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Review

A Brief Primer on Learning and Memory-Based Strategies to Enhance Memory Function

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Abstract

***Background*:** Learning and memory, unquestionably, are critical for many aspects of life, including acquisition and retention of educational material. The purpose of this brief narrative review is to provide a primer on empirical-based, learning and memory techniques.

***Methods*:** A narrative review approach is employed.

***Results*:** This review is structured by first discussing contextual factors that influence learning and memory, followed by addressing several specific techniques to help facilitate learning and memory retention.

***Conclusions*:** Investigation of the efficacy for such consciously employed, effortful techniques to translate from laboratory environments to practical settings is important for educational achievement, maintenance of cognition throughout older adulthood, and personal and professional development in larger social systems.

Keywords

Cognition; education; knowledge; retention

1. Introduction

Learning and memory, unquestionably, are critical for many aspects of life, including acquisition and retention of educational material. The purpose of this brief narrative review is to provide a primer on empirical-based, learning and memory techniques. Thus, the aim of this succinct review is not to discuss the totality of empirical work delineating learning-based techniques, but rather, to highlight available learning strategies that can be utilized to enhance learning and memory. This has practical implications for nearly all fields, but as discussed herein, this paper will also guide other researchers who are interested in evaluating potential individual and synergistic effects of learning strategies and health behaviors (e.g., exercise) on memory function.

This review is structured by first discussing contextual factors that influence learning and memory, followed by addressing several specific techniques to help facilitate learning and memory retention. Investigation of the efficacy for such consciously employed, effortful techniques to translate from laboratory environments to practical settings is important for educational achievement, maintenance of cognition throughout older adulthood, and personal and professional development in larger social systems.

2. Contextual Factors

The Encoding-Specificity Paradigm [1] indicates that memory will be enhanced when contextual factors are similar between learning and retrieval (e.g., studying and taking an exam in the same room). Numerous studies have provided support for this paradigm, including congruence between environmental characteristics [2-5] as well as congruence between emotional state [6-10] (e.g., being in the same mood during learning and retrieval). Thus, a potential useful strategy may be to, when feasible, match behavioral, environmental and psychological characteristics between learning and retrieval.

3. Levels of Processing

Material can be processed at a variety of different levels, ranging from shallow to more deeper levels of cognitive processing. Various levels include, for example, 1) intentional learning (i.e., using any desired level of learning), which is often unregulated by experimenters, and thus, self-selected by research participants in line with their preferred learning style; 2) counting and reporting the number of letters while studying words (letter counting; shallow level of processing), 3) counting the number of syllables in the word (syllable counting; shallow processing), and 4) judging how relevant the words are to themselves (self-reference judgement; deeper level of processing). Generally, deeper levels of processing are superior to memory retention than shallow levels of processing, and memory performance tends to be contingent upon the level of processing required to satisfy task-recall demand [11].

Utilization of effective strategies often involves three main techniques, including organization, elaboration, and mental imagery. When feasible, organize material (e.g., categorization of content) in existing schemas. Effective elaboration techniques involve processing of information in terms of

its relevance to the individual (i.e., assign meaning to the content). For mental imagery, the more distinct the imagery, the greater likelihood it will be remembered [12].

4. Specific Learning and Memory Strategies

4.1 Clustering

Recall of material can also be enhanced when it is organized based on a spatiotemporal context [13-17]. This can be accomplished via several techniques, including chaining (i.e., consecutive recall of items that were positioned together) [18, 19] and positional coding (i.e., recall of items in their correct positional state).

The peg-word method [20], used to enhance serial learning, involves learning a list of words in sequential order and using that information to guide retrieval of other content. For example, the first step is to commit a series of words to memory and then remember the serial order of these words (e.g., pocket, shoe, tree). Then, using visual imagery, connect these words with the three target words (e.g., matches, compass, knife). Thus, this peg-word example might involve remembering this storyline: *matches* are stored in my *pocket*, the *compass* was smashed by stepping on it with my *shoe*, and the *knife* was stuck into the *tree*. Relatedly, the acronym method [21] involves linking words by the initial letter (e.g., the acronym IPMAT could be used to remember the following biological phases: interphase, prophase, metaphase, anaphase, and telophase). The linking *by story* method [22] involves creating a story that incorporates each item.

In the context of affective clustering, previous research demonstrates that memory recall may be enhanced when emotional features are integrated into a spatiotemporal context [23]. In the context of semantic clustering, recall of content, that is semantically related, can help to facilitate memory recall [24]. For example, if “pillow” and “blanket” are both presented in a word list, along with other words, the participant could remember the context of these items (e.g., items located in a bedroom), which could help facilitate the retrieval of these items [25]. Further, learning material into different categories can help to facilitate learning and memory [26, 27]. For example, when being exposed to a list of words, after hearing each word, think about whether the word/item can fit into a shoebox or judge whether the item is living or not. This categorization can provide a useful contextual cue to facilitate memory retrieval. Relatedly, chunking material together [28], or remembering material in distinct chunks (e.g., recalling words in 4 sets of 3 consecutively presented words), can help facilitate learning.

4.2 Production Effect

The production effect refers to the beneficial effect of reading material aloud, as opposed to reading the stimuli in silence [29-33].

4.3 Retrieval Practice

When given a list of items and the opportunity to restudy or practice retrieving those items, memory is typically better for retrieval practice, rather than restudy [34, 35]. However, this may vary as a function of various factors, such as the retrieval task used [36].

Distributed Learning vs. Massed Learning. Even when matched for the same volume of time spent studying, breaking up the learning (i.e., distributed or intermittent learning) can help to

facilitate memory retention [37, 38]. This may allow for greater contextual cues to help facilitate learning, as well as an increased likelihood in developing a reliable mnemonic to use.

4.4 Minimizing Distraction

Reducing distraction has obvious implications in enhancing attention, and in turn, learning and memory. For auditory stimuli, closing the eyes when listening to stimuli can help to facilitate learning and memory [39].

4.5 Time-of-Day Consideration

Individuals may have different peak (i.e., ideal) times of the day when they are able to more effectively learn and retain information [40]. Learning at this peak time of the day may be particularly useful for explicit-based memories, whereas implicit memory may be enhanced when studied at off-peak times [41]. Individual differences are pronounced between older and younger adults, largely due to changes in age-related sleep-wake patterns, with younger adults generally demonstrating heightened cognitive performance in the late afternoon [40].

4.6 Stimulants

It is not within the scope of this brief primer to comprehensively discuss the effects of pharmaceutical stimulants on learning and memory. Among older adult coffee drinkers, however, caffeinated coffee consumption has been shown to attenuate memory decline from the morning to afternoon (time of day effect) [42]. Caffeine may also help to improve memory for young adults during off-peak times [43].

4.7 Post-Learning Sleep

Learning material prior to sleep may help facilitate consolidation of the memory trace [44]. Sleep is important to facilitate memory consolidation because it may help prevent interference and forgetting of memories [45]. Thus, a useful strategy may be to study material immediately prior to going to sleep at night. Additionally, there is some suggestive evidence that taking a nap during the day may help to reduce forgetting information over the day [46].

4.8 3-R Technique

The 3-R technique refers to Read-Recite-Review [47]. That is, first read the stimuli, then recite as much of it aloud as possible without looking at the material, and then re-read the stimuli. An alternative technique is the SQ3R, which stands for survey, question, recite-and-review. Survey stands for skimming or surveying the material to get a broad overview of the content. Following this, ask yourself questions about the material that was just surveyed. Then read, recite, and re-review (3R) the material. In combination with this approach, making meta-comprehension judgements (e.g., judgements of learning or inference) can help facilitate subsequent studying behavior, and in turn, facilitate learning [48]. A judgement of learning example would be asking oneself the question, “how well do I understand this material?” A judgement of inference would be to evaluate how well one can integrate and apply the core information. For example, after

reading this paper, one could ask, "how well can I differentiate learning strategies of lower levels of processing to higher levels of processing, and would I be able to apply this knowledge to help a friend who has difficulty learning academic material?"

4.9 Self-Referential Processing

When individuals associate unfamiliar content with familiar content, this can help to facilitate learning and memory retention of unfamiliar content. For example, using prior knowledge of familiar individuals in a person's life has been shown to mediate the learning of facts of unfamiliar people and unfamiliar places [49]. Further, increased exposure of self-referential information may precipitate enhanced learning, as one's sense of self is considered a stable and robust storage site for knowledge and future social-contextual judgment [50]. Alzheimer's patients, whom are known to experience substantive decline in memory across time, have been shown to retain memory for personality features, as other aspects associated with meaningful life events, and memory for loved ones, progressively decays [51].

As part of this self-referential processing, the keyword method [52] involves creating an association between a to-be-remembered term's meaning with what it sounds like in one's primary language. For example, for the Spanish word "queso", which means "cheese," sounds like "case-oh". Thus, to remember that this word means cheese, one could envision a briefcase full of cheese. Lastly, the method of loci [53] organizes to-be-remembered information within the context of well-established visual mental images (e.g., imagine all the rooms of your house and then place the to-be-remembered stimuli into relevant rooms of your house).

4.10 Cue Integration

Utilization of cues plays an important role in retrieving memories. Importantly, utilizing cues during learning can also be highly effective in facilitating memory retrieval [54]. Additionally, it is important to use highly specific cues as opposed to more general cues [55]. Lastly, and in general, when attempting to retrieve a memory via cue utilization, think about the physical environment at the time of learning, think about your internal state (e.g., mood, feelings), and attempt to identify any particular thoughts that might have occurred at the time of learning. If unsuccessful in retrieving the cue-attempted memory, persist with additional attempts, as retrieval-attempt frequency is positively associated with memory retrieval [56].

4.11 Future Memories

Remembering to complete a memory in the future (e.g., taking medicine with dinner) is referred to as prospective memory. To help facilitate prospective memory, use an external cue (e.g., reminders through associations [57]) and place it in a prominent location (e.g., place your pill container in the kitchen that will be observable when preparing dinner); create imaginary cues when it is difficult to use an external cue (e.g., when dining out at a restaurant, imagine that the waiter/waitress is named Paul/Paula, with the "P" prompting you to take your pill out of your pocket to be taken with the meal), use implementation intentions (i.e., "if-then" statements, such as, if I see XX, I am going to do YY); complete the task when you think of it (i.e., when the idea comes into your mind, do it at that moment, as opposed to telling yourself that you will do it in a

few minutes or later in the day); and after completing the task, make a note of it (e.g., after taking the medication, check it off on the calendar, as it may be problematic if you failed to remember that you took the medicine, and then later in the day, another dose was taken) [58].

5. Conclusion

This brief primer serves as a practical guide to help facilitate learning and memory. Various empirical-based techniques have been discussed. Additionally, this primer may also serve as a useful framework for researchers interested in examining the potential independent effects of learning techniques on memory retention. Further, from an interdisciplinary perspective, this primer may help guide researchers across various disciplines who have an interest in examining the potential synergistic effects of a learning strategy coupled with a discipline-specific behavior (e.g., physical activity behavior) on memory recall. Regarding the latter, our group [59, 60], as well as other laboratories, are starting to show that acute bouts of exercise may subserve memory recall. However, little research has explored the potential additive effects of exercise and learning strategy implementation on long-term memory function. Memory is relevant to not only our recollection of previous experiences, but also dynamically serves as a scaffold for present human behaviors and abilities to confer future predictions about probable events we may encounter. Thus, this brief primer aims to serve as a utility for practitioners, educators, students, and researchers to refine and tailor the research and application of functional learning and memory strategies.

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Competing Interests

The authors declare that they have no conflict of interest.

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