Spaced Learning: Its Implications in the Language Classroom

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Abstract

For a substantial period of time, researchers have studied the effects of spaced learning on memory, and numerous studies show the benefits of distributed learning in the classroom. However, despite the ubiquitous presence of evidence in literature and the overwhelming number of empirical learning experiences, both students and professors often fail to acknowledge what scientific investigations have shown. The aim of this review paper is to synthesize information about cognitive memory and how the research findings in this field can benefit the learning process if applied both to content distribution and to revisiting this content after a period of time.

Key words: spaced learning, distributed learning, massed learning, second languages, cognitive memory, language acquisition

Resumen

Durante mucho tiempo, investigadores en los campos de psicología y educación han estudiado los efectos de la distribución del aprendizaje en la memoria y han demostrado sus beneficios en el salón de clase. Sin embargo, a pesar de la abundante evidencia proporcionada en la literatura y adquirida por medio de la experiencia diaria, tanto estudiantes como profesores parecen ignorar los hallazgos científicos al respecto. Este artículo busca sintetizar información sobre la memoria cognoscitiva y enlazar los aportes en el campo con los procesos de enseñanza al aplicar esta práctica tanto en la distribución de contenidos como en su revisión luego de un período de tiempo.

Palabras claves: aprendizaje distribuido, aprendizaje espaciado, aprendizaje en masa, segundas lenguas, memoria cognitiva, adquisición de lengua

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"You can get a good deal from rehearsal
If it just has the proper dispersal.
You would just be an ass,
To do it in a mass:
Your remembering would turn out much worsal".
Ulrich Neisser (1928-2012)

"We remember what we understand,
We understand only what we pay attention to;
We pay attention to what we want."
Edward Bolles

In the first of the quotes above, Ulrich Neisser, a well-known cognitive psychologist, presents a short and direct idea of what is pursued in this paper: repeated distribution of information through time benefits memory. In the second quote, Bolles refers to the other element that has a great deal of influence in language learning, which is the understanding of material that allows storing and subsequent retrieval of information when it is needed.

Introduction

In our effort to cover more content in second language learning, we sacrifice the opportunity for students to learn things more in depth and more permanently. Language classrooms have become places where educators try to transmit a large amount of information to students in a short period of time without really considering the effects that teaching and learning strategies have on students' long-term learning. This review paper tries to bring together the fields of cognitive psychology and education, two fields that, although not always associated at first, share a direct connection in terms of their interests. The term "spaced learning" takes a central role in this paper given the prevailing importance it has for both memory and learning. Spaced learning is defined here as the practice of distributing and revisiting information presented in separate time intervals with the purpose of facilitating the storage of this information in the long-term memory. Massed learning, on the other hand, is used to describe the practice of learning information intensively for just one short period of time. The bulk of literature, as will be seen below,[1] points to the fact that there are clear advantages of spacing learning, and it shows, from many different perspectives, how and why this happens. The purpose of this paper is first to explore the existing evidence that has been gathered by cognitive pshycologists through many years of constant study, and then, in light of these findings, analyze the implications of spacing research in terms of the impact it is likely to have in a second language setting.

Role of memory

First of all, it is important to refer to the role that memory plays in terms of our ability, or lack thereof, to retrieve information that we have previously encountered in our lives. Cognitive psychologists have established that multiple types of memory processes exist. For the purposes of this paper, I will present and describe those relevant to language learning, particularly when recalling grammar forms and eventually learning grammar. Baddeley et al. describe short-term memory as that type of memory that is "applied to the retention of small amounts of material over periods of a few seconds" (p. 9). They further elaborate on this definition to include the type of memory that is used "to refer to performance on a particular type of task, one involving the simple retention of small amounts of information, tested either immediately or after a short delay" (p. 19). As humans we are information-gathering creatures. While we are exposed to many different types of information (imagery, language, smells, sounds etc.), we are selective in terms of what we attend to and process so as to not overload our senses and abilities to process and store information. Once we select information, it is going to initially be stored in our short-term memory. Donna Walker Tileston (2004) reports that "[m]ost brain researchers say that 99% of what we learn comes to us through our senses; that is, through vision, hearing, smelling, tasting, and touching" (p. 12). She also points out the importance of cues in the classroom environment (teachers' explanations, pictures on the wall, music, hearing language, interactive activities between students, etc.) in regard to the effect they may have on a student's learning process. Most professors have probably noticed how things surrounding students while they are exposed to a new topic in class, often become an aid when they try to recall that information for subsequent use.

Baddeley *et al.* also describe short term memory as part of what is called working memory, and they define the latter as the "system that not only temporarily stores information but also manipulates it so as to allow people to performe such complex activities as reasoning, learning, and comprehension… [it is a] [r]ange of complex memory span tasks in which simultaneous storage and processing is required" (p. 19). As professors, we are very familiar with these types of memory as we have witnessed students cram for tests, perform the given task, and then have no recollection whatsoever of the material a few days or weeks after the test took place. These are the types of memory that students resort to when, after numerous repetitions of verb forms or structures the day before the test, they can recall this information long enough to take the test; and sometimes even hurry us, professors, so that they can pour the forms onto a paper before they forget, as they themselves openly admit. According to Donna Walker Titleston (p. 20) "Once information enters the working memory, we have about 15 seconds while the brain decides to process the information or to discard it -about 98% of the information is discarded at this point." Although this is a short amount of time and much information is discarded, it makes a lot of sense if we consider the large amounts of information that we are exposed to on regular basis. This makes me wonder, after so much elimination of information, how is it that we still manage to get information to be part of our long-term memory?

Moving to long-term memory terrains, Baddeley *et al.* following Squire (1992) explain that long-term memory is divided into different components, each of which has specific functions and provides support for the different tasks we normally perform. The first division is drawn between explicit memory and implicit memory. These concepts are in turn subdivided; explicit memory can be called episodic memory if it refers to recollection of specific events that have taken place in our lives; or semantic memory if it refers to our general knowledge of the world which often "involves conscious recollection of the past" and also can be organized into complex hierachical networks (Baddeley *et al.*, 2009, p. 134). For Tileston (2004, p. 38-39), on the other hand, episodic memory is based mainly on context and location, and this context is what allows information to be remembered in an unlimited way. Tileston also affirms that, "the episodic memory system requires little intrinsic motivation to store information for years -forever, if it is rehearsed periodically." Moreover, according to her, semantic memory, on the other hand, "is the memory system most often used in education" (p. 34), and it is a system where information is "limitied by chunks (7-10 per adult)" (p. 38). Furthermore, following Baddeley *et al.,* implict memory, on the other hand, refers to "situations in which some form of learning has occurred, but which is reflected in performance…" (p. 10). I strongly believe that all of these forms of memory contribute in different ways, to our learning in general and to our learning of languages in particular.

There are multiple language learning situations, involving vocabulary and language structures, where a learner can trace back to facts or environmental cues that contributed to the learning of that particular form. It may be one particular language classroom or professor (episodic memory); how that language form or its use is related to something they already know about the language (semantic memory); or how a particular learner can use a form without planning while holding a conversation in the target language (implicit knowledge). I am sure language learners can think of personal situations that would fit the above descriptions.

Going back to the concept of semantic memory, throughout history many researchers have proposed different ways of explaining how semantic memory is organized. Given that we can, very quickly, provide answers to different questions involving information said to be stored in the semantic memory, Baddeley et al. claim that this is an indication of how highly organized information is stored in memory. Baddeley et al.'s claim is based on spreading activation semantic network theory (Collins and Loftus, 1975). According to this theory, "whenever a person sees, hears, or thinks about a concept, the appropriate node in semantic memory is activated. This activation then spreads most strongly to other concepts that are closely related semantically…" (p. 120). We can infer from this idea that the more nodes there are carrying information about one particular concept, the more nodes are going to get activivated when a concept is required, resulting in higher possibilities of retrieving and using the information we have stored in relation to the given concept. Wouldn't this hint at the idea that the more chances students have to study a given structure, the more nodes of information could be created and thus the posibilities they would have of accessing information about that given form would be greater?

Along these same lines, importance is given to the proper distribution of rehearsal through time so that concepts become strong enough to be recalled easily. In a study carried out at the University of Western Australia by Lewandowsky, Wright and Brown (2007, p. 139-141), where participants were presented information in increasing and decreasing fashion both in quiet conditions and in conditions where articulatory supression (repetitive vocalization of words while studying) was present, findings point to the importance of the role of time. In this study, they found that "items that were widely separated in time were remembered better than items that were temporally crowded" (p. 141). This idea will be developed in length below. This study suggests that different links exist between node structures within semantic memory, rehearsal and time. Following these findings it seems logical that information widely spread in time may offer the chance, through rehearsal, of creating and subsequently activitaing nodes and traces that allow appropriate retrieval of information.

In this same vein, Hermann *et al.* (2002) refer to the importance of a large number of psychological modes that interact with memory in learning and remembering. They classify these modes in different categories, one of them being individual differences. In this mode they talk about memory expertise, and they point to the fact that "many people develop special memory expertise due to repeated experiences with a certain memory task…" (p. 21). These authors have also devoted a lot of time to the investigation of what they define as "mental manipulations". These are strategies which people may resort to when they want to retrieve information, and which depend on paying enough attention to "informational clues." For these information cues to function properly; the authors refer to the activation of traces (referred to above as nodes). For these authors "[o]nce traces are sufficiently activated, this activation spreads and converges on the desired trace, causing it to emerge from long-term memory into consciousness"(p. 86). One of these mental manipulations, which is of interest to us in this section is part of the category of learning manipulations and is called *strength manipulation*. For the authors, one way to exert *strength manipulation* is through rehearsal, which is helpful in registering information through attributes and associations with secondary traces and which at the same time strengthens traces so that we can access information more effectively.

To finish this account on memory and its relation to learning, at this point, one last concept will be introduced; that is the concept of priming, which is associated with taking advantage of prior experience. According to Baddeley *et al.*, priming is a "process whereby presentation of an item influences the processing of a subsequent item, either making it easier to process (positive priming) or more difficult (negative priming)"[2] (p. 12). Therefore, priming is said "to occur if presenting an item influences its subsequent perception and processing" (81). Multiple studies discussed by the authors (among them Ebbinghaus (1880s), Baddeley & Longman (1978), Schacter (1992), Pashler *et al.* (2007)) show that participants in these studies exhibited a clear advantage for remembering words, pictures and other information if they had been exposed to this information more than once. This idea supports the claim of the importance of repetition and more importantly spaced repetition in learning. I am sure this does not come as a surprise to most. Just from life experiences, we are aware of the fact that being exposed to something several times (i.e. a grammatical structure) contributes to it becoming more familiar to us. In other words, we understand the features of it better and often feel more conformable with its form and general use. This is a fact that is encountered in all aspects of our life; professional soccer or basketball players do not stop practicing just because they practiced three or six months before. If they want to be really successful at what they do, they make sure that even if they have been exposed to the common elements of their discipline once (courts, balls, goal, tactics, specific moves, etc.) and are completely able to recognize their uses, they still continue to practice. They train so that when the time comes, they will succeed at what they do. In between their trials or practices, they rest, giving their muscles a chance to recover and maybe they even mentally study what they did. They may even think of different ways of doing it, that is, mentally preparing for the next time they have a chance to prove what they can do.

This sports analogy is a useful way to conceptualize learning grammar. For instance, if students begin studying perfect tenses, they start by learning the structure of the sentences containing these verb forms; they study the forms of the auxiliaries and past partciples and the different uses of the perfect tenses. They study theory and practice using these verb forms communicatively for a couple of weeks and then move on to the next topic. Given all the necessary information, the space for practice and feedback, and the time needed to process this information, students are going to retain some (not all) of the information related to perfect tenses in their long-term memory. As a regular class continues, students are going to study other grammar topics while having repeated chances to encounter information that may lead them to think of the present perfect information they have been exposed to. Then, after some time, let's say in the next level of their major, students can go back to the topic of perfect tenses again and then have the possibility of activating the traces they created the first time, as mentioned above in the literature. While they study the topic once again, not only will they be able to activate the traces they already have, they will also be able to strengthen these already existing traces, and they will have the chance to create new traces related to this information which will eventually ensure information storage in their long-term memory and the eventual simplicafication in the retrieval of this knowledge.

Spaced Learning and Memory

The existing body of literature on the importance of spaced learning and memory studies overwhelmingly refers to Hermann Ebbinghaus (1885) as the first psychologist to put forward experimental evidence on the benefits of spaced learning for memory retention. He said: "A poem is learned by heart and then not again repeated. We will suppose that after a half year it has been forgotten: no effort of recollection is able to call it back again into consciousness" (Ebbinghaus 1850-1909). After his contributions, many different studies have addressed the topic and the bulk of them point to the different benefits that are obtained from distributed practice. However, most students and professors do not yet use spaced learning for the purposes of long-term retention. Toppino *et al.* (2009) found that we tend to mass our study when we feel we have not encoded something properly (we feel that we have not learned it), and we tend to space our study if we have the feeling that we have encoded this information correctly. There is a plethora of studies that show how wrong we are by following the metacognitive practice described above. Although it may serve us to pass a test, it does not serve long-term learning purposes. In the subsequent paragraphs some of these studies are described. The selection of studies presented below shows, from various perspectives, some of the different advantages of spaced learning. Through the implementation of diverse experiments, these researchers show the effects that spaced learning has on the brain, particularly in terms of retention of information (both in length and quality) and on the effects that existing information plays following a process of rehearsal (where this information is strengthened) and subsequent retrieval of this information from long-term memory. All of the investigations are relevant to the context of a language classroom in second language acquisition. Only a selected set of research is reviewed here, but the preponderance of research on the topic shows that spaced learning usually results in better memory retention.

In the first study, Xue *et al.*, (2011) deal with the idea that spaced learning improves recognition memory by means of the reduction of neural repetition suppression, which is a reduction of neural response that is often observed when information is encountered more than once and which is usually related to better memory performance. The spaced effect, referred to in the literature also as spaced learning or distributed practice is related to "the fact that memory is better for items whose repetitions are interleaved (i.e., spaced learning [SL]) than those whose repetitions are massed (i.e, repetitions are adjacent in time massed learning [ML])." (p. 1624). In their study, the authors scanned participants while they were intentionally memorizing a set of words. Half of the participants did so through massing the information, and the other half participated of spaced learning practice. At the end of the study, the participants who practiced spaced learning were able to recognize more items than the participants working under massed learning. The researchers found that "SL (spaced learning) reduced RS (repetition supression) in the brain regions that were responsible for memory encoding, which in turn led to increased activation and better SM (subsequent memory)" (p. 1628).

They also determined in this study that there was a relation between remembering and reduced repetition supression during the learning period, while spaced learning also reduced repetition priming and improved the ability of memory recognition. That is, spaced learning promotes the reduction of neural response characteristic of encountering known information and enhances participants' abilities to recall. This in turn led the authors to propose that there is a connection between neural repetition suppresion and episodic memory. As a consequence of this, it may be understood that the opposite also applies; if the encoding of information into memory is weak or deficient, then long memory recognition is not going to take place. Imagine the risk our students take when being exposed to a linguistic form only once. If they missed that one chance of appropriately encoding information in the brain; that means that they are completely missing the chance of learning and recalling all together.

Another finding of this study is that "the same bilateral fusiform region is involved in repetition priming and explicit memory encoding" (2011, p. 1631). This is fundamentally important in a classroom because it points to the fact that through priming, that is, through enabling students process an item with help from a previously presented item; students encode this information into their memory. In sum, the study proves that spaced learning has a direct consequence on memory; both in recognition and maintance; and that this is achieved through repetition suppression, the neural response observed when information is encountered several times. This serves as an indication of the fact that the spacing effect is a facilitator between neural repetition suppression and explicit memory, that part of long term memory containing both the episodic and semantic memory described at the beginning of this paper, where we want information to be stored permanently for subsequent retrieval and use.

A second study, Sisti *et al*. (2007), claims that "[i]nformation that is spaced over time is better remembered than the same amount of information massed together" (p. 368). The researchers investigated the consequences of spaced learning in "the adult dentate gyrus of the hippocampal formation," which is a region of the brain that is an active part of learning and memory, where new neurons are in continuous generation. They found that a number of new cells survived over time when the type of learning used was spaced. Their experiment involved rats that had to get out of a tank of water maze by finding a platform to do so. In their experiment they found that not only did the rats that had participated in spaced training remember the location of the platform for a longer span of time than the ones trained with massed practice; but they also found that in the second group the memory of animals "gradually decays" while the memory in the first group of animals (the ones under spaced conditions) remained some time after the experiment is over.

The information in this study confirms the findings of the first study. Sisti et al. however, contribute another piece of key information for the purposes of this paper. They show that not only spacing, but also learning has a direct effect on the number of neurons that survive in the dentate gyrus as evidenced by the association between how strongly memory is maintained and the number of neurons that are present in the dentate gyrus. Moreover, they found that "learning is a critical factor; animals that were trained but did not learn did not posssess any more cells than animals that were not trained at all…and good learners retained more of the new cells after training than did poor learners … and good learners were predominantly from the group trained with spaced trials" (p. 371-372). They explain these findings from two perspectives: A quantitative perspective indicates that spaced trials would have an effect on more cells because the training period is longer; the qualitative explanation says that spaced learning affected the cells in a way that involves quality of "gene expression and protein synthesis" resulting in high quality cells during the learning experience. According to the authors, these explanations support the fact that subjects in spaced conditions learned well and also remembered information better as well as longer than the other subjects.

This study can be interpreted as having important implications for the classroom context, given that if students do not learn the first time they are exposed to the linguistic forms, not only will they be unable to remember after some time, they will not be able to remember at all even after a short time; nor would they be able to rescue some of the cells in that hippocampal region. The authors conclude by providing a series of reasons why distributed learning is better than massed learning. First, the extention in time provides more opportunities for the individual to rehearse. This in turn results in a stronger memory that contains more traces to the original memory, facilitating the retrival of information from memory. Second, the distribution of events in time allows for the possibility of more and different contexts, resulting again in different traces that produce a stable memory with information that could be retrieved over longer and longer periods of time. They conclude saying that "training with spaced trials induces a more persistent memory and the strength of that memory relates to the number of new cells that survive in the adult hippocampus" (p. 373).

In the third study selected, Karpicke & Bauernschmidt (2011) investigated the role of information retrieval in relation to different time schedules to see whether some schedules were more beneficial than others in terms of learning. They defined spaced retrieval as "gradually expanding the interval between tests" (p. 1250). They compared the different effects that different schedules had; they studied the success of initial tests and also set out to find if expanding schedules would result in patterns of difficulty that would eventually lead to long-term retention. They define *absolute spacing* as the complete number of trials that take place between all tests once a given study concludes; and *relative spacing* as how the tests that are repeated during the process are distributed in relation to one another. In their experiment they divided subjects into four groups: short spacing, medium spacing, long spacing and no spacing as a control group. These groups had the task of learning a set of words in Swahili. They determined that subjects under massed condition had no advantage in recalling items; however, when spacing was introduced between the tests there was clearly greater retention. Comparing all the different retrieval conditions they found that "[a]ll spaced retrieval conditions produced greater retention than the massed condition….", and found that "[i]ncreasing the absolute spacing of repeated retrievals enhanced long-term retention" (p. 1254). They established that after an item was recalled for the first time, there was a reduction in terms of the time it required for the subjects to recall this item in subsequent attempts, thus indicating that retrieval became less difficult with each attempt, even when there were long intervals of time among attempts, strongly suggesting a connection between the level of difficulty retrieval and retention in memory.

This view suggests that the more effort learners made to recall information, the stronger the information is going to be established in long-term memory. Karpicke & Bauernschmidt also concluded that while *relative spacing* did not play a role, *absolute spacing* did, for "[t]he results confirmed that increasing the absolute spacing of repeated tests enhances long term retention. Repeated retrieval with long intervals between each test produced a 200% improvement in final recall relative to repeated retrieval with three massed tests. However, whether repeated tests occurred in expanding, equally spaced or contracting schedules did not produce any measurable impact on long-term retention" (p. 1255). In general, the study shows once again that spaced retrieval has a very strong effect on long-term retention; the subjects that participated in the massed practice exhibited the same features as the ones who had been exposed to the information only once. On the other hand, retention proved to be present in the subjects under spaced conditions at the end of the study regardless of the distributions of tests in relation to one another during the same period. This shows that "increasing the absolute spacing of retrieval attempts has clear value for learning, but how tests are spaced relative to one another may not be critical" (p. 1256). Again these findings provide key information for classroom settings. Setting tests apart or together in relation to each other inside the continuum of learning one topic is not going to make a difference; the real difference is exerted by the absolute (complete) duration of the study of this topic in time, let's say throughout the duration of a major, for instance.

The next three studies deal with metacognition. Bahrick and Hall (2005) studied the spacing effect in what they called a naturalistic learning context in relation to long-term access to knowledge. Their discussion deals with metacognitive monitoring of encoding strategies and how these provide clear benefits to long-term retention in contexts of widely spaced practice. They found that the extent of efficacy of the strategies that individuals use to encode information varies; some may last minutes while others may extend for weeks or months. Learners realize whether that strategy serves or not, only by using it, and in some cases by failing to retrieve the information they need. The authors emphasize, however, that this strategy needs to be tested allowing enough time to really ensure that it works; if enough time is not alotted, the learner may think that the strategy really works, although it may not work in a long-term context (p. 568). This is why, in their study, they used from 0 to 30 day intervals of training in order to determine which interval proved to be more beneficial. After each training session, students could indicate which strategy had worked and which one had not, and then were given a chance to modify the strategy.

One main finding in this study is that the repeated implementation of this metacongnitive practice, monitoring and control functions proved advantageous for the retention of content that was acquired by the subjects under broadly distributed practices (p. 569). For learners under the spaced condition, the results in the first tests were not always good; students in the spaced condition would forget more frequently during the earlier distributed sessions than students under more reduced spreading. The latter did better in the first tests (closer to their study sessions) but their performace progressively declined the farther apart the session was from the test. On the other hand, the long-term results provide much better outcomes for the learners under spaced conditions; these learners exhibited better acquisition at the end of the complete process. The authors determined that "[t]he widely spaced training intervals slowed acquisition but enhanced long-term retention" (p. 570). They attribute these results to both the number of exposures and tests students encountered along the way, as well as to the adjustment of strategies students implemented after realizing that a previous metacognitive strategy may not have worked. The fact that students may have failed several times during the retrieval of information in long-spaced intervals is seen as positive because it allowed them to have new feedback and new opportunities to encode the forms adequately, in succeeding study sessions, which interestingly also became progressively shorter over time (p. 574). For the authors, it is key that learners are given the chance to adjust the time of study or their metacognitive strategies after receiving feedback; they claim that this can only be achieved if several repetitions are present. As mentioned above, the authors insist that the exposures to information must be "spaced sufficiently to yield differential failure probabilities as a function of target difficulty…educators will need…to know how best to balance the cost of lengthened training with the benefits of extending long-term maintanance of knowledge" (p. 576). Educators again are given the task of thinking in terms of long-term memory; otherwise, students are going to end up with practices that do not contribute to learning, particularly in the case of second language acquisition settings.

In her paper "Metacognitive Control and the Spacing Effect", Lisa K. Son (2010) describes metacognitive control as "the process of using one's own judgements to guide behavior" (p. 256). The subjects in her study, a group of children and a group of adults, applied what is called judgements of learning where they had to decide to either mass or space their study as a reflection of their own metacognitive decisions. In some cases, the decisions made by the learners were honored; in other cases, the computer program provided a strategy opposite to the one the learners requested (spacing when massing was requested and vice-versa). Interestingly, she found that the spacing effect was observed when the decisions made by the learners were honored, but not if these were disrespected. She concludes that, if the learner has not requested a spacing strategy, professors should be cautious about imposing it on students, even when there is plentiful evidence that shows that a specific strategy is the right one to follow and that it would bring benefits in the long run. The spacing effect disappeared in the adult group when their decisions were not honored but this did not happen in the children's group; children did benefit significantly when spacing was forced onto them. She concludes that the spacing effect is upheld in both children and adults when their metacognitive decisions are honored; it tends to diminish for adults in the cases were decisions were dishonored (p. 260). Both of the groups remembered the spaced information more than the massed information when their metacognitive decisions were respected. This of course represents a challenge in the classroom where we need to provide the right amount of practice for learners that may choose different metacognitive strategies. As the author states, "metacognitive control is driven by a personal mechanism and may be invaluable for optimizing one's learning" (p. 261). We as educators are, once more, given the mission of providing a context that serves all.

Along this same line of study of metacognition, Logan *et al.* (2012) analyzed the relationship between repetition, feedback after practice and instructions about judgments of learning for distributed and massed metacognitive practices. The subjects of their four experiments were asked to provide judgments of learning after they participated in each of the study sessions. The researchers found that after the first experiment, even though the massed and spaced strategies averaged similarly, judgments of learning favored the massed strategies. That is, learners attributed success to massed strategies when actually spaced strategies had been used. They found that although participants recalled more items that were learned through the spaced practice, their judgments of learning failed to acknowledge the use of this strategy correctly. The researchers attributed these results to a possible lack of feedback regarding how beneficial the practice really is for learning. The second and third experiments showed similar results despite the fact that participants were given direct feedback. There actually was an improvement in judgments of learning that identified spacing as the metacognitive practice, but the learners still undervalued the recall for spaced items. For these researchers, it is important to recognize that there was some effect in the judgments of learning, which may indicate that it is important to create an awareness of the benefits that spaced learning can have. In their fourth experiment, the researchers provided not only feedback, but also direct instruction on the benefits of spacing practices. This resulted in a noticeable improvement of spaced strategy identification for recall, yet not to the degree that these practices were implemented.

Despite the different adjustments throughout the experiments and an increment in the ability to differentiate between the spaced and massed practice, the participants continued to fail to acknowledge the recall of spaced items while massed practice identification tended to be more accurate. The authors think this may be associated with the fact that learners value fluency or ease of processing over time. Learners have the feeling that they have stronger access to information learned through massed practice and a weaker access to information learned through spaced practice and thus, they favor to acknowledge the use of massed practices more consistently. The researchers suggest that learners may prefer massed learning identification of strategies because based on their previous experiences of preparation for tests those are the type of strategies that they have used, and they think have worked for them before. These learners have crammed for tests and gotten good results on these tests, so they think massing information works as a helpful strategy. Of course, in this case, they are not considering the implications that the strategy has for long-term memory and learning. It is important for educators to enable learners to "discover and understand how spacing can enhance both memory performance and long-term learning in self-regulated learning environments" (p. 193). If long-term retention is what we pursue, this practice must become imperative; given that students fail to recognize the benefits of spacing, even when they use it, educators must ensure that the practice is implemented and that its value is recognized.

The last study selected for review provides interesting input on dealing with semantic-feature variability in relation to the spacing effect, and may also have direct implications for the classroom setting. McFarland *et al.* state that "[a]nyone who regularly investigates human memory knows that repeated presentations of the same stimulus item induce greater retention, if they are separated at input rather than if they occur in immediate succession." They support this claim by explaining that spacing is better than massing information because it provides more ways to retrieve the information we have been exposed to. They found that the encoding of information depends on the external semantic context in which the word is encoded and on the cognitive context where the word appears. Along the same lines of all the other studies presented above, this study also found that recall of items that had been distributed over time was higher than recall of items presented only once. However, they claim that the spacing effect diminishes if the different presentations of information reflect various semantic contexts or if they represent the diverse functional contextual meanings for a given item. What this means is that encodings of distinct meanings for a single item (fax (verb) and fax (noun)) or of the corresponding functional meanings (a past participle functioning as an adjective or as part of a perfect verb) undergo different encoding processes and thus need to go through different spacing strategies to ensure long-term retention. They conclude saying that "collective encoding of the separate presentations becomes more elaborate due to the breadth of analysis involving a large number of activated semantic features" (p. 171). Once again, as in-class educators, we need to make time for the repeated presentation of elements so that the necessary repetition would cover for the diverse uses and their functions.

Implications in the classroom

In relation to second language acquisition in particular, a longitudinal study by Bird (2010) shows a direct, positive correlation between spaced practice and English-syntax second language learning. He found that learners were able to score better grades after applying spaced practice strategies while learning

English syntax. Also, his findings show that syntax learning stands for another area that could also benefit from this type of practice, reinforcing once again the idea discussed in this paper in terms of the importance of implementing spaced learning in our classrooms. This, once more, hints at the importance of this practice both for learning programs and syllabus design in general.

As mentioned throughout the paper, educators play an essential role in the implementation of spacing strategies in the classroom. Son (2007) found that even teachers are not aware of the benefits of spacing learning. I strongly believe that if an entire faculty would plan curriculums in terms of the best learning practices for students, as opposed to what is easiest for the instructors, spacing would be an integral element. Educators have to be aware of the risk of students not learning if they are exposed to contents only once. On the other hand, if students are presented information in a spaced manner, the time that it takes for subjects to remember is reduced every time they study the subject and learners have the chance of remembering the information better and for a longer period of time. Educators need to think of long-term results, and they have to create awareness in students so that students themselves select and use spacing strategies. This is all possible if both students and educators work together to achieve the same goal; that is, acquiring information for the long run.

The ideas above are reinforced by the spacing suggestions that Son & Simon (2012) outline in their article. First, educators may observe the possibility of implementing review sessions. I think this can be done both throughout the period of a course and the program. The authors mention that these sessions may or may not be followed by tests that could be checked but not necessarily graded. Second, they suggest the use of contextual variability. For them this could be achieved in different ways; one is by inviting people to teach or talk about a given topic in our classroom and the other by changing physical settings. Given that professors (and people in general) oftentimes have different perspectives on one same topic, this would likely result in different contexts as well. Third, Son & Simon acknowledge the issue of time and say that "[i]ndeed, many classroom topics are presented only once, and unfortunately, the same is often the case for textbooks…" (p. 393). Considering the issue of classroom time and the amount of content that needs to be covered, they suggest that educators should motivate learners to space their study so that learners can obtain the most benefits possible out of this practice. The fourth recommendation is for educators to instill in students the importance of spacing outside the classroom. I believe that if the educators raise students' awareness, this objective may be achieved using their creativity and interest. This is possible since, as educators, we can motivate students to be part of grammar, conversation or reading clubs. The fifth suggestion is overtly to make students conscious of the control that they can exert over the metacognitive practices they choose and the different results these have. This can be done by the use of explicit self-regulatory strategies such as setting up a spaced practice schedule. Finally, they suggest that one technique that may be implemented by learners is the strategy of summarization. It should take place after a certain period of time has elapsed in reference to the last study session.

For me, all the above possibilities offer the advantage of students revisiting material and receiving feedback. This would in turn give them time to modify metacognitive strategies if neccesary and would eventually result in long-term retention of information and knowledge. All of the above strategies can be easily implemented and are completely realistic for use in second language acquisition.

Conclusion

The evidence presented speaks for itself. Additionally, the preponderance of research in this area reinforces the key point, which is that spaced practice enhances long-term memory retention. The benefits are numerous: (1) spaced learning has a direct effect on brain functioning by improving memory performance while reducing neural repetition supression and by allowing cells to survive in the adult dentate gyrus of the hippocampus; (2) it enhances the ability to recall (through activation of episodic memory) by showing better item recognition and longer maintainance of information in memory; (3) it allows more opportunity for rehearsal which facilitates the strengthening and creation of nodes or traces which in turn favor retrieval of information; and (4) it promotes acquisition if the learners are given adequate practice, feedback and opportunity to implement personal metacognitive practices. Beneficial outcomes occur if the practice is distributed appropiately and if the entire continuum of the process is evaluated. Both students and professors must find a way to give spacing practices the privileged position they must have.

If we utilize this knowledge of spacing in the students' learning environment, both inside and outside the classroom, we could have students taking advantage of review sessions under professors' supervision or in less supervised environments. This would give students the opportunity to become fully aware of their responsibility in their own learning process and in making the best choices concerning metacognitive strategies.

To capitalize on what this research review has shown us about spacing requires faculty and students to commit to changing how they approach the learning process. Both must proactively incorporate spacing: faculty into the design and implementation of courses and curriculum, and students into their study habits and choice of metacognitve practices. A concerted effort is likely to bring rewards and satisfaction to all involved.

Notes

1. For an interesting reference on evidence on the effectiveness of spacing, through repeated exposure resulting in better information retention see Enikö A Kramar et al. "Synaptic evidence for the efficacy of spaced learning." Proceedings for the National Academy of Sciences of the United States of America, March 2012. Published March 12, 2012. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3323981/

2. According to the literature the idea of difficulty being more commonly present in cases involving amnesic patients.

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