Remembering (Recall)

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Remembering or Recall in memory refers to the retrieval of events or information from the past. Along with encoding and storage, it is one of the three core processes of memory. There are three main types of recall: free recall, cued recall and serial recall. Psychologists test these forms of recall as a way to study the memory processes of humans and animals. Two main theories of the process of recall are the Two-Stage Theory and the theory of Encoding Specificity.

Theories

Two-stage theory

The two-stage theory states that the process of recall begins with a search and retrieval process, and then a decision or recognition process where the correct information is chosen from what has been retrieved. In this theory, recognition only involves the latter of these two stages, or processes, and this is thought to account for the superiority of the recognition process over recall. Recognition only involves one process in which error or failure may occur, while recall involves two. However, recall has been found to be superior to recognition in some cases, such as a failure to recognize words that can later be recalled.

Encoding specificity

The theory of encoding specificity finds similarities between the process of recognition and that of recall. The encoding specificity principle states that memory utilizes information from the memory trace, or the situation in which it was learned, and from the environment in which it is retrieved. Encoding specificity helps to take into account context cues because of its focus on the retrieval environment, and it also accounts for the fact recognition may not always be superior to recall.

History

Philosophical questions regarding how people acquire knowledge about their world spurred the study of memory and learning. Recall is a major part of the study of memory and often comes into play in all research. For this reason, the main studies on memory in general will also provide a history to the study of recall.

Hermann Ebbinghaus

Beginning with Hermann Ebbinghaus in 1885, the study of memory has continued to be a popular topic among researchers. Ebbinghaus created nonsense syllables, combinations of letters that do not follow grammatical rules and have no meaning, to test his own memory. He would memorize a list of nonsense syllables and then test his recall of that list over varying time periods. He

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discovered that memory loss occurred rapidly over the first few hours or days, but showed a more steady, gradual decline over subsequent days, weeks, and months. Furthermore, Ebbinghaus discovered that multiple learning, over-learning, and spacing study times increased retention of information. Ebbinghaus' research influenced much of the research conducted on memory and recall throughout the twentieth century.

Frederic Bartlett was a prominent researcher in the field of memory during the mid-twentieth century. He was a British experimental psychologist who focused on the mistakes people made when recalling new information. One of his well known works was Remembering: A Study in Experimental and Social Psychology, which he published in 1932. He is well known for his use of North American Native folk tales, including The War of the Ghosts. He would provide participants in his study with an excerpt from a story and then asked them to recall it as accurately as they could. Retention intervals would vary from directly after reading the story to days later. Bartlett found that people strive for meaning, by attempting to understand the overall meaning of the story. Since the folk tale included supernatural elements, people would rationalize them to make them fit better with their own culture. Ultimately, Bartlett argued that the mistakes that the participants made could be attributed to schematic intrusions. Their current sets of knowledge intruded on their accurately recalling the folk tale.

Ulric Neisser

In the 1950s there was a change in the overall study of memory that has come to be known as the cognitive revolution. This included new theories on how to view memory, often likening it to a computer processing model. Two important books influenced the revolution: Plans and Structures of Behavior by George Miller, Eugene Galanter, and Karl H. Pribram in 1960 and Cognitive Psychology by Ulric Neisser in 1967. Both provided arguments for an information-processing view of the human mind. Allen Newell and Herbert Simon constructed computer programs that simulated the thought processes people go through when solving different kinds of problems.

In the 1960s, interest in short-term memory (STM) increased. Before the 1960s, there was very little research that studied the workings of short-term memory and rapid memory loss. Lloyd and Margaret Peterson observed that when people are given a short list of words or letters and then are distracted and occupied with another task for few seconds, their memory for the list is greatly decreased. Atkinson and Shiffrin (1973) created the short term memory model, which became the popular model for studying short term memory.

The next major development in the study of memory recall was Endel Tulving's proposition of two kinds of memory: episodic and semantic. Tulving described episodic memory as a memory about a specific event that occurred at a particular time and place, for example what you got for your 10th birthday. Semantic memories are abstract words, concepts, and rules stored in long-term memory.

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Furthermore, Endel Tulving devised the encoding specificity principle in 1983, which explains the importance of the relation between the encoding of information and then recalling that information. To explain further, the encoding specificity principle means that a person is more likely to recall information if the recall cues match or are similar to the encoding cues.

The 1960s also saw a development in the study of visual imagery and how it is recalled. This research was led by Allan Paivio, who found that the more image-arousing a word was the more likely it would be recalled in either free recall or paired associates.

There has been a considerable amount of research into the workings of memory, and specifically recall since the 1980s. The previously mentioned research was developed and improved upon, and new research was and still is being conducted.

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Types

Free recall

Free recall describes the process in which a person is given a list of items to remember and then is tested by being asked to recall them in any order. Free recall often displays evidence of primacy and recency effects. Primacy effects are displayed when the person recalls items presented at the beginning of the list earlier and more often. The recency effect is when the person recalls items presented at the end of the list earlier and more often.

Cued recall

Cued Recall is an experimental procedure during which a person is given a list of items to remember and is then tested with the use of cues in order to study memory. Participants are given pairs, usually of words, A1-B1, A2-B2...AL-BL, (L is the number of pairs in a list) to study. Then the experimenter gives the participant a word to cue the participant to recall the word with which it was originally paired. The word presentation can either be visual or auditory.

There are two basic experimental methods used to conduct cued recall, the study-test method and the anticipation method. In the study-test method participants study a list of word pairs presented individually. Immediately after or after a time delay, participants are tested in the study phase of the experiment on the word pairs just previously studied. One word of each pair is presented in a random order and the participant is asked to recall the item with which it was originally paired. The participant can be tested for either forward recall, Ai is presented as a cue for Bi, or backward recall, Bi is presented as a cue for Ai. In the anticipation method, participants are shown Ai and are asked to anticipate the word paired with it, Bi. If the participant cannot recall the word, the answer is reveal. During an experiment using the anticipation method, the list of words is repeated until a

certain percentage of Bi words are recalled.

The learning curve for cued recall increases systematically with the number of trials completed. This result has caused a debate about whether or not learning is all-or-none. One theory is that learning is incremental and that the recall of each word pair is strengthened with repetition. Another theory suggests that learning is all-or-none, that is one learns the word pair in a single trial and memory performance is due to the average learned pairs, some of which are learned on earlier trials and some on later trials. To examine the validity of these theories researchers have performed memory experiments. In one experiment, Irwin Rock University of Illinois had a control group and experimental group learn pairs of words. The control group studied word pairs that were repeated until the participants learned all the word pairs. In the experimental group, the learned pairs remained in the list while unlearned pairs were substituted with recombinations of previous words. Rock believed that associations between two items would be strengthened if learning were incremental even when pairs are not correctly recalled. His hypothesis was that the control group would have a higher correct recall probability than the experimental group. He thought that repetition would increase the strength of the word pair until the strength reaches a threshold needed to produce an overt response. If learning were all or none, then the control group and the experimental group should learn the word pairs at the same rate. Rock found experimentally there was little difference in learning rates between the two groups. However, Rock's work did not settle the controversy because in his experiment he rearranged replaced word pairs that could be either easier or harder to learn than the original words in the word- digit pair. In further experiments that addressed the question, there were mixed results. The incremental learning hypothesis is supported by the notion that awhile after Ai-Bi pairs are learned, the recall time to recall Bi decreases with continued learning trails.

Another theory that can be tested using cued recall is symmetry of forward and backward recall. Forward recall is generally assumed to be easier than backward recall, i.e. forward recall is stronger than backward recall. This is generally true for long sequences of word or letters such as the alphabet. In one view, the independent associations hypothesis, the strength of forward and backward recall are hypothesized to be independent of each other. To confirm this hypothesis, Dr. George Wolford tested participants' forward and backward recall and found that forward and backward recall are independent of each other. The probability of correct forward recall was .47 for word pair associations and the probability of correct backward recall of word pair associations was .25. However in another view, the associative symmetry hypothesis, the strengths of forward and backward recall are about equal and highly correlated. In S.E Asch from Swathmore College and S. M Ebenholtz's experiment, participants learned pairs of nonsense syllables by anticipation recall. After reaching a certain threshold of learning, the participants were tested by free recall to determine all pairs and single items they could remember. These researchers found that backward association was greatly weaker than forward association. However, when the availability of forward and backward recall were basically the same, there was little difference between forward and

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backward recall. Some scientists including Asch and Ebenholtz believe in the independent association hypothesis think that the equal strengths of forward and backward recall are compatible with their hypothesis because forward and backward recall could be independent but with equal strengths. However associative symmetry theorists interpreted the data to mean that the results fit their hypothesis.

Another study done using cued recall found that learning occurs during test trials. Mark Carrier and Pashler (1992) found that the group with a study-only phase makes 10% more errors than the group with a test-study phase. In the study-only phase, participants were given Ai-Bi, where Ai was an English word and Bi was a Siberian Eskimo Yupik word. In the test study phase, participants first attempted to recall Bi given Ai as a cue then they were shown Ai-Bi pair together. This result suggests that after participants learn something, testing their memory with mental operations helps later recall. The act of recalling instead of restudying creates new and longer lasting connection between Ai and Bi.

Another study showed that when lists are tested immediately after study, the last couple of pairs are remembered best. After a five second delay, the recall of recently studied words diminishes. However, word pairs at the beginning of a list still show better recall. Moreover, in a longer list, the absolute number of word pairs recalled is greater but in a shorter list of word pairs, the percentage of word pairs recalled is greater.

Sometimes, when recalling word pairs, there is an intrusion. An intrusion is an error that participants make when they attempt to recall a word based on a cue of that word pair. Intrusions tend to have either semantic attributes in common with the correct word not recalled or have been previously studied in another word pair on the current list or a previously studied list or were close in time to the cue item. When two items are similar, an intrusion may occur. Professor Kahana and Marieke Vugt at the University of Pennsylvania examined the effects of face similarity for face-name associations. In the first experiment, they wanted to determine if performance of recall would vary with the number of faces in the study set similar to the cue face. Faces were similar if the radius of the faces were within a range. The number of faces within a radius is called a neighborhood density. They found that the recall of a name to face exhibited a lower accuracy and slower reaction time for faces with a greater neighborhood density. The more similarity that two faces have, the greater the probability for interference between the two faces. When cued with face A name B may be recalled if face A and B are similar. The probability of correct recall came from the number of faces with similar faces.

Cues act as guides to what the person is supposed to remember. A cue can be virtually anything that may act as a reminder, e.g. a smell, song, color, place etc. In contrast to free recall, the subject is prompted to remember a certain item on the list or remember the list in a certain order. Cued recall also plays into free recall because when cues are provided to a subject, they will

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remember items on the list that they did not originally recall without a cue. Tulving explained this phenomenon in his research. When he gave participants associative cues to items that they did not originally recall and that were thought to be lost to memory, the participants were able to recall the item.

Serial recall

Serial recall refers to our ability to recall items or events in the order in which they occurred. The ability of humans to store items in memory and recall them is important to the use of language. Imagine recalling the different parts of a sentence, but in the wrong order. The ability to recall in serial order has been found not only in humans, but in a number of non-human primate species and some non-primates. Imagine mixing up the order of phonemes, or meaningful units of sound, in a word so that "slight" becomes "style." Serial-order also helps us remember the order of events in our lives, our autobiographical memories. Our memory of our past appears to exist on a continuum on which more recent events are more easily remembered in order.

Serial recall in long-term memory (LTM) differs from serial recall in short-term memory (STM). To store a sequence in LTM, the sequence is repeated over time until it is represented in memory as a whole, rather than as a series of items. In this way, there is no need to remember the relationships between the items and their original positions. In STM, immediate serial recall (ISR) has been thought to result from one of two mechanisms. The first refers to ISR as a result of associations between the items and their positions in a sequence, while the second refers to associations between items. These associations between items are referred to as chaining, and according to research it is an unlikely mechanism. Position-item relationships do not account for recency and primacy effects, or the phonological similarity effect. The Primacy Model moves away from these two assumptions, suggesting that ISR results from a gradient of activation levels where each item has a particular level of activation that corresponds to its position. Research has supported the fact that immediate serial recall performance is much better when the list is homogenous (of the same semantic category) than when they are heterogeneous (of different semantic category). This suggests that semantic representations are beneficial to immediate serial recall performance. Short-term serial recall is also affected by similar sounding items, as recall is lower (remembered more poorly) than items that do not sound alike. This is true when lists are tested independently (when comparing two separate lists of similar sounding and not similar sounding items) as well as when tested using a mixed list. Alan Baddeley first reported such an experiment in which items within a list were either mutually dissimilar or highly similar.

There is evidence indicating that rhythm is highly sensitive to competing motor production. Actions such as paced finger tapping can have an effect on recall as the disruptive impact of paced finger tapping, but lack of consistent effect of paced irrelevant sound, is indicative of motor feedback from the tapping task disrupting rehearsal and storage.

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Seven different effects are generally seen in serial recall studies with humans:

1. List length effect

Performance for serial recall decreases as the length of the list or sequence increases.

2. Primacy and recency effects

Primacy effects refer to better recall of items earlier in the sequence, while recency effects refer to better recall of the last few items. Recency effects are seen more with auditory stimuli rather than verbal stimuli as auditory presentation seems to protect the end of lists from output interference.

3. Transposition gradients

Transposition gradients refer to the fact that recall tends to be better for item identity rather than the order of items in a sequence. Basically, subjects tend to remember the correct items in the wrong order.

4. Item confusion errors

When an item is incorrectly recalled, there is a tendency to respond with an item that resembles the original item in that position. When tested with verbal stimuli, the mistakes tended to be phonological (e.g. DOG instead of FOG), while spatial stimuli tended to have spatial similarity (e.g. spatial proximity).

5. Repetition errors

These occur during the recall of a sequence when an item from an earlier position in the sequence is given again in another position. This effect is fairly rare in humans.

6. Fill-in effects

If an item is recalled incorrectly at an earlier position than its original place, there is a tendency for the next item recalled to be the item that was displaced by this error. For example, if the sequence is 'LMNOP' and recall began 'LMO', then the next item is likely to be 'N'.

7. Protrusion effects

These occur when an item from a previous trial is recalled in a current trial. This item is likely to be recalled at its position from the original trial.

8. Word-length effects

Short words are recalled more accurately than longer words. The word-length effect is larger in

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serial recall than it is in probed recall.

Neuroanatomy

The anterior cingulate cortex, globus pallidus, thalamus, and cerebellum show higher activation during recall than during recognition which suggests that these components of the cerebello-frontal pathway play a role in recall processes that they do not in recognition. Although recall and recognition are considered separate processes, it should be noted that they are both most likely constitute components of distributed networks of brain regions.

Cerebellum

Cerebellum

Globus Pallidus

Globus Pallidus highlighted in blue circle.

According to neuroimaging data, PET studies on recall and recognition have consistently found increases in regional cerebral blood flow (RCBF) in the following six brain regions: (1) the prefrontal cortex, particularly on the right hemisphere; (2) the hippocampal and parahippocampal regions of the medial temporal lobe; (3) the anterior cingulate cortex; (4) the posterior midline area that includes posterior cingulate, retrosplenial (see retrosplenial region), precuneus, and cuneus regions; (5) the inferior parietal cortex, especially on the right hemisphere; and (6) the cerebellum, particularly on the left.

Cerebellum, Hippocampus highlighted in Red

The specific role of each of the six main regions in episodic retrieval is still unclear, but some ideas have been suggested. The right prefrontal cortex has been related to retrieval attempt; the medial temporal lobes to conscious recollection; the anterior cingulate to response selection; the posterior midline region to imagery; the inferior parietal to awareness of space; and the cerebellum to self-initiated retrieval.

Cerebellum, Anterior cingulate cortex

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In recent research, a group of subjects was faced with remembering a list of items and then measured when trying to recall said items. The evoked potentials and hemodynamic activity measured during encoding were found to exhibit reliable differences between subsequently recalled and not recalled items. This effect has been termed the subsequent memory effect (SME). This difference in these specific brain regions determines whether or not a item is recalled. A study by Fernandez et al. has shown that the differences that predict recall appear both as a negative deflection in the rhinal cortex of an event-related potential (ERP) 400 m/sec after stimulus exposure, and as a positive hippocampal ERP beginning 800 m/sec after stimulus onset. This means that recall only occurs if these two brain regions (rhinal cortex and hippocampus) are activated in synchrony.

Factors that affect recall

Attention

The effect of attention on memory recall has surprising results. It seems that the only time attention largely affects memory is during the encoding phase . During this phase, performing a parallel task can severely impair retrieval success. It is believed that this phase requires much attention to properly encode the information at hand, and thus a distractor task does not allow proper input and reduces the amount of information learned. Experiments have been done that suggest that the early encoding phase, in which words are identified, is the source of the word frequency effect. Because rarer words (low frequency) are composed of unusual and features that may be difficult to encode, they require more attention. Differences in letter frequency were controlled for. Next, we considered the late phase of encoding, in which meaning is elaborated and connected to the participants' semantic network. The experimenters explored the hypothesis that semantic information does not contribute to the word frequency effect and found a mirror patterned normative frequency effect when words were studied and tested. When study, test, or both involved objects, the mirror pattern was disrupted and normative frequency had little or no effect on recognition memory. Much of the recognition memory literature has focused on distinguishing between memory models based on the nature of retrieval from memory. However, when looking at the effect of attention on memory retrieval, it has been found that there are only slight inconsistent impairments. This evidence suggests that memory retrieval is an automatic process. One effect of attention on memory recall is that of latency and retrieval time. This is especially evident in free recall. The competition provided at the time of recall due to divided attention slows down the process, yet has little to no effect on its accuracy. Another possible finding for the minimal effect of divided attention is that the process of recall may include less parallel processing than other memory processes. It has also been observed that different parts of the brain are at work depending on whether one is recalling with full rather than divided attention. Evidence for this comes from fMRI data. Performing a secondary task concurrently with a study task has a detrimental effect on later memory for studied items. To investigate the mechanisms underlying

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this effect, the processing resources available for an incidental encoding task were varied by manipulating secondary task difficulty. Greater activity at study for words later remembered versus words later forgotten-were identified in the left ventral inferior frontal gyrus and the left anterior hippocampus. These effects did not vary according to whether the encoding task was performed concurrently with the easy or the hard secondary task. However, as secondary task difficulty increased, study-item activity declined and auditory-item activity increased in dorsolateral prefrontal and superior parietal regions that have been proved to be in the support of executive and control functions. The findings suggest that dividing attention during encoding influences the probability of engaging the encoding operations that support later episodic memory, but does not alter the nature of the operations themselves. The findings further suggest that the probability of engaging these encoding operations depends on the level of general processing resources engaged in service of the study task.

Motivation

Motivation is a factor that encourages a person to perform and succeed at the task at hand. It can be in the form of presented incentive, or personal fear of failure. Any form of motivation thus generally leads a person to better recall. In an experiment done by Roebers, Moga and Schneider (2001), participants were placed in either forced report, free report or free report plus incentive groups. In each group, they found that the amount of correct information recalled did not differ, yet in the group where participants were given an incentive they had higher accuracy results. This means that presenting participants with an encouragement to provide correct information motivates them to be more precise. However, this is only true if the perception is that success is providing correct information. When it is believed that success is the completion of the task rather than the accuracy of that completion, the number of responses is higher, yet its accuracy is lowered. This shows that the results are dependent on how success is defined to the participant. In the Roebers, Moga and Schneider (2001) experiment, the participants that were placed in the forced response group had the lowest overall accuracy. They had no motivation to provide accurate responses and were forced to respond even when they were unsure of the answer. Another study done by Hill RD, Storandt M, Simeone C tests the impact of memory skills training and external reward on free recall of serial word lists. In contrast to older learners, similar effects were seen in children. Two studies were conducted to test incentive magnitude effects on free recall. Experiment I examined whether two incentive levels would differentially influence rehearsal of words paired with the incentive values. Fifth and eighth graders and college adults were tested in conditions in which they were instructed to (a) do all rehearsal overtly or (b) engage in a counting task subsequent to item presentation and refrain from overt and covert rehearsal. College subjects rehearsed and recalled significantly more 10¢ than 1¢ words. Eighth graders tended to favor 10¢ items in recall and rehearsal, but the differences were of questionable reliability. Fifth graders failed to produce reliable Incentive Level effects. Experiment II showed that fifth graders, as well as older subjects,

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recalled more high-incentive words under standard free-recall instructions in which rehearsal was presumed to be covert. Results support theories emphasizing rehearsal as a mediator of incentive level effects on learning. These results lead to the conclusion that depending on how success is defined to the person, motivation increases a person's inclination to succeed at appropriate recall.

Interference

In the absence of interference, there are two factors at play when recalling a list of items: the recency and the primacy effects. The recency effect occurs when the short-term memory is used to remember the most recent items, and the primacy effect occurs when the long-term memory has encoded the earlier items. The recency effect can be eliminated if there is a period of interference between the input and the output of information extending longer than the holding time of short-term memory (15-30 seconds). This occurs when a person is given subsequent information to recall preceding the recall of the initial information. The primacy effect, however, is not affected by the interference of recall. The elimination of the last few items from memory is due to the displacement of these items from short term memory, by the distracting task. As they have not been recited and rehearsed, they are not moved into long-term memory and are thus lost. A task as simple as counting backwards can change memory recall; however an empty delay interval has no effect. This is because the person can continue to rehearse the items in their working memory to be remembered without interference. Cohen (1989) found that there is better recall for an action in the presence of interference if that action is physically performed during the encoding phase. It has also been found that recalling some items can interfere and inhibit the recall of other items. Another stream of thought and evidence suggests that the effects of interference on recency and primacy are relative, determined by the ratio rule (retention interval to inter item presentation distractor rate) and they exhibit time-scale invariance. Three experiments investigated serial position effects in immediate and final free recall. Each word in a 10-item list was both preceded and followed by a 15-sec period of distraction activity. In Experiment 1, half of the lists were immediately followed by either a recall test or a recognition test; the remaining lists were not tested, but were followed by a different distraction activity. After presentation of all lists, a final recall or recognition test was given. Primacy was observed only in immediate free recall and in all final tests following immediate free recall, demonstrating that primacy develops from a free-recall storage strategy. No recency was observed in Experiment 1. In Experiment 2, every list was followed by an immediate free-recall test, with a final free-recall test after the last list. The primacy results of Experiment 1 were replicated. Furthermore, the appearance of recency in Expriment 2 suggests that recency results from a retrieval strategy that failed to develop in Experiment 1 because some lists were not tested immediately. To eliminate an artifact account, Experiment 3 used an experimenter-paced distractor task and replicated the findings of Experiment 2, which used a subject-paced distractar task. Contrary to previous claims, the pattern of results in the continuous distractor paradigm is seen as completely consistent with the account offered by

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multistore models of serial position effects in standard free recall.

Context

Context-dependency effects on recall are typically interpreted as evidence that the characteristics of the environment are encoded as part of the memory trace and can be used to enhance retrieval of the other information in the trace. In other words, you can recall more when the environments are similar in both the learning and recall phases. Context cues appear to be important in the retrieval of newly learned meaningful information. In a classic study by Godden and Baddelley (1975), they demonstrated that deep-sea divers recalled their training more effectively when trained underwater, rather than being trained on land. An academic application would be that students may perform better on exams by studying in silence, because exams are usually done in silence.

State-dependent memory

State-dependent retrieval is demonstrated when material learned under the influence of a drug is best recalled in that same drug state. A study by Carter and Cassady (1998) showed this effect with antihistamine. In other words, if you study while on hay fever tablets, then you will recall more of what you studied if you test yourself while on antihistamines in comparison to testing yourself while not on antihistamines after having studied on antihistamines.

A study by Block and Ghoneim (2000) found that, relative to a matched group of healthy, non-drug-using controls, heavy marijuana use is associated with small but significant impairments in memory retrieval. Cannabis induces loss of internal control and cognitive impairment, especially impairment of attention and memory, for the duration of the intoxication period.

Stimulants, such as cocaine, amphetamines or caffeine are known to improve recall in humans. However, the effect of prolonged use of stimulants on cognitive functioning is very different from the impact on one-time users. Some researchers have found stimulant use to lower recall rates in humans after prolonged usage. MDMA users are found to exhibit difficulties encoding information into long-term memory, display impaired verbal learning, are more easily distracted, and are less efficient at focusing attention on complex tasks. The degree of executive impairment increases with the severity of use, and the impairments are relatively long-lasting. Chronic cocaine users display impaired attention, learning, memory, reaction time and cognitive flexibility. Whether or not stimulants have a positive or negative effect on recall depends on how much is used and for how long.

Gender

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Consistently, females perform better than males on episodic memory tasks including delayed recall and recognition. However, males and females do not differ on working, immediate and semantic memory tasks. In general, neuro-psychological observations suggest that anterior lesions cause greater de?cits in females than in male. It has been proposed that the gender differences in memory performance re?ect underlying differences in the strategies used to process information, rather than anatomical differences. However, gender differences in cerebral asymmetry received support from morphometric studies showing a greater leftward asymmetry in males than in females, meaning that men and women use each side of their brain to a different extent. There is also evidence for a negative recall bias found in women, which means females in general are more likely than males to recall their mistakes. In a eyewitness study done by Dan Yarmey (1991) from the University of Guelph, he found that women were significantly more accurate than men in accuracy of recall for weight of suspects.

Phenomena

The phenomenological account of recall is referred to as metacognition, or "knowing about knowing". This includes many states of conscious awareness known as feeling-of-knowing states, such as the tip-of-the-tongue state. It has been suggested that metacognition serves a self-regulatory purpose whereby the brain can observe errors in processing and actively devote resources to resolving the problem. It is considered an important aspect of cognition that can aid in the development of successful learning strategies that can also be generalized to other situations.

Tip-of-the-tongue

A tip of the tongue (TOT) state refers to the perception of a large gap between the identification or knowledge of a specific subject and being able to recall descriptors or names involving said subject. There are two prevalent perspectives of TOT states: the psycholinguistic perspective and the metacognitive perspective.

Psycholinguistics views TOT states as a failure of retrieval from lexical memory (see Cohort Model) being cued by semantic memory (facts). Since there is an observed increase in the frequency of TOT states with age, there are two mechanisms within psycholinguistics that could account for the TOT phenomenon. The first is the degradation of lexical networks with age, where degrading connections between the priming of knowledge and vocabulary increases difficulty of successfully retrieving a word from memory. The second suggests that the culmination of knowledge, experience, and vocabulary with age results in a similar situation where many connections between a diverse vocabulary and diverse knowledge also increases the difficulty of successful retrieval of a word from memory.

The metacognitive perspective views TOT states simply as the awareness felt when such an event

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occurs and the perception of the experience involved. Mainly being aware of a TOT state can result in the rapid devotion of cognitive resources to resolving the state and successfully retrieving the word from memory. Such an explanation leaves much to be desired; however, the psycholinguistic perspective and the metacognitive perspective on TOT states are not mutually exclusive and both are used to observe TOT states in a laboratory setting.

An incubation effect can be observed in TOT states, where the passage of time alone can influence the resolution of the state and result in successful recall. Also, the presence of a TOT state is a good predictor that the problem can be resolved correctly, although this has been shown to occur more frequently with older-young-adults than young-adults or seniors. This is evidence for both the metacognitive perspective as well as the psycholinguistic perspective. It demonstrates the devotion of resources to searching memory, a source of cumulative information, for the desired correct information, and it also shows that we are aware of what information we know or do not know. This is why the current debate between the psycholinguistic view of TOTs as retrieval failure and the metacognitive view of TOTs as a tool for learning continues.

Involuntary memory retrieval

Often, even after years, mental states once present in consciousness return to it with apparent spontaneity and without any act of the will; that is, they are reproduced involuntarily. Here, also, in the majority of cases we at once recognise the returned mental state as one that has already been experienced; that is, we remember it. Under certain conditions, however, this accompanying consciousness is lacking, and we know only indirectly that the "now" must be identical with the "then"; yet we receive in this way a no less valid proof for its existence during the intervening time. As more exact observation teaches us, the occurrence of these involuntary reproductions is not an entirely random and accidental one. On the contrary they are brought about through the instrumentality of other immediately present mental images. Moreover they occur in certain regular ways which in general terms are described under the so-called 'laws of association'.
--Ebbinghaus, H (1885), as translated by Ruger & Bussenius (1913)

Until recently, research on this phenomenon has been relatively rare, with only two types of involuntary memory retrieval identified: involuntary autobiographical memory retrieval, and involuntary semantic memory retrieval. Both of these phenomena can be considered emergent aspects of otherwise normal and quite efficient cognitive processes.

A visual representation of Spreading Activation

Involuntary autobiographical memory (IAM) retrieval occurs spontaneously as the result of sensory cues as well as internal cues, such as thought or intention. These cues influence us in our day-to-

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day lives by constantly and automatically activating unconscious memories through priming. It has been demonstrated in many studies that our specific goals and intentions will most frequently result in the retrieval of related IAM, while the second most frequent IAM retrievals result from physical cues in the surrounding context. Autobiographical memories that are unrelated to any specific cues, whether internal or external, are the least frequent to occur. It has been suggested that in this case, an error in self-regulation of memory has occurred that results in an unrelated autobiographical memory reaching the conscious mind. These findings are consistent with metacognition as the third type of experience is often identified as the most salient one.

Involuntary semantic memory retrieval (ISM), or "semantic-popping", occurs in the same fashion as IAM retrieval. However, the elicited memory is devoid of personal grounding and often considered trivial, such as a random word, image, or phrase. ISM retrieval can occur as a result of spreading activation, where words, thoughts, and concepts activate related semantic memories continually. When enough related memories are primed that an interrelated concept, word, thought, or image "pops" into consciousness and you are unaware of the extent of its relatedness within your memory. Spreading activation is thought to build over a period of many hours, days, or even weeks before a random semantic memory "pops".

False memories

False memories result from persistent beliefs, suggestions via authority figures, or statements of false information. Repeated exposure to these stimuli influence the reorganization of a person's memory, affecting its details, or implanting vivid false accounts of an event. This is usually accounted for by source-monitoring error, where a person can recall specific facts, but cannot correctly identify the source of that knowledge because of apparent loss of the association between the episodic (specific experience, or source) and semantic (concept-based, or gist) accounts of the stored knowledge. An example of this is cryptomnesia, or inadvertent plagiarism, where a one duplicated a work that they have previously encountered believing it to be their original idea. False memories can also be accounted for by the generation effect, which is an observable phenomena where repeated exposure to a belief, suggestion, or false information is better remembered with each subsequent generation. This can be seen with the misinformation effect, where an eye-witness account of an event can be influenced by a bystander account of the same event, or by suggestion via an authority figure. It is also believed to influence the recovery of repressed shocking or abusive memories in patients under hypnosis, where the recovered memory, although possibly a vivid account, could be entirely false, or have specific details influenced as the result of persistent suggestion by the therapist.

Focal retrograde amnesia

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Retrograde amnesia is typically the result of physical or psychological trauma which manifests itself as the inability to remember information preceding the traumatic event. It is usually accompanied by some type of anterograde amnesia, or inability to acquire new knowledge. Focal retrograde amnesia (FRA), sometimes known as functional amnesia, refers to the presence of retrograde amnesia while knowledge acquisition remains intact (no anterograde amnesia). Memory for how to use objects and perform skills (implicit memory) may remain intact while specific knowledge of personal events or previously learned facts (explicit memory) become inaccessible or lost. Amnesia can result from various different causes, including encephalitis, severe traumatic brain injury, vitamin B1 deficiency as seen in Korsakoff's Syndrome, and psychotic episodes, or by witnessing an emotionally traumatic event (Dissociative amnesia). Dysfunction of the temporal and frontal lobes have been observed in many cases of focal retrograde amnesia, whether metabolic or the result of lesions. However, this evidence only appears to correlate with the symptoms of retrograde amnesia as cases have been observed where patients suffering from minor concussions, showing no visible brain damage, develop FRA. It has been suggested that FRA could represent a variety of different disorders, cognitive deficits, or conditions that result in disproportionate loss of explicit memory, hence Disproportionate Retrograde Amnesia.

In popular culture

This "In popular culture" section may contain minor or trivial references. Please reorganize this content to explain the subject's impact on popular culture rather than simply listing appearances, and remove trivial references. (August 2010)

Memory phenomena are rich sources of storylines and novel situations in popular media. Two phenomena that appear regularly are total recall abilities and amnesia.

Total recall

The Argentinean author, Jorge Luis Borges wrote the short story Funes the Memorious in 1944. It depicts the life of Ireneo Funes, a fictional character who falls off his horse and experiences a head injury. After this accident, Funes has total recall abilities. He is said to recall an entire day with no mistakes, but this feat of recall takes him an entire day to accomplish. It is said that Borges was ahead of his time in his description of memory processes in this story, as it was not until the 1950s and research on the patient HM that some of what the author describes began to be understood. A more recent instance of total recall in literature is found in Dan Brown's books The Da Vinci Code and Angels & Demons, in which the main character, Dr. Robert Langdon, a religious iconography and symbology professor at Harvard University, has almost total recall ability. Also the character of Firefighter Stuart "Recall" McKensie from the TV series London's Burning has a total recall ability. In The Curious Incident of the Dog in the Nighttime by Mark Haddon, the main character,

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Christopher Boone, is a 15-year old autistic boy with total recall abilities.

The Curious Incident of the Dog in the Nighttime

Total recall is popular in television. It can be seen in Season 4 of the television show Criminal Minds", in which the character Dr. Spencer Reid claims to have total recall ability. Agent Fox Mulder from the television show "The X-Files" has a photographic memory, a popular term for total recall. Also, the character of hospital resident Lexie Grey on the television show "Grey's Anatomy" has total recall ability.

Amnesia

Amnesia the damage or disruption of memory processes is a very popular subject in movies since 1915. Although its portrayal is usually inaccurate, there are some exceptions. Memento (2003) is said to be inspired by the condition of the famous amnesic patient known as HM. The main character Leonard suffers from anterograde amnesia after a traumatic attack in which his wife dies. He maintains his identity and shows very little retrograde amnesia. He also displays some of the daily memory problems that are experiences by most amnesics, such as forgetting names or where he is going.

Another fairly accurate portrayal of memory disturbances is the non-human character Dory in Finding Nemo (2003). This fish, like Leonard, shows memory problems faced by most amnesics where she forgets names, has difficulty storing and recalling information, and often forgets what she is doing, or why she is doing something.

Se Quien Eres (2000) gives a relatively accurate portrayal of the memory disturbance known as Korsakoff's syndrome, which includes severe memory loss.

Movies tend to show amnesia as a result of head injury from accidents or attacks. The loss of identity and autobiographical memory shown in Santa Who? (2000) in which Santa suffers from amnesia that destroys his identity and memory of himself is very unlikely in the real world. This is also portrayed in The Bourne Identity (2002) and The Bourne Supremacy (2004) where the main character forgets he is a trained assassin. The comedy The Bourne Identity Crisis (2003) introduces a character who forgets he is gay and thinks he is a trained assassin instead. All of these cases of amnesia are very improbable in reality.

Another misrepresentation of the reality of memory loss in the movies can be seen in Clean Slate (1994) and 50 First Dates (2004) where the characters are able to encode memory during the day but lose all memory of that day at night, while sleeping.

Movies often restore victim's memory through a second trauma, or through a kind of cued recall when they revisit familiar places or see familiar objects. The phenomenon of the second trauma can be seen in Singing in the Dark (1956) where the victim experiences the onset of amnesia because of the trauma of the holocaust, but memory is restored with a blow to the head. In The

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Woman with No Name (1950), a familiar door restores the character's memory, and in Scared By the Bells (2003) a tour of a familiar place brings back the main character's memory.
Although neurosurgery is often the cause of amnesia, it is seen as a solution in some movies, including Deluxe Annie (1918) and Rascals (1938).
Memory erasure is portrayed in Eternal Sunshine of the Spotless Mind (2004) and in the Men in Black movies. Men in Black features a device to erase the potentially harmful memories of extraterrestrial interactions in members of the general public. Eternal Sunshine of the Spotless Mind describes a process that targets and erases memories of interpersonal relationships the patients would rather forget so that they are no longer able to recall the experience.
In Paycheck (2003) and Total Recall (1990) memory suppression is used to control and the characters are able to overcome the attempts and recall pieces of their memory.

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