

RELATIONSHIP BETWEEN RECALL AND LANGUAGE

Abstract

Memory is an important cognitive domain for different walks of life and is found to be crucial for mediating the activities of daily living. Recall is an integral aspect of memory. Memory would involve stages like encoding, storage, and retrieval. The way we encode the information enables us to remember information for a longer time. The ability to store information varies from one individual to another. While retrieval and recognition would involve access to the stored representation. Language and cognition are interrelated in nature. The same is applicable to language and recall as well. The linguistic aspects like semantic relatedness, and phonemic relatedness would facilitate easy encoding. Factors like word length, nature of the word (concrete vs abstract), and the grammatical class of the given word (nouns v/s verbs) would influence the storage as well access. This in turn can have an effect on recall. The current book chapter reviews the studies relating to language and recall and can help in devising assessment and therapeutic strategies for cognitive-linguistic intervention.

Keywords: Encoding, storage, retrieval, linguistic parameters

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I. INTRODUCTION

Verbal recall refers to the recollection of verbal information, and it forms a major crux in the study of memory. Studying recall helps to give an insight into the memory process of an individual. Several models have been put forth to describe the process of recall. One such model is the Generate-Recognize model. The model assumes that during the an item is initially recovered from memory by the method of searching, and then the returned item is evaluated by the method of recognition to see if it is on the list of items that need to be recalled. ^[1] Thus, to recall a word, it must both be successfully retrieved and recognized. Another explanation is based on the Encoding Specificity principle. According to this theory, memory utilizes information from the situation in which it is obtained, the memory trace, and the context in which it is stored, i.e., memory is better when the information accessible at the time of encoding is also present at the time of retrieval. ^[2] The encoding specificity principle considers the effect of these contextual cues. The scientific study of recall dates to 1993, when a sequence of nonsense syllables was used to evaluate the subject's knowledge acquisition and memory recall over the course of up to 31 days ^[3]. One of the important observations that he made was a "this type of fast, accurate recall did not guarantee that the list had been learned in a manner that would allow its recollection later. Instead, it only indicated that the series had been briefly grasped at periods of concentrated effort. He also observed that to acquire a stable memory state, it required added repetitions of the series. Throughout the twentieth century, it was Ebbinghaus' research that influenced the research carried out on recall and memory ^[4]. Bartlett was a significant researcher about recall and remembering in the middle of the 20th century. ^[5,6] His studies emphasized the mistakes that people made when retaining new knowledge. The study gave participants a brief excerpt from a story before asking them to recollect it. Intervals from presentation 14 to the time between reading the narrative and when it is remembered can range from instantaneously to days afterward.

The researcher noticed that although participants tried to comprehend the story's general meaning before trying to recollect it, their present body of knowledge interfered with their capacity to do so ^[7]. The study of memory was altered by the cognitive revolution of the 1950s, which also gave rise to new views on how to approach memory and recall. The study observed that when people were given a small list of words to learn and later distracted from the task for a slight duration, the number of items recalled from the list decreased significantly ^[8]. From these earlier studies, it was seen that recall could be categorized into different types like serial and free based on the order of recall, cued recall if a cue is given, and immediate and delayed based on the time duration given for recall. The ability to recall in these different ways can give insight into the different ways in which memory processes are functioning in the brain.

II. TYPES OF RECALL

Free recall, serial recall, and cued recall are the three types of recall that exist., and each of these can be recalled in two ways/patterns depending on the time duration given: immediate and delayed.

- 1. Immediate Recall:** The ability to recall events or objects immediately after it is learned. Here the recall period starts instantly after the final item in the presented list.

2. **Delayed Recall:** The ability to recall events or objects after a given period after it is learned. Here, a short distraction period is interpolated amidst the final item in the list and the initiation of the recall period.
3. **Free Recall:** The ability to recall events or objects without any cues in any order. Here, the participants are presented with a list of items that need to be remembered one by one. After the presentation of the entire list, the participants are asked to recall items in any order that he or she prefers and hence called a free recall task.
4. **Cued Recall:** The ability to recall events or objects when partial information or cues relating to the target is given. Here cues are given during the experiment to help in the recall. If the link between the cue and the target word is stronger, then recall would be improved.
5. **Serial Recall:** The capacity to remember things or experiences in a particular order. Language use requires the capacity to organise information in memory and afterwards recall it. One can recollect the sequence of measures in our life, our autobiographical experiences, etc. by using serial-order recall. The ability to recall is also governed by certain factors like attention, motivation, linguistic abilities, etc. These factors determine how well an individual can recall.

III. FACTORS AFFECTING RECALL ABILITIES ARE DETERMINED BY FACTORS

1. Cognition and Behavior

- **Attention & Motivation:** Attention affects the recall during the encoding phase. When parallel tasks are performed during the encoding phase, with less attention given to individual tasks, recall abilities are impaired as the parallel task does not allow for the encoding of appropriate input, and it also reduces the amount of information that is learned^[9]Where as motivation leads to better recall. It was observed that when reinforcements are paired with recall tasks, the recall abilities are better^[10]

2. Age and Gender

- **Age:** Younger adults are assumed to recall more items than children/older adults^[11]
- **Gender:** Gender differences are less examined in research associated with recall, and out of the available research, the results are mixed in nature. Certain authors^[12, 13]reported that there is no relation between gender and recall abilities, whereas authors reported that there was a significant difference between the recall abilities of males and females and attributed this difference to age-related changes in brain volume. They observed that males had larger cerebral volumes than females^[14]Contradicting this finding was who reported that atrophy was more in males compared to females and that atrophy also differed according to brain regions^[15]

3. Language

- **Word Length Effect:** Recall abilities reduce as the word length increases. This is due to the fact that working memory's phonological store can accommodate a greater number of brief words than long ones. ^[16]
- **Serial Position Effect:**
 - **Primacy effect:** In any list, the first few items may be recalled better. This is because there are higher chances for these words to be repeated and rehearsed and thus encoded into more stable memory stores.
 - **Recency effect:** Here, the items in the last may be recalled well as these items would still be present in the rehearsal buffer at the time of recall.
- **Similarity Effect:** Related words are recalled better compared to unrelated words (Semantically) because the properties of the words that are encoded are similar and hence easy to retrieve.
 - **Word frequency:** Words that are more frequently encountered (familiar) are easier to recall. This is because these words are used more often and are readily available and accessible in their memory storage.
 - **Imageability:** Words that can be visualized are easily recalled (concrete vs abstract words). Concrete words have a verbal and imaginal system. The verbal information is processed by the verbal system, and the imaginal system processes the nonverbal information. These images provide additional information during encoding and hence contribute to better recall.

4. Stimulus factors and Physiological state

- **Presentation Rate:** Items presented at a slower pace enhance the ability to recall items. When the words are presented slowly, there is more time for encoding and hence facilitating a better recall.
- **Physiological State:** Drugs such as marijuana and alcohol impair recall performance as they have an effect on hippocampus functioning.

Neurological substrates of recall Different brain structures are involved in the process of recall. Post-mortem studies were used initially to study the areas involved, but it was seen that such approaches were more beneficial in identifying the neuro-anatomical pathways and structures necessary to carry out memory tasks rather than the identification of specific components of memory. Recently, with the advent of neuro-imaging techniques, considerable research has been carried out to explore the brain areas involved in specific components of memory like recall. To identify the areas involved in the recall, The research carried out Positron Emission Tomography (PET) study using a paired-associate word task. The participants for the study were 12 students within the age range of 19 to 31 years. The stimuli used were 192-word pairs (e.g., parents-piano)^[17] Here, participants were made to read the paired words on a computer and then were given one word from the pair and were requested to recall the second word verbally aloud. The stimulus was presented for four seconds with an inter-stimulus duration of one second. Regional Cerebral Blood Flow measures (RCBF) were used to identify the areas involved. It was observed that during the process of recall, the right prefrontal cortex,

anterior cingulate cortices, right inferior parietal cortex, and cerebellum were activated. The right prefrontal area is often attributed to the process of a recall attempt, which was earlier reported^[18] He reported that the right prefrontal area is not directly related to the actual recall of the information that is stored but rather to the attempt the effort that is put into such recovery. The anterior cingulate cortex is typically stimulated when performing tasks that demand greater initiation., like the generation tasks where participants are given a category and then asked to name items from that category, e.g., verbs relating to nouns, semantic categories^[19], willed action tasks, where participants need to choose between two responses that are equally appropriate^[20], metaphor interpretation tasks^[21] The authors report that the initiation hypothesis is also true in case of recall as it is a task that involves more self-initiated processing^[22] Initiation hypothesis states that encoding of a specific event is governed by the internal states of the individual like comprehension, elaboration of the event and in part by the external state or the environment. Successful recall happens when these mental states are reinstated and if the environment is like the encoding phase. If this does not happen, then the individual must rely on self-initiated processing in order to recreate the original encoded environment. Free recall tasks are usually devoid of environmental cues and hence are highly dependent on self-initiated activities, which depend on the integrity of the frontal lobes and anterior cingulate cortices.

The right inferior parietal cortex is involved in perceptual tasks. It depends upon the amount of perceptual information that is available for processing^[23] Hence, it is more active in tasks where a part of the information is given i.e., in cued recall. Cerebellum was earlier thought to be only associated with motor learning. More recently, it has been found that it is also involved in cognitive processes^[24] Cerebellar damage produces deficits in processing speed, cognitive planning, 20 verbal fluency, and recall^[25,26] As previously mentioned ,there call involves self-initiated processing, which is also a function of the cerebellum particularly it is involved in generating the response candidates. The retrieval of recent objects has also been linked to the left inferior frontal gyrus., especially in memory interference resolution^[27] Differential activation of brain regions is reported with respect to the types of recall. One of the types of evidence using RCBF measures is provided studied free recall and temporal-order memory (serial recall) on 12 students with a mean age of 25. The stimuli used for the study were 560 concrete nouns of word length between 4-8 letters, which were divided into retrieval and study lists. Participants were asked to retrieve the studied word from a given pair (one word from the study list and a new word) in the free recall test and in the serial recall task both the word pairs were from the study list, but participants had to choose which item appeared first and which appeared at a later stage in the study list. It was found that compared to serial order task, free recall was more related to an increase in activations in bilateral temporal regions, forebrain regions, including the anterior part of the parahippocampalgyrus; whereas serial recall was related to differential activations in the frontal, posterior midline and the lateral parietal regions^[17].

Language and Recall Cognition plays a role in language and communication. Language comprehension and formulation are part of the cognitive system. This is evident from studies that have tried to correlate neuro-anatomical sites of language and comprehension. Transcranial 21 magnetic stimulation investigations have provided evidence that the left inferior frontal gyrus has a role in successful interference resolution^[28] This region also includes Broca's area, which is associated with language functions,

especially syntactic processing^[29] The study described a computational model of sentence processing which emphasizes that recall is necessary for accurate sentence processing.^[30] Evidence from research in Aphasia suggests that there is close association between processing of words and verbal STM.^[31] The study reported that aphasic individuals show overall reduction in recall and memory.^[32] Recall is also influenced by linguistic contexts in a number of different ways. The language spoken helps to create the external context^[33]; language in which mental activities are carried out creates the internal context^[34]. The study reported that "mental reinstatement of the language used in an earlier occasion may serve to produce increased recall just as the mental reinstatement of context does"^[35] These findings suggest that recall is uniquely linked with language abilities. Difficulty in recalling is the most vexing problem human beings face. Recall abilities vary according to the linguistic stimulus presented. Evidence provided by older and younger participants indicates that there were age-related differences in semantic tasks and digit span tasks.^[36] It was seen that in older and younger adults, the performance in digit span tasks was better compared to performance in the conceptual span tasks or semantic tasks. The authors argue that for processing the conceptual span task contribution from the semantic short-term memory (SSTM) was necessary, but in contrast, digit span recall relies on the phonological STM to a greater extent because digits have a shallow meaning and that recall of digits require sequential rehearsal in the phonological loop.^[37] This is supported from neuropsychological data which showed that patients with phonological STM deficits are impaired in this test. The researchers studied recall abilities for digits from 1-10 in English, Hebrew, Arabic, and Spanish. They observed that recall was better for English digits compared to the other languages. English numbers can be spoken rapidly and hence requires only less pronunciation time, whereas the numbers in other languages contain more syllables. This suggests that greater recall is associated with less pronunciation rate and also less number of chunks in the short-term memory.^[38] Certain authors reported that the length of the stimulus also had an effect on recall abilities as the length of the words in the list increased recall abilities decreased. The authors studied the syllable size on immediate serial recall and discovered that recall skills declined with syllable length.^[39] In addition, they discovered that across individuals and materials, reading speed and articulation speed were connected with serial recall, which shows that the amount of time it takes to enunciate the list items matters more than their syllabic count. There was a claim that the reason for this impact was that more short words could be practised in the phonological storage before decay set in.^[37] This was mainly called as the globalist view. On the other hand, the localist assumption is that recall of words depends not on the list context but on the characteristics of the word itself.^[40] Both types of models suggest that the overall proportion of correct items should decrease for a list of fixed length, as proportion of long words increase. This was again re-examined on 40 undergraduate students. The stimulus included lists of words with increasing lengths of complexity up to seven letters. A significant effect of length on the recall was obtained in their study.^[41] It is believed that language characteristics like lexicality, word usage, and semantic resemblance affect how well words are remembered.^[42] According to the theory, recall is improved when items belong to a single lexical category.^[43, 44, 45, 46, 47] The reconstruction hypothesis was put forward to account for this.^[44, 48, 49] According to this hypothesis, similar lists would be recalled better because, at recall, the category of the list will contribute to the increase in the likelihood of retrieving the long-term representations, either because the grouping would further serve as an indication of retrieval^[50,46,49] or as a result of their long-term associative relationships, these related things would have their long-term representations

engaged to a greater extent, which would indicate increased item recall for lists of thematically identical items.^[47] An effect of semantically similar words on recall was explored. In their study, with lists that were semantically identical or different, the instant serial recall task was carried out either independently or while being suppressed articulatory. Articulatory suppression is a method of asking someone to talk during the study or while in the period of retention in order to avoid repetition. The participants were 252 younger adults (French speakers), and each list contained seven items. The same 24 items were used in similar and dissimilar lists, but words were sampled across categories in the dissimilar list. The sequence of presentations for the task of writing was given to the participants. The participants repeated aloud the word *mathématiques* in averaging three utterances per two seconds; the articulatory suppression state is present continually. They started suppressing as soon as a trial began, and they kept doing it until the recall was through. Findings showed that under silent and suppressing conditions, greater numbers of items from comparable lists were recalled than from distinct ones. In the event of suppression circumstance, there were greater order mistakes compared to the silent condition.^[51] The authors claim that a larger deterioration or loss of the phonological traces is the source of reduced recall during suppression. As fundamental retrieval cues, the phonological traces are thought to degrade more quickly, resulting in decreased item recall.^[49] The researchers did a similar study on the recall of words and non-words. They found that recall of words had a superior effect than that of non-words^[52] In the case of words, decayed memory traces in phonological short-term memory can be reconstructed using either lexical or phonotactic knowledge and hence resulting in better recall than nonwords^[53]

IV. AGING AND RECALL

Advanced aging is often associated with changes in brain morphology and structure^[54] Postmortem examinations of brain tissue have revealed a varied array of age-related changes in the brain. The authors examined patterns of change in brain structure with aging in 148 normal adults (48-77 years) using Magnetic Resonance Imaging (MRI). The prominent changes were reported in the Pre-Frontal Cortex (PFC) at a rate of 4.9% per decade. Shrinkage in the area of PFC is also reported, which mediates the increase in perseveratory errors in older adults^[54] Theories of aging in decline in performance across age in a variety of tasks, either with respect to a deficit in the core cognitive function or according to deficits in a small set of cognitive functions like processing speed^[55], inhibition^[56], working memory capacity^[57] and attention^[58] It is well known that aging interacts with memory performance and among the memory processes, recall is affected the most. The study performed a study of list recall and text recall on 106 adults over a span of 16 years and reported an age-related decline in recall abilities^[59]

The study reported that older adults had poorer recall abilities when compared to younger adults^[60] and subsequent work done indicated that with aging the recitation rate slows down and hence will have difficulty in rehearsing leading to poor recall^[61] Certain authors argued that this is because of the limitation in the capacity to hold information^[62] and others hypothesized that it could be due to difficulties in the process of chunking information^[63] He also stated that older adults make weaker item-to-item associations compared to younger individuals and this, in turn, leaves the elderly at a disadvantage in being able to use these associations in forming multiple chunks in serial order recall The study reported that older adults particularly lack in memory that requires the binding of information to contextual

elements^[64]The study suggested that during recall a "self-initiated processing" is involved, and that older people have difficulty to carry out such operations than younger adults because with aging again frontal lobe atrophy happens which helps in this initiation process^[65]According to the study, elderly people perform less poorly on activities that require automated processing or a lot of assistance from the environment (such as comprehension tasks), but they execute worse with age on tasks like free and serial recall where these cues are not present.^[66]

On similar lines, the authors studied differences in recall and recognition in younger and older individuals. They predicted that recollection would be harder for participants to do than recognition and that the elderly would perform worse on recall tasks than younger individuals on recognition activities. The participants were 15 younger adults with mean age of 20.7 and 15 older adults with mean age of 72.8 years. A total of 144 items were included in the study, classified a computer's display at a pace of a single item every five seconds, divided into 12 lists of 12 phrase word items. There were 2 practice lists among them. Finally, for both the cued recall task and the recognition task, there were 60 targets in total. Both memory and recognition exercises were given to the participants. In the recall test, participants were asked to respond by saying aloud the target for each of the cue phrases. In the recognition task, participants had to respond by saying "yes" or "no," depending upon whether the target appeared in the presentation lists. Results revealed that older participants performed poorly than their younger group on recall, i.e., there was a reliable age decrement in the recall, however, when it came to the recognition test, they slightly outperformed the younger participants. The authors conclude by saying that during recall tasks, more processing resources such as attention, speed initiation, and inhibition are all required than the recognition task^[65] Older people are limited in these processing resources and hence show poor recall abilities. The cognitive processes are guided by the external cues linked with the task itself in the task of recognition, where the information is re-presented to the participant, making it simpler. Contrarily, there are very few indicators in recall that the person should self-initiate the right cognitive processes, which puts them at a disadvantage when recollection is involved. Serial position functions in younger adults are also dissimilar from those produced by older adults, as reported by^[67]Probability of First Recall (PFR) curves of younger adults (18-21) and older adults (66-88 years) were studied^[68]PFR curves are serial position curves for the first items recalled^[69].

Effects of recency and lag-recency were investigated. Lag recency effects refer to the tendency for people to remember things that are close by or concurrent with each other in time, i.e., they are more likely to come from nearby serial positions than from far-off ones.^[70,71]They found that both groups started to recall the recent items initially, but the lagrecency effect was notably reduced in older adults compared to younger, which suggests a deficit in the associative processes which are consistent with^[72]Age-related changes with respect to temporal associations in different task conditions were also explored by certain authors. The study experimented the abilities of younger and older adults to recall in "conditions where the temporal organization was largely incidental (free recall) by employing an uncategorized list, we identify "those in which temporal organization was largely intentional (serial recall)". The study found that serial order recall was more hard than free recall for both age groups resulting in fewer correct responses, and reported that compared to younger adults (mean age, 20 years), there was a greater decline in serial order performance in the older adults (mean age, 73 years). The younger group also demonstrated a greater ability to recall a larger number of words in the list than the elderly group. A follow-up analysis was then carried out

to examine the position of the items recalled in relation to the other items in the list, which showed that the elderly were not able to employ order information. On observation, it was seen that the effect of younger adults demonstrated a tendency to recall objects together in free recall when they had first been presented jointly, indicating that contiguity varied with age.^[73] The study analyzed of order in older adults revealed that they were at a disadvantage in using the temporal context information and hence they might rely on semantic data despite it being insignificant. This lack of temporal organisation is comparable to recent research showing impairments in retaining sequential data in elderly persons.^[74] and in generating associations between units of information^[70, 72, 70, 75] Similar findings were obtained^[57], but they hypothesized the difficulty arises in these tasks because in free recall tasks, while serial recall tasks need active preservation and evaluation of prior responses, which is challenging as people age, "on-line" storage and manipulation of the available information is necessary.

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