Informatics 1 Cognitive Science – Tutorial 9 Solutions

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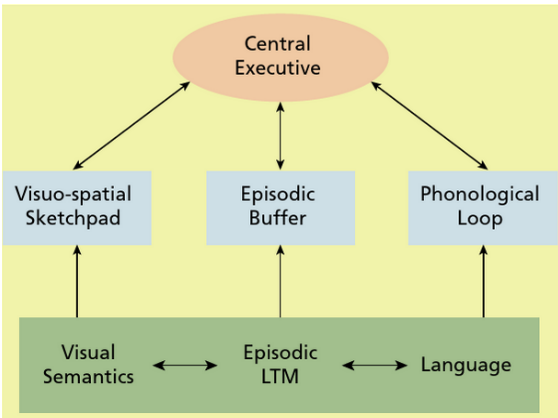
Week 10

In the lectures we discussed two different memory systems: short term memory and long term memory. Short term memory is characterised by a limited capacity and a short retention duration, whereas long term memory has a much larger capacity and a much longer duration. In this tutorial we will discuss models of these two memory systems.

Part 1

In the lecture you saw some evidence (Meredyth Daneman and Patricia Carpenter, 1980) that short term memory does not appear to be a simple buffer with limited capacity, but has multiple subsystems from which stored information can be selected. Moreover, information is not maintained in its raw sensory form, but is transformed into a more abstract form that can be manipulated and combined with other information. This is formalised in a model by Alan Baddeley and Graham Hitch (first published in 1974 and updated in 2000), who proposed that short term memory is composed of several components, summarised in the following figure:



Short-term systems are shown in blue, and long-term memory systems are shown in green. You can find a brief description of this model in the recommended reading for week 9 (The Student's Guide to Cognitive Neuroscience: Chapter 11 - The remembering brain).
Questions:

1. Describe the components of the model and their function.

Solution: The model consists of three components: the central executive (red), several short-term storage components (blue, phonological loop: verbal information, visuo-spatial sketchpad: visual/spatial information, eposiodic buffer: short-term memory). In addition, the model includes long-term memory (green).
The central executive controls which information from the short-term storage components is

accessed based on task goals, so it can be loosely seen as a component that directs attention in a goal-directed manner. Each of the short-term storage components hold items that decay over time, but can be refreshed by rehearsal. The phonological loop is responsible for the temporary storage of verbal information. It consists of two parts: the phonological store, which holds the information, and the articulatory control process, which rehearses the information (think of repeating a phone number to better remember it). The visuo-spatial sketchpad is responsible for the temporary storage of visual and spatial information. It is viewed as a mental whiteboard to hold and manipulate visual imagery. The episodic buffer (added to the model later) integrates information from episodic memory about events or experiences. Long-term memory is not part of the short-term memory system, but it can feed into it.

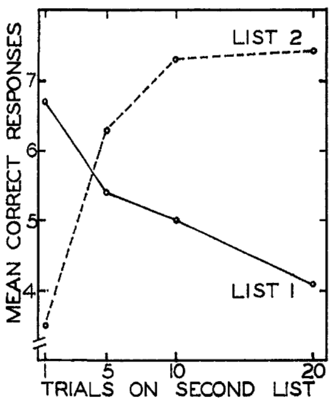
2. A key insight this model provides is that short-term memory is not a simple buffer, but has multiple subsystems that can be selectively accessed. What does this model predict in the following situations:
(1) You are listening to a lecture and trying to remember the main points. The lecturer often includes unnecessary additional words in their sentences. Does this model predict this will impact comprehension?
(2) You are cooking a meal and listening to the news at the same time. Does this model predict that you will be able to remember the news?

Solution: (1) Baddeley's working memory model predicts that unnecessary additional words in a lecture can hinder comprehension. The phonological loop in the model has a restricted capacity. Unnecessary words take up some of this space and compete with the relevant words. In addition, the central executive allocates attention. If the lecturer uses a lot of filler words, attention can be diverted, making it harder to focus on the core information you need to remember.
(2) In this scenario, multitasking might be fairly efficient. The visuospatial sketchpad can handle some the cooking steps (especially if well rehearsed, e.g. for a familiar recipe). At the same time, the phonological loop can process the news as long as it's not too complex and doesn't require significant attention. If the news are particularly interesting or the cooking requires more focus, then attention has to be switched back and forth, which can lead to errors or missed information.

Part 2

Questions:

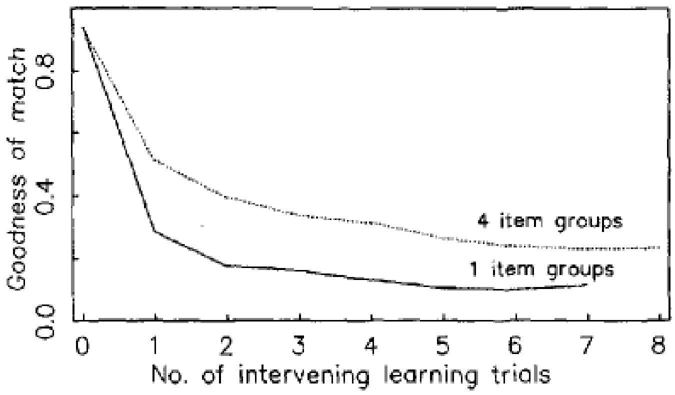
1. The following figure summarises the results of the study: *Barnes, J.M. and Underwood, B.J., 1959. "Fate" of first-list associations in transfer theory. Journal of Experimental Psychology, 58(2), p.97..*



In this experiment, participants were asked to learn a list of word pairs, where the first word consisted of two nonsense syllables and the second was a two-syllable adjective. Participants first learned a list of word pairs, and then a second list for a given number of trials (x-axis in the graph). After the leaning the recall of the pairs was tested for both lists, where they had to recall the second word of each pair when presented with the first word. What does this figure tell us about the nature of forgetting?

Solution: This experiment shows that the more often the second list is learned, the more the first list is forgotten. This is a demonstration of the phenomenon of retroactive interference, where new learning interferes with the recall of old learning. It is assumed to be a form of forgetting that is not due to decay of the memory trace, but due to the interference of new learning.

2. Now let's compare this to a result from a connectionist model. The following figure shows the results of a simulation of a simple MLP trained with the backpropagation algorithm to associate a set of input patterns with a set of output patterns. The network was trained with a first set of patterns until it performed well, and then on just one additional pattern pair. The following figure shows the performance of the network on the first set of patterns as a function of the number of training trials on the final pattern:



(from *Ratcliff, R., 1990. Connectionist models of recognition memory: constraints imposed by learning and forgetting functions. Psychological Review, 97(2), p.285.*)

What does this figure tell us about the nature of forgetting in the MLP, and how does it differ from the human result?

Solution: This figure shows that the first patterns are almost immediately is forgotten (goodness of match refers to the similarity of the output pattern to the target pattern). This is a demonstration of catastrophic forgetting, where new learning interferes with the recall of old learning. In contrast to the human result, where memories gradually decay, the MLP shows a sudden and catastrophic loss of performance on the first set of patterns.

3. Discuss the implications of these differences for the design of artificial systems.

Solution: This is a general issue with neural networks and is also known as the stability-plasticity dilemma. One common solution in cases where a network has to solve multiple tasks is to interleave them during training. But this is not how we learn. There is no good solution in the literature, so one could speculate how this can be solved in artificial systems. Perhaps using short-term memory mechanisms such as the one discussed in Part 1 could offer a solution.