From the Lab to the Dorm Room:

Metacognitive Awareness and Use of Spaced Study

Abstract

Numerous laboratory studies have demonstrated the long-term memory benefits of studying material in multiple distributed sessions as opposed to one massed session, given an identical amount of overall study time (i.e., the *spacing effect*). The current study goes beyond the laboratory to investigate whether undergraduates know about the advantage of spaced study, to what extent they use it in their own studying, and what factors influence its utilization. Participants (n = 285) completed a web-based survey responding to questions about their study behaviors, metacognitive awareness of spacing, the factors that contribute to the distribution of their study time, and independent measures of metacognitive self-regulation and use of elaboration study strategies. Results indicate that participants are aware of the benefits of spaced study and use it more than massing when they study, but do not implement it frequently. Students also endorsed several factors as important in the decision to distribute their study time. Further, level of metacognitive self-regulation and use of elaboration techniques were associated with the tendency to space material. Additional research is needed to examine student study habits in a naturalistic setting, and to explore effective ways to encourage behavior change through motivational and teaching techniques.

Keywords: metacognition; spacing effect; study strategies

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Numerous laboratory studies have demonstrated that given a set amount of time, the distribution of learning over multiple sessions is superior to the massing of learning in a single session for the long-term retention of information (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). This is known as the *spacing effect*, and has a long history extending back to Ebbinghaus' discovery of it in his classic memory studies (Ebbinghaus, 1885). Conceptual explanations for the spacing effect include increased encoding and contextual variability that enhances the effectiveness of retrieval cues (Glenberg, 1979), and increased between-session forgetting that leads to a need for more effort in later sessions to learn or re-learn the material (e.g., Cuddy & Jacoby, 1982; Krug, Davis, & Glover, 1990).

Prior research has shown benefits of spacing for little known facts (Cepeda et al., 2006), word lists (e.g., Balch, 2006), inductive learning of artistic styles (Kornell & Bjork, 2008), and more complex types of information such as mathematical knowledge (Rohrer & Taylor, 2006), among others. Indeed, the spacing effect is one of the most robust psychological phenomena. More recently, it has been investigated through a metacognitive lens, and also in educational settings with a focus on students' retention of course material. Relevant to this applied focus, a recent meta-analysis suggested the spacing advantage is especially large over longer retention intervals (i.e., a week or more) (Cepeda et al., 2006), a timeline that is meaningful for learning and memory in undergraduate courses.

Metacognition and the Spacing Effect

Metacognition can be defined as the ability to know, monitor, and regulate what one knows (e.g., Halpern, 1998). It is associated with the broader literature on self-regulated learning, or self-regulated study, the goal of which is to effectively and strategically adapt to

different learning situations (Wolters, 2003). Prior research with undergraduate students has demonstrated high correlations between metacognitive ability and cognitive strategy use (e.g., Sperling, Howard, Staley, & DeBois, 2004).

With regard to spaced study, recent research has overall shown a lack of metacognitive awareness for the specific cognitive strategy. For example, participants experiencing the benefits of spacing incorrectly judge the effectiveness of their learning and, in a display of erroneous metacognition, rate massing as more useful (Kornell & Bjork, 2008; Kornell, 2009). Kornell and Bjork (2008) presented paintings by 12 different artists; depending on the condition, they were presented in either massed or spaced (interleaved) fashion, and participants were later tested on inductive learning of the artistic styles. Results from two experiments showed that, in support of the spacing effect, 85% of participants did as well or better in the spaced compared to the massed condition; however, 83% of participants rated the massed condition as being equally as or more effective than the spaced condition. A plausible theoretical explanation relevant to these results is that newly learned knowledge that seems fluent and easily accessible during a single (i.e., massed) session does not necessarily lead to successful retrieval at longer intervals; this has been conceptualized as one type of *metacognitive illusion* (e.g., Kornell & Bjork, 2008; Karpicke, Butler, & Roediger, 2009).

However, even when participants do not directly experience the massed and spaced conditions, and as such have no opportunity to be fooled by an illusion of fluency from massing, they are still unable to predict the benefit of spacing as it was implemented in the Kornell and Bjork (2008) study. McCabe (2011) found extremely low metacognitive awareness of the spacing (interleaving) advantage when participants simply read and made predictions about learning outcomes from the conditions described in Kornell and Bjork. These findings taken

together illustrate a metacognitive disconnect between what is actually effective (at least in laboratory studies) and what is perceived by participants to be best for learning.

Interestingly, laboratory studies that have given participants the option to either distribute or mass their learning have demonstrated that participants will choose to space material more than if it were left to chance (Son & Kornell, 2009), and more than they choose to mass it (Pyc & Dunlosky, 2010). Therefore, even if people believe that massing is better, some research suggests that in real-time behavior they will still practice spaced study. These inconsistencies in what people experience, believe, and actually do highlight the complex metacognitive picture involved in understanding the spacing effect.

Further, metacognition may play a role in determining when and under what conditions people choose to space or mass their study. One critical factor in this decision may be the ease or difficulty of the to-be-learned information. Studies investigating this factor have found discrepant results, possibly due to differences in paradigms. Son (2004) asked participants to make metacognitive judgments of learning about word-pairs that were viewed for 1 second, and then decide how (and whether) to study them in the future. Results showed that participants spaced more of the easy items and massed the more difficult ones. In contrast, a study by Benjamin and Bird (2006), in which the time frame for initial encoding was longer (5 seconds) and in which participants were required to space half of the items and mass the other half, found that easier items were massed and difficult items were spaced. Pyc and Dunlosky (2010) attempted to clarify this discrepancy by suggesting that non-metamemory causes, such as difficulty in perceiving the material in the Son (2004) study, could at least partly explain why participants allocated their study times differently in the two paradigms (also see Toppino, Cohen, Davis, & Moors, 2009). Thus, in typical circumstances, with longer presentation times,

spacing may be utilized more for difficult material (but see Son & Kornell, 2009, for evidence suggesting no relationship between item difficulty and spacing use). Aside from the difficulty variable, little research has investigated the other important factors that students may consider in their decision to space or mass when they are in control of their study time.

Survey Research on Study Behaviors

As related to education, the temporal spacing (or distribution) of learning sessions is one of several study techniques classified in the category of *desirable difficulties* (Bjork, 1994), which includes strategies that aid long-term retention but require a significant amount of effort on the part of the learner. Thus, the challenge facing educators is to support students' implementation of such effortful strategies for learning, based on the accumulating evidence that they enhance memory for course material. The first step, however, is to understand student behaviors and beliefs about how they study.

Although there is a large amount of laboratory research on the spacing effect, a more externally valid understanding can be gained only by investigating what students are actually doing when they study, and the extent to which they know about and use this type of desirable difficulty. Prior survey research on the most commonly reported real-world study behaviors has found that students prefer to reread their notes and textbook, rewrite their notes, and use flashcards when preparing for exams (Karpicke et al., 2009; Van Etten, Freebern, & Pressley, 1997). Laboratory research has shown, however, that behaviors such as rereading are not as effective as they seem for long-term memory (Callender & McDaniel, 2009), especially compared to such strategies as spacing (e.g., Rohrer & Pashler, 2007) and also testing (e.g., Roediger & Karpicke, 2006). With regard to the latter, a recent survey study by Karpicke et al.

(2009) showed that undergraduates are overall unaware of the memorial benefits of the desirable difficulty of practicing retrieval (i.e., the *testing effect*).

To our knowledge, a comparable survey study has not been conducted outside of the laboratory with regard to the spacing effect. One qualitative interview-based study examining students' test preparation behaviors found that students know that spreading out their studying is better than cramming, but do not always put this knowledge into practice (Van Etten et al., 1997). Factors involved in the decision to distribute or mass study sessions were not investigated. Given the lack of research on undergraduates' use and knowledge of the benefits of spaced study, the current study examined these issues using survey methodology.

The Current Study

The main goal of the current study was to move beyond the laboratory and explore undergraduates' knowledge and reported use of spacing when they study on their own time. As discussed above, laboratory research on spacing has shown its advantage over massing but has also demonstrated a lack of metacognitive awareness. Further in-depth investigation of this topic is important in order to understand students' behaviors and beliefs with regard to effective ways to study, as well as to contribute to the application of cognition research to real-world issues in higher education.

Our research examined four central questions: (1) Do students know about the spacing effect? (2) To what extent do they use spaced study while studying on their own time? (3) What are the critical factors in the decision to space or mass study? (4) Are there individual differences in metacognitive self-regulation and/or use of elaboration strategies that are correlated with knowledge and use of the spacing effect?

To address the first question, students reported their beliefs about what research has shown regarding the advantage of spaced versus massed study. We did not have a strong prediction about whether students would report metacognitive awareness of the spacing effect. To the extent that the advantage of spacing is a relatively intuitive or well-known learning strategy, as suggested by Van Etten et al. (1997), we may find strong endorsement of spacing. On the other hand, to the extent that our results might parallel the survey results of another desirable difficulty (i.e., testing) described above (Karpicke et al., 2009), awareness of the memory benefits of spacing may be quite low. This latter prediction would also be consistent with the metacognitive findings of Kornell and Bjork (2008). However, it is important to note that in the current study, as in McCabe (2011), participants did not directly experience the learning conditions, and as such could not base their responses on real-time mnemonic cues that may lead to metacognitive illusions associated with massing (e.g., Kornell & Bjork, 2008; Kornell, 2009). Our participants were instead forced to rely on the type of *extrinsic cues* discussed by Koriat (1997) in his cue-utilization framework for metacognitive judgments; specifically, judgments of learning in the current study were presumably based on participants' assessment of learning conditions presented in the survey questions, in the context of their own theories of learning.

To address the second question, and to situate the study behaviors of spacing and massing in the context of other common learning strategies, the survey included rating scales for the frequency of use of a variety of study behaviors. In an attempt to elicit further information about spacing-related behaviors, we also inquired about how students would distribute their study time over the course of several days leading up to a test, in both ideal and realistic conditions. Here, we predicted higher levels of spacing in ideal compared to realistic circumstances, based on the

idea that students may end up cramming for a test even if they know it is not as effective in the long-term (Van Etten et al., 1997).

Next, the survey included items relevant to the third question, examining potential factors in the decision to space or mass (e.g., difficulty level of the upcoming test, level of interest in the material, type of upcoming test, and academic commitments). Other than examination of the difficulty factor (e.g., Son, 2004; Benjamin & Bird, 2006), this is a relatively unexplored area of research.

Finally, we examined the fourth question by including independently-validated scales of *metacognitive self-regulation* (MSR) and *elaboration* (Pintrich, Smith, Garcia, & McKeachie, 1991). MSR measures components of metacognition, and by extension self-regulated learning, by tapping the extent to which students monitor, and take strategic action to improve, their own learning. Higher scores on the MSR scale reflect the ability to monitor one's memory and be able to adjust strategies if necessary. The elaboration scale was included to provide a measure of the extent to which students use more effortful study strategies (i.e., desirable difficulties). Higher scores on this scale generally reflect more integration and connection of information to prior knowledge. We hypothesized that students who score higher on the MSR and elaboration scales would report more use of the study strategies listed in the survey, and would specifically report more knowledge and more frequent use of spaced study.

Method

Participants

Participants were 285 students from undergraduate institutions including four-year universities (57.3%) four-year colleges (32.5%), and community colleges (10.2%). They were recruited through web postings on various websites, social networking sources, and the listserv

for *APA Division 2: Teaching of Psychology*. Participants had the option of entering their email addresses to be placed into a drawing for a gift card at the completion of the survey.

The average age of participants was 23.00 years old (*SD* = 6.84; range = 18-59) and they had completed an average of 3.57 years of college (*SD* = 1.12) with an average GPA of 3.38 (*SD* = 0.47). Further, the participants were predominantly female (64.2%) and the majority were non-psychology majors (71.2%).

Materials and Procedure

A researcher-designed web-based survey was made available to participants. The survey consisted of questions related to the knowledge and use of spaced study, specific study behaviors, factors impacting decisions to space or mass study sessions, metacognitive self-regulation, and the use of elaboration study strategies. Demographic information (i.e., age, type of institution, major, number of years of college completed, and sex) was also collected. The survey consisted of a variety of question formats including Likert-type scales, multiple-choice, and free-write.

As an independently-validated measure of metacognition, the survey included two subscales from the *Motivated Strategies for Learning Questionnaire* (MSLQ; Pintrich et al., 1991). The two scales used were *elaboration* and *metacognitive self-regulation* (MSR), which have an average alpha level of .775 (Pintrich et al., 1991). Eighteen questions (six from elaboration and 12 from metacognitive self-regulation) were included regarding students' study strategies and their ability to regulate and monitor their cognitions. Examples of questions from the elaboration scale are: "When reading material, I try to relate it to what I already know" and "When I study for class, I pull together information from different sources, such as lectures, readings, and discussions." Examples from the MSR scale include: "I ask myself questions to

make sure I understand the material I have been studying" and "If I get confused taking notes in class, I make sure I sort it out afterwards." Each item was rated using a 7-point Likert-type scale with 1 being *not at all true of me* and 7 being *very true of me*. After reverse scoring several items, the mean ratings for each subscale were computed.

To participate in the survey, participants clicked on the link provided to them, and viewed the consent form. In order to consent, participants needed to click a button to signify that they had agreed to participate and also that they were at least 18 years old and current undergraduate students. Upon completing these questions, participants proceeded to the rest of the survey. The entire survey took 10-15 minutes to complete.

Results

The alpha level for all analyses was set at .05, unless otherwise indicated below.

Knowledge of Spacing Effect

Descriptive statistics were computed for participants' awareness of the spacing effect. The survey item stated:

Which of the following strategies do you think research has found to be better for long-term retention of material, assuming the total amount of study time is kept the same?

a) Studying the material in multiple sessions of shorter duration

b) Studying the material in one longer session

c) Both strategies are equally effective

A frequency analysis showed that 84.9% of participants endorsed the long-term benefits of distributed study sessions, 5.8% believed that studying in only one session was superior, and 9.3% believed that both strategies were equally effective in promoting long-term retention. An exploratory post hoc analysis indicated differences in the endorsement of the spacing effect by

major. A greater portion of psychology majors (93.4%) endorsed the benefits of spacing, compared to non-psychology majors (81.8%), $x^2(2) = 7.61$, $p = .022$; in addition, zero psychology majors endorsed the massing option, though 7.7% of non-psychology majors did. Though tentative, these results at least suggest the possibility that students in the psychology major are more aware of the desirable difficulty of spacing as an effective study strategy.

Self-Reported Study Behaviors

Descriptive statistics were conducted on a list of 10 study strategies, each rated on a 5-point scale measuring how often they are utilized (1 = *never*; 3 = *sometimes*; 5 = *always*). Table 1 shows the complete list of study strategies ranked by their reported frequency of use. Rereading notes was the most commonly used strategy by students, with a mean of 4.14 (SD = 1.01). Most relevant to the topic of the current study, distributed study was the 6th most commonly used strategy (M = 3.24, SD = 1.21), whereas massed study was ranked 8th (M = 2.93, SD = 1.15). The difference between the distributed and massed study means was significant, $t(281) = -2.56$, $p = .011$. However, an examination of the means in the context of the other strategies suggests neither study strategy was endorsed heavily.

We next compared spacing-related study behaviors under ideal and realistic conditions. We asked participants two questions using the following format:

> *If you had a total of 5 hours to study for an upcoming test on Friday,* [*IDEALLY or REALISTICALLY*] *how would you spread out your studying (if it took 1 hour to study all of the information)? Please write a whole number in one or more of the spaces below, corresponding to the days leading up to the test.*

Participants reported how many hours (zero through five) they would study on each of the four days leading up to the test; the total number of hours reported had to equal five. Raw

number of hours studied was converted into a total number of days of study, resulting in a range of one (corresponding to complete massing) through four (corresponding to the most spacing). A frequency analysis showed that, for ideal conditions, the category of "one day" included the fewest participants (9.8%), and this number steadily increased to a high for four days of study (46.7%). Under realistic conditions, however, percentages of participants in each category stayed relatively constant across number of days of study, with two days of study being the most common (35.1%) (see Figure 1). To describe the data in a different way, 9.8% of participants would study in a completely massed fashion (i.e., one day) under ideal conditions, whereas twice as many (20.7%) reported massed study under realistic conditions.

A paired-samples *t*-test comparing mean ideal and realistic number of days of study showed a significantly higher mean for ideal ($M = 3.09$, $SD = 1.02$) compared to realistic conditions ($M = 2.47$, $SD = 1.07$), $t(284) = 11.45$, $p < .001$.

Factors in Spacing vs. Massing

One potential factor in the choice to space or mass study is the level of difficulty of to-be-learned information, as indicated by past research (e.g., Son, 2004; Benjamin & Bird, 2006). We expanded on this by asking participants two questions about how they study for tests of different difficulty levels, using the following format:

When studying for a [*DIFFICULT* or *EASY*] *test, do you change the way you study compared to how you would study for a test of average difficulty?*

a) Yes, I spread out my studying more in the days before the test.

b) Yes, I do all of my studying in only one session.

c) No, I study the same way for tests of all difficulty levels.

When preparing for a difficult test, 69.1% of participants indicated they spread out their studying more, whereas when preparing for an easy test only 6.7% indicated they spread out their studying more. Thus, the pattern of spacing and massing choices was almost perfectly reversed for difficult versus easy tests (see Figure 2).

Next, we used a 5-point Likert-type scale to examine other factors that could impact the decision to space or mass studying (see Table 2). Higher numbers indicated a higher likelihood of distributing study and lower numbers indicated a higher likelihood of studying in only one session. One-sample *t*-tests against the neutral "3" (corresponding to *"both strategies are equally likely"*) showed participants were more likely to space out their studying if there was a high future value of material, $t(274) = 12.47$, $p < .001$, if the material was interesting, $t(248) = 5.07$, $p < .001$, if the test was weighed heavily in determining the course grade, $t(249) = 13.14$, $p < .001$, and if there was a lot of material to learn, $t(247) = 16.18$, $p < .001$. Participants were more likely to mass their studying if the upcoming test was of multiple-choice format, $t(275) = -7.80$, $p < .001$, if they had many other academic commitments the same week as the test, $t(274) = -3.26$, $p = .001$, and if they had high confidence in their ability to learn the material, $t(249) = -8.75$, $p < .001$. Students were equally likely to space or mass their study if they had other social commitments the same week as the test, $t(275) = -1.35$, $p = .178$.

Correlations with *Metacognitive Self-Regulation* and *Elaboration* Scales

Bivariate correlations were computed between survey items and scores (using a 7-point scale) on the MSR and elaboration scales. We used the Bonferroni correction for multiple tests, which resulted in a more conservative alpha level of .001. Only the correlations meeting this criterion for significance are reported below.

As expected, the two scales were themselves significantly correlated, $r(283) = .65$, $p < .001$. Also, self-reported GPA was correlated with both the MSR, $r(245) = .233$, $p < .001$, and the elaboration, $r(245) = .263$, $p < .001$, scales, suggesting that higher-performing students were more likely to self-report the abilities tapped by these scales.

In relation to the survey items targeting spacing and massing, MSR was positively correlated with self-reported use of distributed study, $r(281) = .42$, $p < .001$, and negatively correlated with self-reported use of only one massed study session, $r(282) = -.33$, $p < .001$. Thus, as predicted, students high in MSR were more likely to space their study, and less likely to mass. MSR was also significantly correlated with ideal, $r(283) = .31$, $p < .001$, and realistic, $r(283) = .39$, $p < .001$, days of study prior to an upcoming test; thus, students with higher metacognition scores tended to be the ones reporting spaced studying under both ideal and realistic circumstances. The following factors surrounding decisions about whether to space or mass study were correlated with MSR: *multiple-choice test format*, $r(274) = .26$, $p < .001$, a *high future value of material*, $r(273) = .27$, $p < .001$, *social commitments*, $r(274) = .28$, $p < .001$, having an *interest in material*, $r(247) = .24$, $p < .001$, if the *test is weighed heavily in course grade*, $r(248) = .31$, $p < .001$, and if there is a *large amount of material to learn*, $r(246) = .39$, $p < .001$. Keeping in mind that higher scores for the critical factors indicate more inclination to space study sessions, these results suggest that individuals with a higher ability to monitor and regulate their cognitions are overall inclined to space their study under a variety of conditions. For additional correlations between the scales and study behaviors, see Table 1.

Turning to the elaboration scale, scores were positively correlated with use of distributed study, $r(281) = .26$, $p < .001$, and negatively correlated with use of massed study, $r(282) = -.26$, $p < .001$. These results parallel those for correlations with MSR reported above, and further

suggest that study behaviors involving making connections within the material and to prior knowledge are predictive of spaced study. Also similar to MSR results, elaboration was correlated with ideal, $r(283) = .24$, $p < .001$, and realistic, $r(283) = .21$, $p < .001$, number of study days prior to a test. The sole critical factor in the decision to space versus mass study that was associated with elaboration was if there is a *large amount of material to learn*, $r(246) = .27$, $p < .001$.

Discussion

The goal of this study was to explore college students' awareness and implementation of spaced study when they prepare for tests. Although prior laboratory research has examined beliefs and behaviors about spacing versus massing, our study adds to the literature by moving beyond the laboratory to focus on real-world study behaviors in college students. Using survey methodology, we investigated metacognitive awareness regarding the mnemonic benefits of spacing, spacing-related behaviors in the context of other common study strategies, critical factors that may influence the use of spacing, and correlations with independent scales measuring metacognitive self-regulation (MSR) and use of elaboration strategies.

Results indicated that the large majority of undergraduate participants were metacognitively aware of the fact that laboratory research has endorsed the advantage of spacing over massing for long-term retention of material. These findings contrast with those of Karpicke et al. (2009), who found that survey participants were overall not aware of the memory advantage of another desirable difficulty (i.e., testing, or retrieval practice). In the context of prior spacing effect research, our results also differ from prior findings of faulty metacognitive judgments concerning the superiority of massing over spacing (Kornell & Bjork, 2008; also see Kornell, 2009; McCabe, 2011).

Further evidence related to the awareness of the spacing advantage came from our survey item asking participants to distribute a consistent amount of study time over one to four days prior to a test. When comparing their choices to space versus mass study time under “ideal” versus “realistic” conditions, a clear pattern emerged: students would ideally distribute their study over more days, but do not tend to put this into practice realistically. These results taken together suggest that students may realize that it is more effective to distribute their study than to mass it.

Part of the discrepancy between our results and the metacognitive errors reported by Kornell and Bjork (2008) could be due to the fact that unlike prior laboratory studies, our participants did not actually experience spacing and massing conditions before making post hoc judgments of strategy effectiveness. In this way, they were not able to make judgments based on intrinsic mnemonic cues driven by, for example, fluency or ease of retrieval. Because our participants were forced to judge the learning situation using extrinsic cues (Koriat, 1997), we argue that our data offer a cleaner look at spacing effect awareness, uncontaminated by those real-time mnemonic cues that could lead to the illusion of competence associated with massing (e.g., Kornell & Bjork, 2008).

To address the degree to which students choose to implement distributed study, two survey items examined self-reported use of spacing-related study behaviors. As discussed above, participants reported much less spaced study time under realistic as compared to ideal conditions. Indeed, twice as many students chose full massing (i.e., one day of study) under realistic compared to ideal conditions; and only half as many chose the largest amount of spacing (i.e., four days) when comparing realistic to ideal. Clearly, there is a disconnect between what

students believe is best for learning and what they are actually doing in real-world study environments.

An examination of spacing and massing in the context of other study strategies showed only intermediate frequencies of use for both distributed study and massed study; perhaps more importantly, both strategies were ranked well below the most popular ones (e.g., rereading notes), with rankings of 6th and 8th, respectively, in a list of 10 strategies. It is encouraging, however, that the mean frequency of use for distributed study was significantly higher than for massed study. These findings are consistent with those of Pyc and Dunlosky (2010) who found that, in general, participants will space their learning more than mass it, when given the option in a controlled laboratory setting. Still, the lack of frequent utilization of distributed study resembles previously discussed survey findings on the testing effect (Karpicke et al., 2009). These desirable difficulties (Bjork, 1994), which should result in increased long-term retention of material, are not being used often compared to other strategies that may be both less effortful and less effective.

One of the more unique aspects of our study was the detailed investigation of various factors that may impact students' allocation of their study time. This issue is particularly important because we were able to show that most students know distributed study is better for long-term memory, but that under realistic conditions they are not spacing as much as they could. Having established this, the question becomes, *If students know that spacing their study sessions is better, why are they not doing more of it?* Our results suggested that participants were more likely to space their studying for material that held high value for future courses or careers and that was more interesting to them. This suggests that information more personally relevant is more likely to be studied in a manner supportive of long-term retention. Other factors

associated with spaced study included having a lot of material to review for a test, and knowing that an upcoming test is weighed heavily in determining the final grade for a course.

On the other hand, factors that led students to report massing their studying more included a test being multiple-choice format (rather than short-answer or essay) and students having a lot of confidence in their ability to learn the material. Further, and not surprisingly, when a lot of other academic commitments occurred the same week as a test, students indicated that they were more likely to mass their studying. These findings resemble those of Kornell and Bjork (2007) who, also using survey research, found that students were more likely to study whatever work is due soonest (59% of students) rather than plan a study schedule in advance (11% of students).

One critical factor we investigated more thoroughly was the difficulty level of an upcoming test. Given the prior research on a similar difficulty factor (e.g., Son, 2004; Benjamin & Bird, 2006), we chose to investigate this particular topic in more depth by creating two survey questions to inquire about the choice to space or mass when studying for a relatively difficult versus a relatively easy test. We found that participants choose to space their studying more when preparing for harder-than-average tests and mass their studying more for easier tests. Despite using a different methodology, our findings are consistent with those of Benjamin and Bird (2006) who found that participants were more likely to space difficult word pairs compared to easy ones.

One interpretation of our findings is that even given a high degree of metacognitive awareness of the long-term advantage of spacing over massing, students do not feel the need to study in ways that promote their future retention of course information. As such, they may be satisfied with their current massing-heavy study behaviors, assuming they are able to perform at

acceptable levels on course assessments. It is important, therefore, to also assess motivational factors involved in the choice of study behaviors, a topic beyond the scope of this research. Nonetheless, our results regarding critical factors do have implications for educators who want to encourage the long-term retention of the information they teach. For example, increasing the perceived interestingness, and showing the future value of, course material may motivate students to learn and study it in a more distributed, and therefore potentially more effective, manner. Also, relying less on pure multiple-choice tests, and more on tests perceived to have a high difficulty level, may be important steps in encouraging distributed study.

Turning now to survey item correlations with the MSR and elaboration scales (Pintrich et al., 1991), we found consistent results suggesting that students who score high on MSR (i.e., the ability to self-assess and regulate their study strategies) and elaboration (i.e., the use of deep-processing strategies for learning such as connecting information to prior knowledge) were more likely to report using distributed study and, conversely, were less likely to report using massed study. Further, both scales were positively correlated with the number of days students would use to study under both ideal and realistic conditions. Clearly, there is a connection between aspects of general metacognitive ability tapped by the scales and the specific study choice to space learning sessions.

Though not the focus of this study, we noted in Table 1 those study strategies that were correlated with MSR and elaboration. Not surprisingly, and in further validation of the spacing-related correlations, one or both of these scales was positively correlated with the frequency of use of all but three of the listed strategies. Particularly relevant were the correlations involving those strategies that would fall in the category of desirable difficulties (Bjork, 1994), including self-testing, making outlines, and self-referencing. These correlations can be useful in terms of

predicting students' use of effective strategies (including but not limited to spacing), as the MSR and/or elaboration scales can be easily and quickly administered to students at the start of a college course. This exercise could be followed by a self-assessment of results, and an instructor-led discussion of the benefits of the various strategies and behaviors described in the survey items (as suggested by Pintrich et al., 1991).

The findings from this study support increased research efforts on metacognitive aspects of the spacing effect, particularly in the context of real-world academic behaviors. More naturalistic research is warranted to evaluate students' real-time study behaviors with regard to whether they really do practice spacing more frequently than massing. Future research should also examine ways to encourage students to use distributed study, and other such desirable difficulties, through motivational and informational (i.e., teaching) strategies. Although students did signify that they were aware of the benefits of spacing and reported using it moreso than massing, it was not reported as a frequently used study strategy. A related extension of the current work would be to examine not only the fact that students know spacing is better than massing, but more specifically the extent to which they understand the cognitive mechanisms involved in the spacing advantage. Perhaps a focus on this educational element could contribute to the motivation to incorporate distributed study into their repertoire of strategies.

In sum, the current study extends prior laboratory work on metacognition and the spacing effect by showing that undergraduates may indeed know about the benefits of distributed study. According to our results, they also report using spacing more frequently than massing when they study, although we were able to identify numerous factors that contribute to the decision to space or mass study sessions. Investigation of this topic, in the context of other effective study

strategies, can enhance our understanding of how to improve long-term memory for course material, an important goal of higher education.

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Table 1

Means and Standard Deviations for Frequency of Use of Study Strategies

Study Strategy	*M*	*SD*
Reread notes [a b]	4.14	1.01
Self-test (practice recalling material) [b]	3.53	1.27
Make outlines or study guides [a b]	3.43	1.30
Reread textbook	3.34	1.11
Do practice problems [a]	3.25	1.16
Distribute studying over multiple sessions [b]	3.24	1.21
Reference material to self [a b]	2.94	1.15
Study all material in only one session [a b]	2.93	1.15
Use mnemonic devices [b]	2.68	1.27
Make and use flashcards	2.51	1.23

Note: Ratings on a 5-point scale, 1 = *Never*; 3 = *Sometimes*; 5 = *Always*.
[a] $p < .001$ Correlations with MSLQ *Metacognitive Self-Regulation* Scale.
[b] $p < .001$ Correlations with MSLQ *Elaboration* Scale.
All correlations were positive except for *Study all material in only one session*

Table 2

Means and Standard Deviations for Ratings of Critical Factors in the Decision to Space or Mass Study

Factor	*M*	*SD*
There is a lot of material to learn (rather than a little material)	4.16**	1.13
The test is weighed heavily in determining the final course grade (rather than the test is not weighed heavily)	4.02**	1.23
There is a high value of material for future courses or career (rather than a low value)	3.89**	1.19
The material is interesting to me (rather than the material is not interesting)	3.41**	1.19
I have social commitments the same week as the test (rather than no social commitments)	2.90[a]	1.29
I have many other academic commitments the same week as the test (rather than few other academic commitments)	2.72**	1.44
Upcoming test is multiple-choice test (rather than short-answer or essay)	2.44**	1.20
I have high confidence in my ability to learn the material (rather than low confidence)	2.32**	1.23

Note: Ratings on a 5-point scale, 1 = *Much more likely to study in only one session*; 3 = *Both strategies equally likely*; 5 = *Much more likely to spread out studying.*
**$p < .001$. [a]$p = .178$, from one-sample *t*-tests against the neutral "3" response.

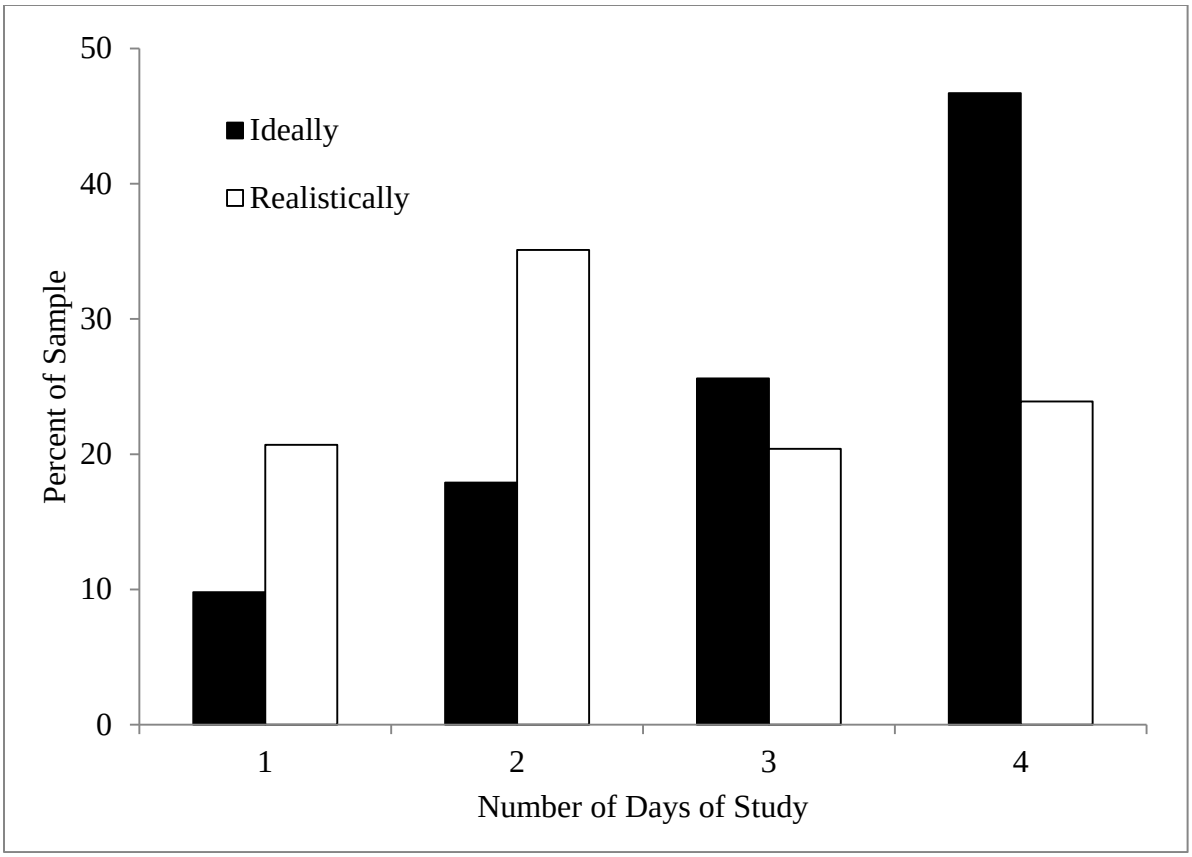

Figure 1. Percentages of participants reporting various numbers of study days under ideal and realistic conditions. For reference, one day of study represents full massing, and higher numbers indicate different degrees of spacing.

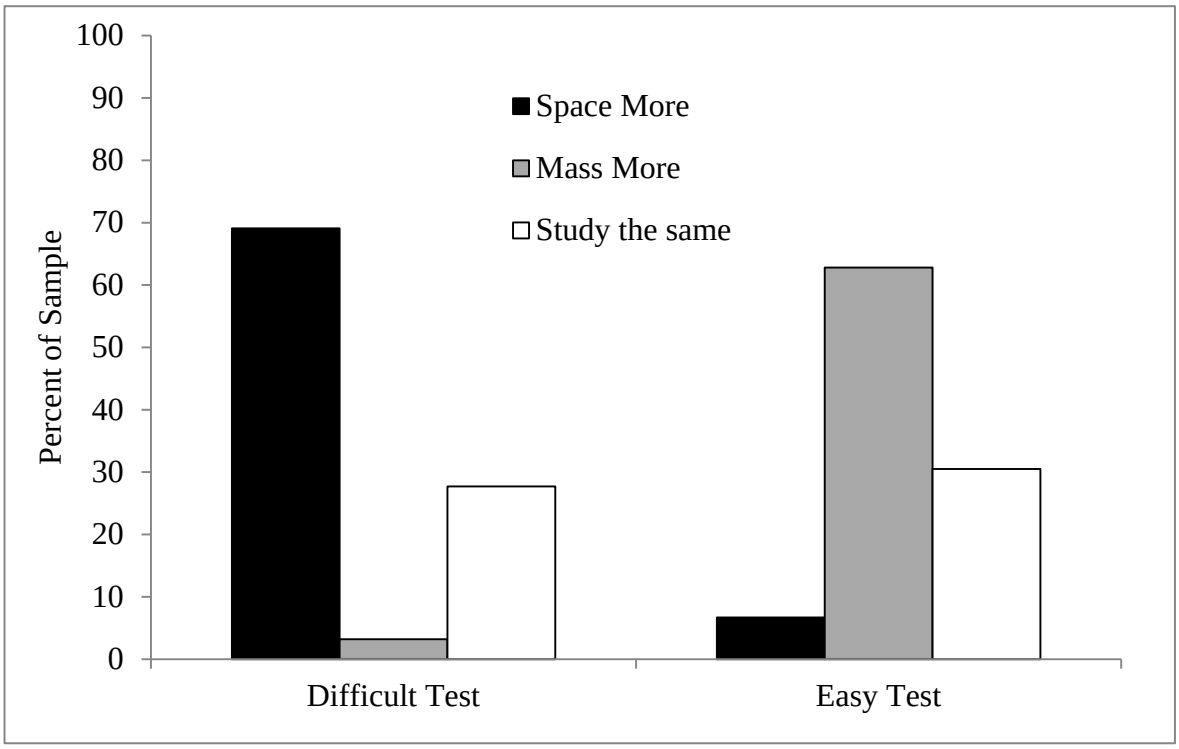

Figure 2. Percentages of participants reporting one of three options for relatively easy versus relatively difficult tests: *Yes, I would spread out my studying more in the days before the test* (i.e., "Space More"); *Yes, I do all of my studying in only one session* (i.e., "Mass More"); *No, I study the same way for tests of all difficulty levels* (i.e., "Study the Same").

Julia Rogers Research Prize Library Essay

One of the most important steps of conducting research in psychology is to review past research on the topic of interest. Finding and reading previous literature provide inspiration and new ideas for projects, and help ground a new study in past work, allowing researchers to see how it fits in with and expands on existing research. This past summer, while participating in Goucher College's Summer Science Research Program, I undertook an extensive literature review on the topic of the spacing effect and metacognition.

In doing this I took advantage of many of the library's resources, using online databases specific to psychology, such as PsycINFO and PsycARTICLES, to find and access relevant articles and chapters. Throughout this process I greatly improved my knowledge of the topics I was pursuing. Due to the wide variety of journals to which we have access, I often received electronic versions of the desired articles immediately, and, when I was unable to do this, I requested the article through Interlibrary Loan and received it shortly after. There was never a time when I was denied an article. All of the research I did enabled me to thoroughly review the relevant work in my field and synthesize it all into a cohesive analysis of prior research, the bulk of which helped form the Introduction section of my manuscript.

Conducting research this past summer not only taught me about the research process in general, but also, through my literature searches and reviews, provided me with extensive knowledge on the topic of my research. I learned how to successfully search for and access relevant articles using keyword, and forward and backward searching strategies. I was amazed at how much my scholarship and knowledge of the field grew due to the research process and the opportunities available to me.

Jonathan Susser

From the Lab to the Dorm Room: Metacognitive Awareness and Use of Spaced Study

Nominating Professor: Dr. Jennifer McCabe