pi remembered: he was able to memorize 31811 digits! In 2005, the new record holder Chao Lu memorized 67890 digits. When we learn about such impressive performances, we might think that there are major differences between how THEY memorize and how the rest of us memorize. However research shows that the differences between their abilities and everybody else's are not due to unique aspects of the brain but are due to the amount of practice and the strategies those record holders use. In a similar vein, the record holder for memorization of the order of cards in a shuffled deck was able to see the cards, memorize the order, and retrieve the order in 31 seconds. Rajan Mahadevan has been studied a lot because of his abilities. It turns out that has normal memory for life events, just like most people. But his special talent is for memorizing numbers.

Memory and identity

memory is fundamental for a person to understand the past, savor the present and have a future thus to know oneself. Loss of memory results in someone being trapped in a perpetual present. This might not seem so bad but it actually is, and we watched a video illustration how difficult life is without memory. Video clip: in class we watched a clip about Clive, a man who has anterograde amnesia. With anterograde amnesia, it was impossible for him to form new memories. So he could remember some things, he would recognize his wife when he saw her. But he would not be able to remember that he had seen her the day before. Every time he sees her, it would be as if he was seeing her for the first time. What was Clive's life like before he had anterograde amnesia? Clive was an outstanding musician. He was a brilliant singer, conductor, piano player and a very intelligent man. Then Clive had a viral infection in his brain. The infection destroyed parts of Clive's frontal lobes. Most importantly the infection completely destroyed Clive's hippocampus, the part of the brain responsible for memory. Not only did he lose his ability to form new memories, but the damage to his frontal lobe causes him to repeat himself a lot and to be very emotional. Note that his senses are intact, and he is still able to have a conversation, he still remembers some facts, but nothing he experiences makes an impression in his memory. He only lives in the minute. He senses all of the information, but as soon as he perceives it, and looks away, all of the experience fades. Clive constantly writes in his diary. Every time an experience fades and he starts a new one, he tries to keep track of it. He looks at his watch and writes the current time on his diary, he also writes about the fact that he is conscious in the moment. When he looks at the diary later, he knows it's his handwriting, but he thinks he was unconscious when he wrote what he wrote, and that he is only conscious in the present moment. His wife describes him as a highly intelligent and lucid man robbed of

his knowledge of his own life. We see that he is frustrated that he doesn't know himself and his life. Our memory allows us to relate to ourselves in terms of the past, the future and the present. Animals are not able to self-reflect, they only live in the present. Interestingly, Clive is still able to play the piano really well and to sing. According to his wife, his able to read music and play the piano is automatic like riding a bike, so he can still do it. As soon as the music stops, Clive has convulsions, as if we was switching from an automatic mode to a world requiring him to think. Clive's language capacity, how he interacts with others, the way he relates to music show that it is not as if he was retarded or completely unable to function. With the video, we get insight into what it is like not to be able to form new memories.

Types of memory

- Sensory memory: memory for the momentary information, for the immediate information of right now
- Working memory: it's about consciousness, what we are trying to figure out now, like when we try to remember a phone number
- Long term memory: is a storage space. The history of our lives, facts we know, etc are stored there

Let's get into the details of these types of memory.

Sensory memory

Sensory memory has two sub-parts: iconic memory for visual stimuli and echoic memory for auditory stimuli. We probably have memory systems for our other senses but those have not been studied much. Sensory memory involves the brief persistence of a stimulus at one of the sense organs. Sensory memory forms automatically, without us devoting attention to it; however it decays very rapidly. Iconic memory was discovered by the researcher Sperling. We did a class demo to illustrate Sperling's research.

Class demo: all of us were asked to focus on a cross on the screen; then at the location of the cross, we were very briefly exposed to 4 rows of letters to memorize. The letters are flashed really fast. Most of us only remember about 4 letters; very few of us get six or more. Researchers used to think that this effect was happening because participants did not have enough time to see everything. Sperling showed that this was not about time, that people were seeing everything but that the information was decaying too fast. He conducted an experiment similar to our class demo, except that after the letters are flashed, participants are only asked about one random row of letters rather than all of the letters. Participants had no idea which row they would be asked to remember. It was found that people did really well, which showed that it was not about time. People were seeing everything but the sensory information was decaying too fast. We do have some retention of the entire scene; we get a lot of information through the entire visual field, we just forget it too fast. Researchers found more about iconic and

echoic memory: iconic and echoic are both short lasting, but they don't last the same amount of time. Iconic memory starts to decay after .3 seconds, echoic memory after 2s. Those time frames are true when we are not devoting any attention to the information, when we are not doing anything particular to help us remember. Why is there a difference between how long echoic and iconic memory last? The effect happens because most auditory information follows a time course. In order to make sense of auditory information, we need to hold it at least a little so that we can link it to the rest of the sentence. This does not happen for visual information. That explains why we can recall the last sentence in a phone conversation even if we were not paying attention a few seconds earlier.

Working memory

The main function of working memory is the active processing of information for manipulation, judgment, and use with other information. Working memory has a much smaller capacity than sensory memory, but the information stays in it for longer: this corresponds to about 30 seconds, 7 plus or minus 2 pieces of information depending on people. If it takes us more than 30 seconds to write down a phone number, we forget it unless we rehearse it or use some strategy to remember it. Working memory has several parts: the **phonological loop, the visuo-spatial sketchpad, and the central executive.**

The phonological loop is for auditory information. We retain language by rehearsal, in cycles. The phonological loop takes information from sensory memory through rehearsal to provide some preservation of the sensory information. If it is not rehearsed, the memory starts to fade. We participated in several class demonstrations to understand working memory.

Working memory capacity demo: we are given 7 lists of numbers. After each list, we are asked to write down what we remember of the list. The first list has 5 digits, the second 6, the third 7 digits, etc, and the last list has 11 digits. Most of us remembered all of the digits for the first list which had only 5 digits, and only one of us remembered all of the digits in the last list with 11 numbers.

Demo: what features of auditory information are stored in the phonological loop? We are given two lists of words one after the other to remember:

- First list: cab, mad, can, map, man, mad, camp
- Second list : broad, wide, fat, big, huge, large, vast

Those two lists have the same number of items but in the first list, the words have different meanings but sound similar whereas in the second list the words have similar meanings but sound very different. Although the two lists have the same number of items, we were much better at remembering the second list than the first. This shows that the phonological loop does not focus on meaning but on sound or acoustic features of the information. Similarity in meaning does not interfere with our ability to remember the list, but similarity in sound does.

Class demo on the use of strategies to improve memory: we were asked to remember the following list: 1,7,7,6,2,0,0,7,2,4,7,9,1,1,2,2,9,0,4. Very few of us could remember more than a few digits. It turns out that the numbers in the list can be grouped as follows: 1776, 2007, 24/7, 911, 22904. Once grouped, the pieces of information have a meaning, which cues us into what to remember and makes the list much easier to recall. This grouping is called **chunking**. By grouping individual pieces into units we increase our storage capacity because rather than storing each individual piece (19 numbers), we store 5 units. It turns out that people who have excellent skills at memorizing huge lists of digits use this kind of strategy: they break the list into meaningful chunks.

The visuo spatial sketchpad is for visual imagery. In class the class demo, we briefly looked at a cartoon, then the cartoon disappeared and we were asked to identify the side of the picture that had a cat. Most of us could remember because we were able to consult the image stored in our visuo spatial sketchpad to find the information.

The central executive directs everything, and constantly manages all components of memory so that we can better use the information.

Long term memory

Long term memory is a long term store of virtually unlimited capacity (if there is indeed a limit, no one knows about it yet). The information can be stored in different ways:

- **Implicit memory:** we have the memory, but we can't easily retrieve the memory when needed.
- **Explicit memory:** memories we can recall when needed. Explicit memory has two parts: declarative memory and episodic memory. **Declarative memory** is memory for facts of the world, like the fact that $2+2 = 4$. **Episodic memory** represents our memories for episodes of our lives, like if we remember what we had for breakfast, and what eating breakfast was like.

One amazing thing about humans is that they have the capacity to remember anything. In one study, people were surveyed at different points of their lives, to see whether or not they remembered their high school classmates. Participant's memory was pretty much as good 34 years after high school than right after high school when they were shown pictures and asked whether or not they recognized the people in the pictures (recognition). Memory was not as good when the participants were asked to recall the names of the people in their class. It's still impressive that their memory would be this good, especially that they were not practicing the names at any point in order to remember them.

How does information go from one part of memory to another?

From sensory memory to working memory, attention is the critical process. Once the information is in working memory, rehearsal is the critical process: practicing can help the information stay in memory and eventually move to long term memory. When the

information moves from working memory to long term memory, it's being **encoded** so that it has more staying power and we can use it later.

Class demo: We were presented with 15 different images of a penny and we were asked to pick the right image that was a real representation of a penny. We all see pennies all the time, but we could not identify the right picture. Why? The details of pennies (like the specificities of what they look like) are irrelevant for how we use pennies in everyday life, so we have never encoded that information in long term memory. Other things affect the encoding process. In class, we were given the following list of words to remember: hand glider, baseball, cheddar, jackrabbit, unicycle, corkscrew, orange, diskette, pinwheel, anchor, monkey, oven mitt. Most of us remembered hand glider and oven mitt but did not remember corkscrew and orange. Information that we hear at the beginning of a list is more likely to be remembered because of its **primacy**: we can rehearse that information more easily without interference. Information at the end of the list is also more likely to be remembered because of its **recency**: there isn't later information that interferes with us remembering it.

Information in the middle of a list is difficult to remember because it is affected by both the information at the beginning and the information at the end. Recency and primacy are encoding processes. **Retrieval** processes are for taking information out of long term memory to use it. We will talk about retrieval next time.

Summary:

- Memory is fundamental to understanding one's identity. When we lose memory, we lose important parts of ourselves.
- Effective memory is about knowing what not to remember, despite all of the information we get in sensory memory.

Clive 15 years later

Clive is 60 years old, and he is still a prisoner of the present moment. He can't live independently, so after spending some time at a psychiatric hospital, he now lives at a special facility for people who have suffered a brain injury. The facility is designed so that everything is simple, and all cues that moments outside of the present moment exist are removed. For example, the staff is trained to only ask questions about the present moment: they might ask him "how is the coffee?" but never "how are you today?". "How are you today?" implies that there is a yesterday, which stresses Clive out. Clive continually makes entries in his diary. He has habituated his condition a little better thus is less emotional. He does not know exactly how old he is and what month it is, but he can approximate. He notices that his wife has grey hair now, but it's not for him as though time has passed. This is a fascinating case that illustrates how one loses a sense of who they are because they have lost the ability to form new memories.