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Richard Atkinson & Richard Shiffrin proposed the **modal** model of memory which was able to incorporate most of the features of memory known at that point of time. This model consisted three stages for the information storage. This was sensory memory, STM and LTM in order.

Duration:

As described by the model, STM can hold 5-7 items for about 15-30 seconds.

Brown and Peterson & Peterson in 1960s used method of recall which helped in determining duration of STM. They performed an experiment in which participants were given some set of alphabets and numbers and were asked to say out the numbers aloud with a difference of three. The counting of numbers allowed stopped the rehearsal process. An important observation was made that if they were asked to count for 3 seconds, they recall the alphabet and numbers with 80% accuracy; in contrast only 12% accuracy was achieved if they were asked to count for 18 seconds. Initially they said that it was due to decay as time passes. Few years later Keppel and Underwood said that it was not due to decay but was due to **proactive interference.** Proactive interference is when previously learned information hinders learning of new information. So instead of just having one trial, they took many trials on same participant and concluded the above. Another popular example for proactive interference is remembering newly changed phone numbers of some person.

Capacity:

The estimated range of STM is said to be between 4-9 items. A popular example is Digit Span, this test can be taken online easily on the web as their are many available websites. Earlier experiments averaged capacity to 9 whereas more recent studies keep the average capacity to 4. (flashing two arrays of squares in succession with one of the squares color is changed.) Increasing squares above 4 significantly reduced the accuracy.

Another important concept is **chunking** that small units can be combined to form meaning units, Units can be phrases, sentences, paragraphs. Prime example being it is far easier to recall the sentence and will be very difficult if sentence was jumbled. Chunk can be defined as collection of some elements which can be associated with each other in some sense but seems very unrelated to other chunks. Chunking helps to increase capacity of STM significantly. A popular study that chunking is extremely helpful was shown when Ericsson was able to increase digit span from 7 digits to 79 digits with help of training. This is also the case in some of abacus classes where chunking improves STM.

LTM help to STM : Example of chess board arrangement is a great example of how LTM can help to increase STM. A master chess player can recall a board from actual games but a novice was not. Also the random board was difficult for both. Thus concluding that familiar boards in LTM helped to remember the presented board.

Information Coding in STM:

Information in STM is stored by a process called **coding (**information presentation way**).** Physiological approach to coding is by determining how neurons are fired in representation of a stimulus. Information can be coded in a variety of ways such as auditory coding, visual coding, semantic coding,

- Auditory Coding :
  - Based on sound
  - Experiment by Conrad in which "F" was mistakenly coded as "S"
- Visual Coding :
  - Remembering Visually
  - Reshading the squares that was presented before as shown by Della Sala
- Semantic Coding:
  - Representation using meaning
  - Proactive interference of similar kind of words presented after is prime example

Coming to Working Memory: Alan Baddely said that STM processes must be dynamic and considered a number of other components which are independent but may interact in some manner.

Working memory was one of the components he described. It is defined as a limited capacity system that have temporary storage and can manipulate information for complex tasks such as thinking of a method for a physics numerical.

STM and working memory are different in some aspect as STM is only concerned with storing of information for a short span of time, working memory is also associated with complex thinking and analysis. STM consisted of a single component but working memory consisted of many more components.

The three components namely *phonological loop, visuospatial sketch pad and central executive* are used to manipulate the information.

- Phonological loop : Two components, phonological store which is of very limited capacity and articulatory rehearsal processes which helps to stop decay information in store. It contains verbal and auditory information. It is the reason for confusion of letters of similar sound such as "F", "S", "X". Word length also matters in this component.
- Visuospatial sketchpad : holds visual and spatial information
- Central Executive : It pulls information from LTM and helps in coordinating activity of phonological loop and visuospatial sketch pad by helping to switch attention from one part to another. One major task is how to divide attention b/w tasks.