Original Manuscript

Self-Generated Memory Cues: Effective Tools for Learning, Training, and Remembering

Policy Insights from the Behavioral and Brain Sciences
1–8

DOI: 10.1177/2372732218788092
journals.sagepub.com/home/bbs
SAGE

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Abstract

People generate a variety of memory cues, such as mnemonic devices and to-do lists, to support memory for difficult information. Self-generated memory cues make difficult information understandable, create links to long-term memory, and ultimately support later retrieval. The primary challenge is generating a cue that is memorable across environmental and mental contexts. Yet, self-generated cues are more effective at supporting retrieval than normative (generic) cues because they are tied to personal experiences, distinctive, and strongly associated to the target information. The effectiveness of self-generated cues can be improved by training people in cue generation, by instructing people to generate stable cues, by combining cue generation with other beneficial strategies, and by using technology to support the creation and memory of the cues. People use their privileged access to their mental states and prior knowledge to flexibly generate memory cues that bolster their memory—useful for students, trainees, elders, and everyone else.

Keywords

mnemonic devices, memory cues, metacognition, self-generation

Tweet

Generating memory cues can expand memory abilities and support learning across a broad range of domains. Using technology can help.

Key Points

- Self-generated memory cues can help students, trainees, older adults, and others remember difficult information, even more than generic memory cues.
- Self-generated memory cues elaborate information in meaningful and distinct ways.
- Instructions, the importance of the information, and the encoding context change the kind of cues that people generate.
- Technology can be harnessed to improve self-generated cues.
- Memory cues can benefit memory at school, in training, and during older ages.

Introduction

When taking notes in meetings, using mnemonic devices, making to-do lists, and naming computer files, people are generating memory cues to support their later retrieval. Memory cues are internal mental transformations of information or external reminders that help people recall target information. Since the time of the early Greeks, people have generated memory cues to support their memories. Cicero practiced the method of loci mnemonic, remembering a list by connecting each item to a specific familiar location (Bower, 1970). Medieval lawyers used memory cues to remember sets of codes and laws (Fentress & Wickham, 1992). Later, during the renaissance, students relied upon memory cues to help them learn grammar and the alphabet (Patten, 1990). To this day, people use a broad array of memory cues to support the recall of important information (Worthen & Hunt, 2017).

Self-generated mnemonic cues have been consistently used throughout history because they boost memory abilities. Self-generated mnemonic cues transform difficult-to-remember information into something meaningful (Worthen & Hunt, 2017), connect it to other information in learners' own long-term memory (Mastropieri, Sweda, & Scruggs, 2000), and create strong and personal retrieval routes to the target that make retrieving it easier (Atkinson & Raugh, 1975). This review examines what kinds of self-generated cues people create, why they are effective, and how they can improve. This has implications for training students, entry-level professionals, and older adults.

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Kinds of Self-Generated Cues

Two broad categories of self-generated memory cues are internal and external cues. Internal cues connect new information to existing knowledge or transform it into something more memorable. Internal memory cues are widely used; for example, 73% of those surveyed by Harris (1980) reported using the first letter of to-be-remembered items to create a simpler memorable word (e.g., list of Great Lakes = HOMES). Similarly, 57% reported using rhymes to help remember (e.g., 30 days hath September, April, June, and November).

Internal mnemonic cues have long supported learning in education and do improve learning of foreign language vocabulary (Atkinson & Raugh, 1975), state capitals (J. R. Levin, Kessler Berry, Miller, & Bartell, 1982), and even information presented in prose (Shriberg, 1982). College students consistently report generating mnemonic cues—rhymes, acronyms, songs, and stories—to remember connections among important ideas (Van Etten, Freebern, & Pressley, 1997). Mnemonic cues may be especially helpful to re-code information in domains where learners must master a wealth of unfamiliar vocabulary or abstract concepts. Indeed, students report generating mnemonic cues for classes that specifically involve learning a lot of new facts and terminology (McCabe, Osha, Roche, & Susser, 2013), and relying on memory cues has advantages for complex domains with vast new vocabularies, including chemistry (Banks, 1941), physics (Gough, 1977), biology (Stagg & Donkin, 2016), and psychology (Richmond, Carney, & Levin, 2011).

People also use a variety of external cues to support memory (for a thorough discussion of external memory, see Finley, Naaz, & Goh, in press). External memory cues are aspects of the environment that people harness to support recall. People may generate external cues (such as lists and notes) even more frequently than the internal cues described above (Park, Smith, & Cavanaugh, 1990). For example, in a survey about the types of cues people use to remember information, 100% of people reported putting items in a special place to remind them of something, 97% reported writing notes to themselves, 93% reported writing shopping lists, and 53% reported using a timer to alert them (Harris, 1980).

Effective external cues help learners retrieve information by coopting features of the external environment to overcome the innate limitations of human memory. The ability of a learner to remember internal memory cues may fade over time; a good external cue can sustain memory retrieval even in the face of considerable forgetting. For example, the first author's statistics professor often joked that we should all get tattoos of the solution to the normal equation to ensure that the equations would never be forgotten (no word on whether anyone has ever gotten the tattoo). The second author routinely writes the day's to-do list on the back of his hand. Beyond tattoos and to-do lists, learners avoid inherent memory limitations by generating a variety of external memory cues, including taking photos, writing notes in classes, and asking others to remind them of something.

Challenges to Creating Effective Self-Generated Memory Cues

Generating effective memory cues for future recall is challenging because learners must anticipate their future cognitive needs and take the perspective of themselves in the future. Successful retrieval partially depends upon the overlap between the encoding and retrieval contexts, so successful cue generation requires learners to generate cues that will match their environmental and cognitive states at the time of retrieval (e.g., Raaijmakers & Shiffrin, 1980). If the cognitive and environmental contexts fluctuate between the time of the cue generation and retrieval, the cue from encoding may not match the cognitive context at retrieval, and recall of the target will suffer.

Context may vary between retrieval and encoding in two major ways: environmental and mental. The physical environment shifts over time, and different amounts or kinds of external information may be available in the retrieval context compared to the encoding context. In addition, mental contexts shift through time (e.g., Estes, 1955). Mental states naturally change through experiences and development. For example, when learners generated descriptions of target items twice across 3 weeks, their descriptions changed for 54% of the targets (Mäntylä & Nilsson, 1988). If cognitive contexts shift between generation and retrieval, the generated cue may not support retrieval.

Anticipating one's future perspective is crucial to effective cue generation and, and more broadly, metacognitive control (Kornell & Bjork, 2009; Ryskin, Benjamin, Tullis, & Brown-Schmidt, 2015). Accurately predicting one's future context is nearly impossible, as unpredictable life events may alter one's cognitive context. For example, people predict relatively little change to their memories over time and underestimate the influence of future forgetting and learning (Kornell & Bjork, 2009). If learners cannot estimate how their memories will change, their ability to take the perspective of their future self across long time spans may be very limited.

Due to failures to predict changes in environmental and mental contexts, self-generated memory cues sometimes fail to support retrieval. For example, external cues that patients utilize to support prescription adherence, such as pill boxes and cell phone reminders, frequently fail: Patients forget to take their medication, and the effectiveness of their prescription is undermined (Osterberg & Blaschke, 2005). A self-generated memory cue can fail in two primary ways: A learner can fail to retrieve the cue (i.e., retrieval deficiency) or the learner can forget how to interpret the cue (i.e., decoding deficiency; Dunlosky, Hertzog, & Powell-Moman, 2005). For example, a chemistry student trying to remember that "molecular weight equals DRT/P" might generate the cue that "cats put DiRT over their P." Retrieval deficiency means that the student forgets "cats put dirt over their pee" when asked about the formula for molecular weight; decoding deficiency means that the student remembers "cats put dirt over their pee" but does not remember how that phrase relates to chemistry.

The effectiveness of internal memory cues seems to primarily be driven by learners' ability to recall their memory cue, rather than by deficiencies in decoding the cues. For example, when learners generate a mediator word to link together two other words, their later cued recall performance depends largely on their ability to remember their mediator, and much less on their ability to decode their mediator (Yuille, 1973). Similarly, when using the method of loci to remember a list of objects, familiar locations lead to better free recall than do unfamiliar locations; yet, when locations are provided to the learners (such that the locations do not need to be recalled), recall is equivalent between the familiar and unfamiliar conditions (Bellezza & Reddy, 1978). These results suggest that the primary impediment to successful recall is the ability to remember the loci, and not the ability to decode the loci. Analogous to cue retrieval deficiencies, people describe problems finding their external cues, as they report many external memory failures caused by losing notes, accidentally deleting digital information, and crashing hard drives (Finley et al., in press).

Effectiveness of Self-Generated Cues

Compared to cues generated by others, self-generated mnemonic cues improve later recall across a wide variety of tasks (Bellezza & Poplawsky, 1974; Jamieson & Schimpf, 1980; Kuo & Hooper, 2004; Saber & Johnson, 2008). For example, during a lab memory task, participants could remember about 450 out of 500 nouns when they were given cues they generated themselves, but could only remember about 275 items when they were given cues generated by other people (Mäntylä, 1986). Self-generated memory cues are also more effective than teacher-generated (Bloom & Lamkin, 2006) or randomly selected cues (Finley & Benjamin, 2012).

The benefits of self-generated memory cues persist over long retention intervals. For example, students who generated their own mnemonic cues for the names of the cranial nerves remembered more of the nerves than those who received the teachers' mnemonic cue 2 weeks after they studied the nerves, and the mnemonic advantage of the self-generated group grew after 10 weeks (Bloom & Lamkin, 2006). Similarly, in a simple word memory task, recall of a long list of words 3 weeks after study remained much higher when prompted by self-generated cues than cues generated by others (Mäntylä, 1986; Mäntylä & Nilsson, 1988; but see Kibler & Blick, 1972).

The advantages of self-generated memory cues may even extend beyond memory tasks. Mnemonic cues boost students' use and comprehension of new vocabulary (McDaniel & Pressley, 1989; Pressley, Levin, & Miller, 1981), help students to integrate information and make inferences (M. E. Levin & Levin, 1990), and allow students to solve higher-order thinking problems (Richmond et al., 2011). Students can even use memory cues to apply and manipulate factual biology and psychology knowledge (Rosenheck, Levin, & Levin, 1989).

Self-generated mnemonic cues may be so effective that they underlie one of the most robust and meaningful learning strategies: retrieval practice. Actively retrieving information from memory enables better long-term retention of that information than just passively rereading it (Roediger & Karpicke, 2006). Retrieval may benefit memory because it helps learners identify which of their memory cues are effective and which are not (Pyc & Rawson, 2010). When learners struggle to retrieve the target information during retrieval practice, they switch to more effective cues, and this helps them remember the target information over long retention intervals.

Why Are Self-Generated Cues Effective?

Learners both remember and decode (interpret) the cues that they generated themselves better than cues generated by others (Tullis & Fraundorf, 2018b). Self-generated mnemonic cues may enable cue retrieval and cue decoding because they rely on the generator's idiosyncratic knowledge to create durable, elaborated retrieval routes to the target. Effective memory cues typically have three characteristics that will be addressed in turn: connections to personal experiences, distinctiveness, and strong associations with the target.

First, learner-generated cues may be effective because they can be *rooted in a learner's unique knowledge and experiences*. Learners rely upon their personal experiences to generate idiosyncratic and unique cues for themselves (Mäntylä, 1986; Tullis & Benjamin, 2015b). For example, when remembering that Rutherford was the first person to show that each atom has a nucleus in its center, a chemistry student can create a cue that says "Ruth is my grandma's name and grandmas are the center of the family." Tying new knowledge into existing, idiosyncratic personal experiences elaborates the new information and is one of the most effective means of supporting memory (Symons & Johnson, 1997). As noted, meaningful personal elaboration benefits memory more than normative elaboration (Kuo & Hooper, 2004).

Reducing reliance on learners' idiosyncratic knowledge impairs the effectiveness of mnemonic cues. For example, when pairs of learners create shared mnemonic cues, the idiosyncrasies of the cues reduce, and ultimately recall diminishes (Andersson & Rönnberg, 1997). Similarly, when learners generate cues for others, they decrease the uniqueness of those cues and reduce the reliance on their own personal experiences (Tullis & Benjamin, 2015b). Cues generated for others consequently do not support one's memory as much as cues generated for oneself (Tullis & Benjamin, 2015b). Cues generated in pairs or for others use less idiosyncratic and less episodic information, becoming difficult to retrieve.

Second, self-generated cues effectively support recall because their *distinctiveness constrains the possible targets* during retrieval. When generating cues for themselves, learners produce distinctive cues that point to fewer potential targets than they do when generating cues for others (Tullis & Benjamin, 2015b). The distinctiveness of a cue (as measured by the number of potential targets that a cue points toward) is related to the cue's effectiveness. If a cue is associated to many potential targets (i.e., it is not distinctive), it is overloaded and recall is impaired (Hunt & Smith, 1996). Across memory tasks, idiosyncratic cues support memory better than common cues because they have fewer extra-list associations (Einstein & McDaniel, 1990). In fact, distinctiveness may be the single most important attribute of a cue that determines whether a target is recalled or forgotten (Nairne, 2002).

Finally, self-generated cues are effective because they *are strongly associated to the target.* Strong relationships between the cue and the target drive successful recall because they allow learners to accurately decode the cue. Using an individual's personal knowledge as a source for cues ensures strong relationships between cues and targets (Tullis & Benjamin, 2015a).

Broadly, learners may be able to generate their own effective cues because their current cognitive state matches their retrieval context better than anyone else's can. Indeed, a person's current and future cognitive states are more similar than two different people's cognitive states (Fraundorf & Benjamin, 2014; Tullis & Fraundorf, 2017). In fact, although only 46% of one's self-generated mnemonic cues remains the same across 3 weeks, only 20% of cues overlapped between different learners (Mäntylä & Nilsson, 1988). Learners, consequently, should be best suited to take perspective of their future selves because they have unique access to their current mental states. Privileged access to one's own mental experiences allows for effective metacognitive control (Tullis & Benjamin, 2011; Vesonder & Voss, 1985) and enables people to generate cues that specifically support their ability to recall information in the future.

Improving the Effectiveness of Self-Generated Cues

The effectiveness of self-generated cues can improve through several interventions. First, instructions given to learners when they generate cues changes the type and effectiveness of the cues. For example, instructions to generate cues to *remember* target words, rather than to *describe* the target words, prompt learners to create more idiosyncratic and distinctive cues and ultimately enable higher recall of the target words (Tullis & Benjamin, 2015a). Other instructions guide learners to increase the cognitive contextual stability of their cues by asking learners to generate "focused" cues (i.e., ones that they would likely generate again; Mäntylä & Nilsson, 1988). When learners create "focused" cues, they are more likely to regenerate those same cues later, and their cues become more effective.

Learners can also tailor their cues to distinguish among similar targets. Cued recall of a list of related items doubles when learners are instructed to create "unique" cues that solely relate to one target item rather than "common" cues that relate to all target items (Hunt & Smith, 1996). Even without instructions to create "unique" cues, learners tailor their self-generated cues to identify a specific target when they are aware of potential competitors. Learners who know that they need to remember very similar target words (e.g., "quiz," "test," and "exam") generate more distinctive cues that are associated only to one of the targets and ultimately reduce confusions among to-be-remembered information (Tullis & Benjamin, 2015a).

Explicit training and experience using memory cues can bolster the effectiveness of learner-generated cues. For example, memory performance improves through extended practice using the method of loci (Baltes & Kliegl, 1992). Memory masters typically practice using a variety of memory cues to succeed at daunting memory challenges (Foer, 2012). Experience and explicit training may be helpful because they can induce people to more accurately predict their mnemonic needs during retrieval (e.g., Tullis, Finley, & Benjamin, 2013). However, limits to this perspective-taking ability exist. Even after experiencing the benefits of transfer-appropriate processing, learners do not adapt their encoding choices to match retrieval contexts (Finley & Benjamin, 2018). More specifically, learners' study requests were driven by a preference for one type of cue for all tests (e.g., requests for rhyming study cues, regardless of whether they expected rhyming or semantic cued recall) even after experience with the different tests. Learners may have difficulty anticipating future specific scenarios and choosing encoding cues to match.

Learners can also tailor the cues they generate based upon the importance of the to-be-remembered information. High incentives for remembering information (in the form of greater cash payments) cause learners to spend more time creating cues and to generate cues that more effectively support their later recall (Tullis & Fraundorf, 2018a).

Finally, self-generated cues may combine with other effective study techniques to yield more impressive recall than any specific technique on its own. For example, after learners generate an internal memory cue, their memory for the cue can be tested (i.e., learners engage in retrieval practice of the cue). Combining cue generation with retrieval practice boosts memory for the target information more than either cue generation or retrieval practice alone (Miyatsu & McDaniel, 2017; Wang, Thomas, & Ouellette, 1992).

The effectiveness of external cues can be improved by combing them with implementation intentions, a prospective memory strategy. Implementation intentions are very specific if-then plans that link situational cues with responses to enhance the translation of intentions into action. Patients trying to remember to take medication can imagine initiating the intended action in precisely specified statements that read "if . . . then I will" (Oettingen, Hönig, & Gollwitzer, 2002). Through this mental rehearsal of detailed plans with detailed environmental cues, patients elaborate on their cues and strongly associate actions with specific situational cues. When the critical environmental cues later appear, patients are more sensitive to noticing the cues (Mäntylä, 1993) and automatically activate the mental representations of the intended actions.

Cues and Technology

Humans have always used technology to extend their abilities and compensate for their limitations, and people use technology to avoid the challenges inherent to generating effective memory cues. Even low-tech tools such as pen and paper afford the powerful ability to offload cue generation and cue retrieval onto the environment. High-tech tools allow even more. For example, alarm clocks and digital calendars are particularly useful for alerting and reminding. In the survey by Finley et al. (in press), 59% of respondents said they rely on high-tech tools to remind them of events/appointments in their everyday life (e.g., 39% phone, 34% digital calendar, and 17% alarm). When tagging computer files with descriptive labels, auto-complete can help generate cues that are popular or that an individual has previously used.

Cues created by technology can be even more powerful than human-generated cues because they can preserve far more detail than the human mind. For example, photographs provide particularly powerful and elaborate cues for memory, such that 69% of people report experiencing powerful emotional responses from looking at photos from their past (Finley et al., in press). Reviewing pictures from a wearable camera at the end of the day improved later memory for the day's experiences (Finley, Brewer, & Benjamin, 2011). Similarly, participants remembered an average of 23% more of their everyday experiences from a week or a month ago when they were cued with pictures of the experiences (Finley & Brewer, 2018). Photos even cued memory for nonvisual aspects of the original experience (e.g., sound, emotions). Photos can serve as effective memory cues for diverse populations, from college students (Finley et al., 2011) to people with Alzheimer's disease and other memory impairments (Berry et al., 2007; Woodberry et al., 2015). For reviews of research on wearable cameras as assistive technology for people with memory impairments, see Allé et al. (2017) and Silva, Pinho, Macedo, and Moulin (2018).

While photographs can serve as valuable external memory cues, creating and finding the memory cues can pose problems for memory. The very act of using the camera may influence one's own memory (Henkel, Nash, & Paton, in press). Taking a photo can disrupt attention (Soares & Storm, 2018), decreasing memory for the viewed objects (Henkel, 2014). Thus, a tension can emerge between creating external cues to assist later memory versus focusing one's attention in the moment to strengthen initial encoding. Improvement of automatic recording devices, such as wearable cameras, may be able to offload the task of creating the memory cues by allowing the camera to choose when to take photos, thereby alleviating this dilemma.

The advent of affordable digital photography and nearly limitless digital storage has created an overabundance of external cues. People can always aimlessly browse their trove of photos for reminiscence, but finding any one particular picture on demand can be difficult. Participants failed to find nearly 40% of their personal photos of family events from over a year ago (Whittaker, Bergman, & Clough, 2010). Thus, for high-tech external cues to be effective, they must confront problems of organization and search. The cross-disciplinary field of personal information management (PIM) addresses these issues. PIM "refers to both the practice and the study of the activities people perform in order to acquire, organize, maintain and retrieve information for everyday use" (Jones & Bruce, 2005, p. 2). Creating too many external cues is a problem that extends beyond photographs. For example, people can become habituated to frequent alarms, especially in professional settings such as health care, a phenomenon referred to as "alarm fatigue" or "alert fatigue" in the human factors literature (Cvach, 2012).

Successful use of external cues, with or without technology, ultimately requires careful coordination of internal and external memory. Technology enables creation of more external cues than ever before, and these cues can expand on internal memories, although not without additional challenges.

Implications

The efficient use of memory underlies a broad array of skills, including taking medications, recalling acquaintances' names, learning new concepts in classes, and remembering what to buy at the grocery store. Generating mnemonic cues is an effective memory strategy that people can utilize to better encode information, control their retrieval circumstances, and bolster their memories across a variety of domains.

Self-generated memory cues allow people to personally elaborate on abstract concepts, establish links to ideas in long-term memory, create unique and persistent retrieval routes, and ultimately sustain memory. Instructions can help people generate effective memory cues across a variety of domains. Education, business, and personal environments can prompt people to generate cues to support their memory for important information. Self-generated memory cues may be particularly beneficial for students with learning disabilities (Mastropieri & Scruggs, 2000), for elderly adults, who may struggle with recall (Verhaeghen, Marcoen, & Goossens, 1992), and for low-performing individuals, who spontaneously generate fewer memory cues than others do (Scruggs, Mastropieri, Jorgensen, & Monson, 1986). Furthermore, if used appropriately, technology can help to create and maintain memory cues.

The strategic control that people exercise over their encoding and retrieval processes largely contributes to individual differences in memory capabilities (Benjamin, 2008). Trusting people to strategically generate their own memory cues joins a growing wealth of research showing that learners almost always control their cognition better than others can (e.g., Finley, Tullis, & Benjamin, 2009; Tullis, Fiechter, & Benjamin, 2018). People use their unique access to their mental states and prior knowledge to successfully and flexibly control their memories. Ultimately, self-generated memory cues are a particularly effective mnemonic tool that people can use to bolster memory.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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