Encoding Specificity as a Function of Working Memory

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Abstract

Encoding specificity is a principle in cognitive psychology that involves the interaction between working memory, short-term memory, and long-term memory. Dissatisfaction with memory quality and a need for more inclusive teaching have prompted intensive research into this subject in recent years. The purpose of this literary review is to examine the practical implications of studies concerning encoding specificity in order to determine the benefit of conscious implementation into learning environments. Testing involved participants creating replicable context at the time of encoding to later be tested at recall. Results of testing revealed a significant improvement in memory retention when participants were tested for recall. In each of the mentioned tests, memory was consistently better when contextual information matched in both encoding and recall. The implications of these findings provide support for the principle's effectiveness in assisting people of all demographics with improving memory retention.

Keywords: encoding specificity, cognitive psychology, state-dependent learning, working memory, memory recall

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Imagine, as an online college student, you are calmly sitting at your desk in your quiet office, taking notes while studying a new topic for a future test. The morning of the test, you awaken to find that, in the night, your wifi stopped working. Knowing you must now take your test elsewhere, you pack up your laptop and head to your local Starbucks to utilize the free wifi. Once there, the whirring of blenders and the chatter from other patrons all around you becomes distracting. As you read through the questions, you find yourself forgetting the information and feeling as if the answers are on the tip of your tongue, but you simply cannot recall them. As prepared as you are for this test, why can you not perform at the same level as you did on the practice test taken at home?

Scenarios such as the one mentioned above demonstrate the usefulness of the principle of encoding specificity in our daily lives. Retracing steps to find lost keys, practicing coping mechanisms learned in Cognitive-Behavioral Therapy (CBT), and even specific investigative interview techniques like cognitive interviews are additional examples of situations where encoding specificity proves useful for assisted memory recall. In each of these examples, the principle of encoding specificity helps the brain transfer information from long-term memory (LTM) to working memory more effectively. Encoding specificity is presumed to significantly increase the probability of a memory successfully being transferred from short-term memory to LTM and later recalled to working memory. If it is possible to recall something better by simply retracing our steps, it begs the question: If our brains make associations to aid in recall even if a memory cue seems irrelevant, is it possible to use encoding specificity to improve our memory recall intentionally, or is it simply an unconscious process of the brain? Luckily for us, research

shows that it is, in fact, possible to make encoding specificity work in our favor by mindfully making connections between contexts in our brains (Zhou & Agadzhanyan, n.d.).

The concept of working memory (WM) is the foundation upon which the principle of encoding specificity exists. Encoding specificity is simply a function of WM. Working memory was first proposed by Baddeley and Hitch in 1974 and differentiates itself from short-term memory (STM) and LTM by acting as a mediator between the two. Working memory, like STM, is limited in its capacity and pulls information from LTM. This information is then manipulated in WM to factor in new information and recall memories stored in LTM. Working memory essentially does exactly what its name implies- work with new and existing information to form new memories and recall old ones. Because of its limited capacity, information being manipulated in WM does not stay there long. In order for one to recall a memory during complex cognition processes, information must go through stages of WM (Baddeley & Hitch, 1974).

Working memory is comprised of three stages: encoding, storage, and recall. During encoding, information to be transferred into memory is perceived or learned. Because the brain constantly perceives stimuli in the world around us, our brains continuously encode context into STM. Whether or not our brains store these stimuli as memories depends on multiple factors explained by related principles and theories. Following encoding, the brain more or less filters out irrelevant stimuli in the storage stage (McDermott & Roediger, 2018). Working memory contains distinct features like holding and processing that set it apart from STM (Baddeley & Hitch, 1974). Unlike STM, WM is more permanent in that previously stored information is recognized and not considered a new memory by the brain; rather, it is an existing memory in LTM that is available for transfer to WM.

The storage stage can refer to information being briefly stored in STM or for an indefinite amount of time in LTM. Storage in STM is incredibly short- only lasting around 15-20 seconds (Peterson, L., & Peterson, M.J., 1959). Likewise, WM has a relatively short duration and is limited in capacity. In contrast, LTM has an unlimited capacity and duration, meaning the amount of time it lasts is variable but not limited, like STM (Cowan, 2008). The storage stage of memory ultimately acts as a filter to remove encoded stimuli that are not relevant to transfer into LTM for whatever reason. Stimuli that make it past the storage stage are converted into LTM and remain there indefinitely or until forgetting occurs.

Finally, the third stage is memory recall. Recall occurs after encoded information is stored in LTM and is needed for WM. This stage is what essentially gives WM its name. Information is retrieved from LTM and transferred back into WM to form a new memory during complex cognitive processes. Complex cognition is also marked by its inclusion of information-holding as well as information processing within WM. During the recall stage of WM, new encoding occurs when a person perceives information around them. In doing so, existing memories, such as having been there before, seeing something you recognize, and others, converge briefly with the newly encoded memories stored in STM (Goldstein, 2021). An example of the role that holding information plays in WM is language translation. Say a bilingual person stops to help Person A and Person B, who speak English and Spanish, respectively. Regarding the translator’s brain, they would perceive and encode the sentence from person A. Holding the English sentence in mind, memory of the Spanish language would be recalled back into WM, where it will be manipulated- or where it will undergo processing. Active processing occurs during the recall phase of WM (Vecchi et al., 2005).

It is during this third stage that the results of encoding specificity can be observed. Although it begins during encoding, encoding specificity primarily focuses on recall. Recall makes retrieving specific memories possible while performing another action, such as recalling grammatical rules as we write a sentence. Recall can encompass many automated tasks like understanding and processing language. It also makes it possible for us to have conversations and perform other actions that require prior memories to be retrieved from LTM in order to form a new memory. One way in which memories are retrieved from LTM is through memory cues, which refer to stimuli such as objects, events, places, people, and sensations that trigger a memory in the brain (Van Gennip et al., 2015) to assist with memory recall. The key takeaway from the functionality of memory cues is that they act as context that can positively impact recall. This is the basis of encoding specificity.

The principle of encoding specificity explains the relationship between contextual factors present at the first stage of memory, encoding, and the third stage, or retrieval. This context can be nearly anything one can perceive- both environmental and mental. Environmental context may include weather, objects, sounds, places, etc. An example of a frequently used memory cue is verbal cues. Mental context concerns internal mood, emotions, and state of mind. The principle of encoding specificity holds that memory recall will be improved when additional context is encoded that is present at both stages. This additional encoded context functions as a memory cue for retrieval of an existing memory being recalled from LTM. Encoding specificity can include external environmental memory cues, such as snow, or internal mental memory cues, such as a depressed mood (Tulving & Thomson, 1973). In a popular study, participants were assigned to one of two groups, dry land or underwater, and asked to memorize words from a list as best they could in their environment. One interesting feature of this study was that it included

both extreme external and internal contexts, such as stress. After a waiting period of 24 hours, participants returned to their respective groups and performed a memory recall test of the words studied the prior day. Results showed support for encoding specificity, with recall improved by around 50% when the conditions present during encoding matched those present during recall (Godden & Baddeley, 1975).

While external context is frequently the main topic while discussing encoding specificity, internal context has also been demonstrated to show a significant outcome. Within encoding specificity, state-dependent learning (SDL) describes exclusively the internal context and conditions present during encoding and retrieval. SDL's contextual information may include one's mood, such as stress, during encoding (Seddon, 2019). Additionally, state of mind is also included in SDL. In one study, Goodwin et al. (1969) examined the link between drunkenness- the state of mind of the experimental group- and memory recall. Results were consistent with those later reported by Tulving & Thomson (1973), that show when participants who were intoxicated during encoding performed significantly better when they were also intoxicated during recall. While there are some concerns regarding the use of memory-altering substances to measure memory, the underlying principle that recall is improved when conditions of encoding and recall match stay the same.

Many often feel that their memory is not as good as desired and would like it to improve. While encoding specificity is a process our brain naturally performs, it is possible to consciously implement it into our lives to benefit from it. The classroom is by far the most widely-discussed arena where cognitive training with encoding specificity is popularly spoken about and practiced. The idea is that self-aware students can make connections between stimuli such as a particular word, picture, or example of a personal experience and the information to be later recalled when

similar conditions are present. Based on the anticipated future context, students can encode memory cues that can help bridge the context at encoding to the context at recall. This commonly includes testing, quizzes, and homework. In an interview, one teacher explains how she uses specific imagery in her lectures during encoding so that the students might associate the information with the image. When they are tested on the material, she again provides them with the image and reports a much greater incidence of recall than otherwise observed (Jones, 2022, 3:40).

Research on encoding specificity shows that students perform best on recall assessments when they test under the same context as the information was originally encoded (Zhou & Agadzhanyan, n.d.). In the example scenario at the beginning of this paper, the context that affected the person's ability to recall information for their test was their retrieval location and their mood at the time of retrieval. If the student was accustomed to learning at their desk at home, free from noisy distractions like those in the coffee shop, encoding specificity asserts that the student would best perform under the original context. The student likely had trouble with recall due to the memory cues missing from mismatched contexts. The student's mood was likely a factor as well since the student was accustomed to encoding in a calm environment. Interestingly, encoding specificity does not relate to the specifics of context; rather, it is solely dependent on the context matching during encoding and retrieval. This is significant because it contradicts other research. The matching of the contexts is the key to encoding specificity working.

Students seeking to take advantage of the benefits of encoding specificity may also benefit by educating themselves on similar memory theories, such as the levels of processing theory proposed by Craik and Lockhart (1972). The levels of processing theory is concerned with

the depth of encoding and states that the deeper the level of processing, the better the memory. However, it is essential to note that this theory has issues within it and is largely subjective. One prevalent method is to utilize the elaborative self-reference effect. The self-reference effect generally results in better memory due to the personal experiences that are deeply engrained into our memory as opposed to a simple semantic fact. We are more likely to remember information if it is relevant to us somehow (Rogers et al., 1977). Utilizing a personal experience to tie in as an example of something being encoded can, in turn, help encoding specificity be more effective. A student may do this by connecting concepts or definitions to something meaningful to them; for example, many high school students are taught fifty-three English prepositions by singing them along to the melody of "Jingle Bells."

Encoding specificity is also a relevant topic when considering people with difficulty during the retrieval stage, such as young children and those with learning disabilities. Though especially applicable to these groups, teaching methods to assist in memory recall can help people from all backgrounds learn better (Storm & White, 2010). Although research also shows impairments during the encoding stage, Fosco et al. (2020) report that as many as 85% of those with ADHD show significant impairments in WM (Skodzik et al., 2017). With the number of ADHD diagnoses rising, there becomes a greater need for teaching methods that work universally for all students. Including activities that use encoding specificity as a function of learning can help students possibly work around these impairments (Sonuga-Barke et al., 2010).

The principle of encoding specificity is not exclusive to students or even to a particular age group, though it has been shown to work better for specific groups. It is known that, with aging, our memories naturally deteriorate to some degree over time. Between semantic and episodic memory, episodic memory deteriorates faster and to a higher extent (Levine et al.,

2002). Episodic memory, encompassing personal experiences and memory for specific events, is especially vulnerable to aging and neurodegenerative diseases such as Alzheimer's Disease and Dementia (Kinugawa et al., 2013). Adults with Alzheimer's Disease (AD) have been shown to benefit less from encoding specificity than those without (Puglisi et al., 1988). Research into cognitive training methods that utilize the principle of encoding specificity yields promising data that supports the hypothesis that, while variable in degree, encoding specificity generally helps people of all age groups with stronger memory recall.

Returning to an earlier point, encoding specificity can be observed as helpful in more than just an academic setting. Another instance where encoding specificity is particularly helpful is during police investigations when cognitive interviews are conducted. In a cognitive interview of a witness, a psychologist brings out details of the crime in an attempt to get a better idea of what occurred. This often takes the form of asking witnesses what the crime scene smelled like, what they were wearing, or how they felt. Additionally, witnesses may be brought back to the crime scene to see if it triggers a memory of the crime. This process utilizes both encoding specificity as well as state-dependent memory. Asking the witness how they felt allows them to focus on the target memory by replicating the context of the memory (Köhnken et al., 1999).

Another real-world application of encoding specificity is how military members are conditioned to remember their training. Personnel may be trained in environments similar or identical to those where they would engage in combat, such as Twentynine Palms, CA. Matching the context between the external environment and the anticipated environment in which retrieval is expected to occur is highly effective in aiding in recall. SDL is particularly useful in military training, as personnel often undergo training where extreme stress is invoked prior to the

training. They are trained under the same internal context as they might face in combat so that they can more easily recall their training if faced with the situation.

Though encoding specificity remains one of the most popular and commonly held principles of memory, it is not without opposition. Some argue that too much emphasis is being placed on encoding specificity, as Nairne (2002) did in research proposing an active process of discrimination as an alternative. It should be noted that the principle of encoding specificity only aims to explain one facet of the complex process of memory. Encoding specificity makes no claims about outside factors. Rather, encoding specificity seemingly only seeks to describe the relationship between the context at encoding and retrieval. It does not exist to explain further variables like the depth of encoding or the quality of the memory cues. It simply defines the contextual congruency between encoding and retrieval.

It can be observed that encoding specificity stands out from other theories of memory because of its universality regarding its use as a memory-strengthening technique. Though many know it simply as “home-field advantage” or “retracing your steps,” it is clear that this concept is one we can all say we have experienced in our daily lives. Harnessing the ability to self-generate memory cues can prove especially useful wherever there is a need for memory recall. Whether in an academic or a professional setting, cognitive training with encoding specificity can work for just about anyone.

Discussion

Upon examination of the literature, it is evident that studies designed to test the principle of encoding specificity have yielded statistically significant data that support the hypothesis originally proposed by Tulving and Thomson. Limitations of these studies include other

principles of memory which may have impacted the results. The levels of processing theory has also been shown to majorly impact working memory, and studies examining encoding specificity are not clear as to whether or not other principles were taken into consideration. Regarding future research, studies which focus on groups with learning disorders such as ADHD may produce data that could influence the way students are taught, ensuring all students are given a more equal playing field for educational success. Theoretical implications of these studies point to promising evidence that developing study techniques centered around the principle of encoding specificity may lead to more successful learning and memory retainment in students and other groups. Although encoding specificity is just one of many principals of memory, these principles can be adapted into practical, working solutions for everyday memory recall.

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