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Spacing Effects in Real-World Classroom Vocabulary Learning

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Summary: As a primary goal, educators often strive to maximize the amount of information pupils remember. In the lab, psychologists have found efficient memory strategies for retaining school-related materials. One such strategy is the spacing effect, a memory advantage that occurs when learning is distributed across time instead of crammed into a single study session. Spaced learning is not often explicitly utilized in actual classrooms, perhaps due to a paucity of research in applied settings and with school-aged children. The current study examined the spacing effect in real-world fifth-grade classrooms. We taught 39 children unfamiliar English words using both massed and spaced learning. Five weeks later, we tested vocabulary recall. One-week spacing produced superior long-term retention compared to massed learning. This finding demonstrates that the spacing effect can be generalized to vocabulary learning in applied settings and middle-school-aged children. Copyright © 2010 John Wiley & Sons, Ltd.

The spacing effect (distributed practice effect; lag effect) refers to a memory advantage that occurs when people learn material on several separate occasions, instead of a single massed study episode. Numerous studies have demonstrated spacing benefits for long-term retention of verbal information, including vocabulary learning (e.g. Bloom & Shuell, 1981), memorizing facts (e.g. DeRemer & D'Agostino, 1974) and word list learning (e.g. Zechmeister & Shaughnessy, 1980). Spacing effect benefits in verbal learning are ubiquitous and well documented (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006) in an adult population.

Despite decades of laboratory research on the spacing effect and its clear relevance to educational contexts, the majority of spacing effect research has been conducted using undergraduate students, possibly out of convenience. There have been only a small number of studies testing children (Cepeda et al., 2006), which leaves open the possibility that due to changes in working memory, attention and other cognitive developmental factors, spacing effect benefits operate differently in child and adult populations. In order to generalize to grade school populations, it is imperative that additional studies are conducted with children, particularly those in elementary- and middle-school grades.

Within the existing literature on the spacing effect and children, only a few studies have examined word learning. In one example (Childers & Tomasello, 2002), 2.5-year-old children were taught novel words in either spaced or massed conditions. Children produced words more readily if they heard them once per day for 4 days rather than eight times in a single day, when tested 1 minute, 1 day or 1 week later. In another study (Vlach, Sandhofer, & Kornell, 2008), 3-year-old children were presented with a memory task in which they learned the names of new toys. A new toy was presented either in a massed condition (once for 30 seconds) or in a spaced condition (three times for 10 seconds, with 30 second gaps between the presentations). The results showed a significant advantage for spaced learning.

In studies with older children (fifth and eighth graders: Cuvo, 1975; third and sixth graders: Toppino & DeMesquita, 1984; fourth and eighth graders: Wilson, 1976), word lists were used outside of a meaningful, real-world context. While use of abstract contexts is common in the spacing literature (Moss, 1995), this usage hardly can be considered educationally relevant. Additionally, most of the above studies used very short study interval gaps (e.g. 30 seconds: Vlach, Sandhofer & Kornell, 2008) or simply varied the number of intervening items in a word list (Cuvo, 1975; Toppino & DeMesquita, 1984; Wilson, 1976). In actual educational settings, there are likely to be much longer gaps of time between learning presentations, making it difficult to connect real-world educational practice with the existing literature.

While vocabulary learning has been a subject of previous spacing studies (e.g. Bahrick & Phelps, 1987; Dempster, 1987), we have located only a single study that examined spacing effects for vocabulary learning in a real-world educational context. Bloom and Shuell (1981) conducted a study as a part of regular, ongoing classroom activities with high school students enrolled in a French course. The class was divided into two groups who learned 20 French vocabulary words for 30 minutes. The spaced group studied for 10 minutes on each of three consecutive days, while the massed group studied the words once for 30 minutes. Learning of vocabulary words through spacing resulted in 35% higher recall 4 days later. Notably, no one has examined real-world vocabulary learning in middle-school children, which is a question we examine in the current study.

More broadly, few spacing effect studies have been conducted in actual K-12 classrooms. Moss (1995) found that out of 120 reviewed studies, only three were conducted in actual K-12 classrooms. Since then, only a few more studies have been added to this literature (e.g. Carpenter, Pashler, & Cepeda, 2009; Seabrook, Brown, & Solity, 2005). One study (Seabrook et al., 2005) examined phonics learning in first-grade children. Items were taught either 2 minute per day for three consecutive days, or in a single 6-minute session. Two weeks later, the spaced-

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learning group showed better knowledge of letter sounds and better reading ability. Another study (Fishman, Keller, & Atkinson, 1968) implemented spacing in a fifth-grade classroom using computerized spelling drills. Children learned sets of words either through spaced (two sets of words, presented three times, once every other day) or massed (six sets of words, one set learned each day, each set presented three times) study. Recall was tested 10 and 20 days after the final learning session, and performance was higher in the spaced study condition. Though conducted in a school, this study took place in a computer laboratory where children performed the task at computer terminals, making it similar to a laboratory study. As long as research remains laboratory based, there is not enough information available to support the widespread use of the spacing effect in real-world classrooms (Dempster, 1988).

The current study adds to the small literature on whether the spacing effect generalizes to real-world classrooms, middle-school children and vocabulary learning, using educationally relevant learning episode gaps and retention intervals. Children learned GRE vocabulary words, taught by the regular classroom teacher in a manner that matches typical classroom instructional technique. Definition recall was assessed 5 weeks after the final learning episode. We predict that a 1-week interval between learning episodes will improve recall 5 weeks later, as compared to a single massed learning episode.

METHOD

Participants

Forty-six participants ($M \approx 10$-years-old; 19 female) were recruited from two fifth-grade classrooms in an upper-middle SES Ontario middle school. Data from seven participants were dropped because of failure to complete all sessions due to missing class during one or more sessions, resulting in a final sample size of 39 participants.

Materials

Eight English words, judged by the experimenters to be new to fifth-grade children, were selected from the GRE word list (i.e. accolade, coerce, edict, gregarious, latent, salient, tacit and vex). According to WordCount.org (Harris, 2003), all words fell outside of the most frequently used 9000 words in spoken and written English. Four words (two adjectives, one noun and one verb) were randomly assigned to each study condition (massed and 1-week); this word assignment was the same for all children. All vocabulary words were presented to children in a workbook consisting of three pages (Appendix A). The first page listed four vocabulary words to be learned; the second page showed the actual definitions of the words; the third page had a space for children to write down the definition of the word and to use the word in a sentence. In addition to the booklets, teachers were given a set of overheads that contained these same words and definitions as well as rules for the exercise.

Design

Within each class, all children participated in both massed and spaced conditions. The massed condition consisted of two consecutive learning sessions separated by less than 1 minute, and the 1-week condition consisted of two learning sessions separated by 7 days.

Procedure

Each entire learning episode consisted of five steps that took in total approximately 15 minutes to complete (including distribution/collection of materials, children writing their names, etc.). Formal learning time was 10 minutes, and was the same for both experimental conditions. In Step 1, the booklets were handed out to children, and all four words, their definitions and sample use in a sentence were shown to children using an overhead projector. Children were instructed to read the overhead along with the teacher, who read out the definitions and sample sentences once. The overhead was then removed. In Step 2, the children were given 3 minutes to complete the first page of the booklet (containing vocabulary words only) by writing down the definitions for all four words. In step 3, children were instructed to turn to page two of the booklet (containing the correct definitions of each word). Definitions and use in a sample sentence were repeated by the teacher. Then, children were given 1 min to read over the definitions by themselves. In Step 4, children were given 3 minutes to complete the last page of the booklet, by writing down the definition of each word in the provided space and writing down a novel sentence using each word. Then, the teacher collected the booklets. Because different words were used for each experimental condition, the data from Step 4 of the first learning episode were used to ensure that word difficulty was equal across conditions. During the learning session, the teacher circulated the classroom to ensure that children remained on task and followed instructions.

The second learning session took place according to the spacing schedule: either massed, 1 minute after the first learning session; or spaced, 1 week after the first learning session. During the second learning session, children were re-taught the same words, using the same method as during the first learning session.

After a retention interval of 5 weeks following the second learning session, children were given a vocabulary test to assess their retention. Children were given a list of four words, and were responsible for writing down the definition of each word. Children were given 10 minutes to complete this task. Each child participated in two final test sessions (four words each), so that retention interval remained constant across massed and spaced conditions.

RESULTS AND DISCUSSION

We assessed the effects of differently spaced-learning sessions (massed; spaced by 1 week) on definition recall after a 5-week retention interval. To ensure that vocabulary words in each condition were equally difficult, we analysed performance for massed and spaced items from the first learning session (i.e. Step 4 in the Procedure). Words in each

experimental condition were equally difficult (massed: $M_{correct} = 61.8\%$; spaced: $M_{correct} = 61.1\%$), $t(38) = 1.10$, $p > .05$. We also found that the two classrooms performed at similar overall levels on the first test ($t < 1$); therefore, data were collapsed across classrooms. Definitions were considered correct if the semantic meaning matched the one given during the learning sessions.

A paired sample *t*-test revealed that the percentage of definitions recalled in the spaced condition ($M = 20.8$, SEM = 4.3) was 177% higher than in the massed condition ($M = 7.5$, SEM = 2.0), $t(38) = 3.0$, $p = .004$, $d = 0.48$ (Figure 1). In the spaced condition, children recalled almost three times as many definitions as they did in the massed condition.

Re-learning the same material after a 7-day gap resulted in superior performance compared to massed review, as shown by a final test 5 weeks after the last learning episode. These findings extend existing classroom research and suggest that the spacing effect generalizes to real-world classroom settings and middle-school children. Merely reorganizing the structure of classroom lessons, without increasing overall time spent on teaching, is sufficient to improve student performance on a later vocabulary-learning test.

The current findings are in line with some of the most prominent spacing theories (for review, see Verkoeijen, 2005). For example, the current findings potentially could be explained by the encoding (or contextual) variability hypothesis (Glenberg, 1979). The encoding variability hypothesis states that an item is usually encoded in memory along with a particular context (e.g. the teacher's intonation when reading out the definitions, background noise, events preceding a study episode, etc.). This context leaves a number of memory traces. The greater the number of memory traces, the greater is the number of retrieval routes for later recall. Therefore, since variation in context is more likely for the spaced presentations because they occur further apart in time, in this case a whole week apart, spaced learning results in higher recall.

The present study also addresses one major reason why teachers might not wish to implement the spacing effect, namely, the failure of psychologists to demonstrate that the spacing effect benefits retention in real-world classrooms (Dempster, 1988). Moreover, this experiment demonstrates one practical technique teachers can use to improve children's retention. Our previous research (Cepeda, Coburn, Rohrer, Wixted, Mozer, & Pashler, 2009; Cepeda, Vul, Rohrer, Wixted, & Pashler, 2008) demonstrated that spacing can double or triple long-term retention in laboratory and web learning contexts. The present study shows that similarly large spacing benefits can be achieved in a real-world classroom context.

In order for the spacing effect to be implemented successfully, it is of vital importance to have collaboration of researchers, teachers and administrative staff. Also, it would be helpful to teach these skills at the commencement of a teacher's career, before routines have been established. Teacher candidates should be encouraged to apply spacing techniques while learning and practicing generating lesson plans (Dempster, 1990). While teachers are subjected to certain pressures to cover the curriculum, and relearning sessions might be difficult to implement, there are a number of ways that spacing can be introduced into the classroom. As suggestions, teachers might use classroom activities, such as quizzing on key concepts, several days after teaching these concepts, assigning and collecting homework, working in small groups to discuss concepts introduced in earlier lessons, writing reflections or summaries on key topics several days after initial learning and using cumulative tests and mini assessments to provide children with additional opportunities for spaced learning.

This study has demonstrated that spacing of vocabulary learning results in higher performance than massed learning, in middle-school children, using educationally relevant spacing intervals between learning episodes and an educationally meaningful retention interval. Future research should expand on these findings by looking at a wider range of item types, including complex material. For instance, it is unclear whether the spacing effect will apply to math and science material (but see Pashler, Rohrer, Cepeda, & Carpenter, 2007; Rohrer & Taylor, 2006). It is also imperative to look at a greater range of spacing gaps between learning sessions. Based on the results of this and other classroom studies (e.g. Carpenter et al., 2009), the spacing effect appears to be robust to the increased variability present in real-world classroom contexts.

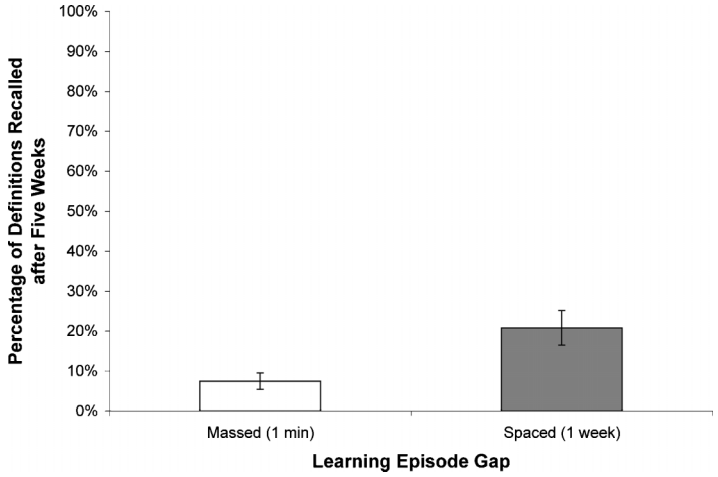

Figure 1. Percentage of definitions recalled at the final test session. Error bars represent one SEM

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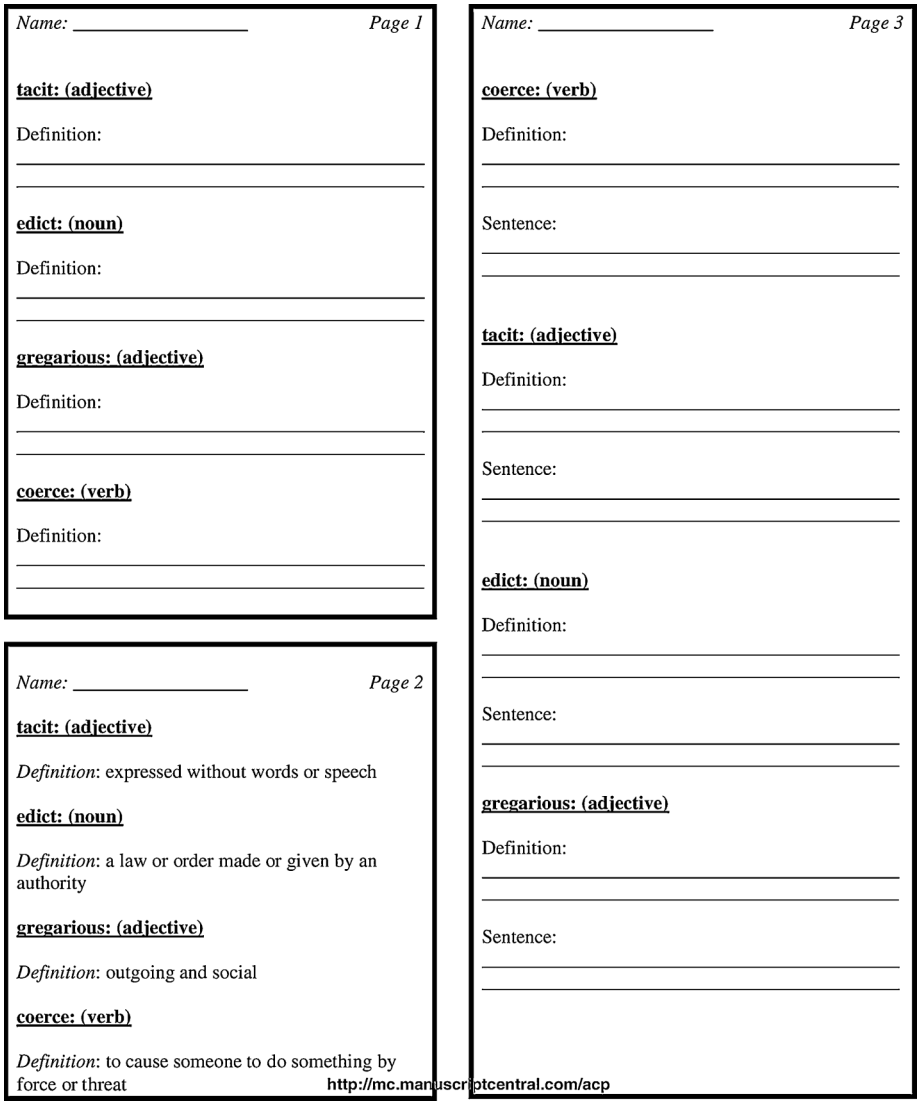
APPENDIX A: SAMPLE BOOKLET



Name: _____ *Page 1*

tacit: (adjective)

Definition:

edict: (noun)

Definition:

gregarious: (adjective)

Definition:

coerce: (verb)

Definition:

Name: _____ *Page 2*

tacit: (adjective)

Definition: expressed without words or speech

edict: (noun)

Definition: a law or order made or given by an authority

gregarious: (adjective)

Definition: outgoing and social

coerce: (verb)

Definition: to cause someone to do something by force or threat

Name: _____ *Page 3*

coerce: (verb)

Definition:

Sentence:

tacit: (adjective)

Definition:

Sentence:

edict: (noun)

Definition:

Sentence:

gregarious: (adjective)

Definition:

Sentence: