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Study strategies and beliefs about learning as a function of academic achievement and achievement goals

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Abstract

Prior research by Hartwig and Dunlosky [(2012). Study strategies of college students: Are self-testing and scheduling related to achievement? *Psychonomic Bulletin & Review*, *19*(1), 126–134] has demonstrated that beliefs about learning and study strategies endorsed by students are related to academic achievement: higher performing students tend to choose more effective study strategies and are more aware of the benefits of self-testing. We examined whether students' achievement goals, independent of academic achievement, predicted beliefs about learning and endorsement of study strategies. We administered Hartwig and Dunlosky's survey, along with the Achievement Goals Questionnaire [Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality & Social Psychology*, *80*, 501–519] to a large undergraduate biology course. Similar to results by Hartwig and Dunlosky, we found that high-performing students (relative to low-performing students) were more likely to endorse self-testing, less likely to cram, and more likely to plan a study schedule ahead of time. Independent of achievement, however, achievement goals were stronger predictors of certain study behaviours. In particular, avoidance goals (e.g., fear of failure) coincided with increased use of cramming and the tendency to be driven by impending deadlines. Results suggest that individual differences in student achievement, as well as the underlying reasons for achievement, are important predictors of students' approaches to studying.

Keywords

Study habits, metacognition, student achievement, achievement goals

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Comments

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Study Strategies and Beliefs about Learning as a Function of Academic Achievement and Achievement Goals

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Abstract

Prior research by Hartwig and Dunlosky (2012) has demonstrated that beliefs about learning and study strategies endorsed by students are related to academic achievement: higher performing students tend to choose more effective study strategies and are more aware of the benefits of self-testing. We examined whether students' achievement goals, independent of academic achievement, predicted beliefs about learning and endorsement of study strategies. We administered Hartwig and Dunlosky's survey, along with the Achievement Goals Questionnaire (Elliot & McGregor, 2001) to a large undergraduate biology course. Similar to results by Hartwig and Dunlosky, we found that high-performing students (relative to low-performing students) were more likely to endorse self-testing, less likely to cram, and more likely to plan a study schedule ahead of time. Independent of achievement, however, achievement goals were stronger predictors of certain study behaviors. In particular, avoidance goals (e.g., fear of failure) coincided with increased use of cramming and the tendency to be driven by impending deadlines. Results suggest that individual differences in student achievement, as well as the underlying reasons for achievement, are important predictors of students' approaches to studying.

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Study Strategies and Beliefs about Learning as a Function of Academic Achievement and Achievement Goals

Every day students are confronted with a number of decisions about what, when, and how to study. Understanding the factors underlying these decisions is essential in helping students become successful learners, as effective study habits (or lack thereof) can influence educational outcomes such as academic achievement and attrition.

Decades of research on human cognition have revealed a number of techniques that enhance learning. Two widely-cited techniques are *retrieval practice* and *distributed practice*. Retrieval practice involves testing oneself after learning as opposed to simply restudying the material. The memory enhancement for tested vs. restudied material has been widely demonstrated (for reviews, see Kornell & Vaughn, 2016; Rowland, 2014). Distributed practice involves separating study sessions in time rather than cramming learning into one study session. Increased long-term retention that results from distributing study rather than massing or cramming has also been widely demonstrated (see Carpenter, in press, for a review). The voluminous research on these techniques suggests that students should make use of retrieval and spacing as part of their study routine.

Survey research on students' approaches to studying reveals that, contrary to the widespread benefits of retrieval and distributed practice, students often report re-reading course material and cramming shortly before the test (Hartlep & Forsyth, 2000; Susser and McCabe, 2013). For example, McCabe (2011) presented students with six hypothetical learning scenarios that involved choosing one of two study strategies, either an optimal strategy (e.g., testing) or a sub-optimal strategy (e.g., restudying), and found that students rarely (23%) endorsed the

optimal strategy. Similarly, Karpicke, Butler, and Roediger, (2009) found that students are more likely to use re-reading than retrieval practice.

Metacognition and Study Strategies

One potential reason for the adoption of suboptimal strategies is that students lack metacognitive awareness of the direct benefits of retrieval and distributed practice. In the study by Karpicke et al. (2009), when students did endorse retrieval practice, they did so to gauge their knowledge of the material rather than to directly enhance learning. This is consistent with results from other survey studies (e.g., Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; McAndrew, Morrow, Atiyeh, & Pierre, 2016; Morehead, Rhodes, & DeLozier, 2016; Yan, Thai, & Bjork, 2014) showing that students are more likely to use testing as a metacognitive tool than as a learning tool.

Recent data, however, have shown that some students are more likely than others to endorse effective study strategies. Hartwig and Dunlosky (2012) showed that academic performance, denoted by self-reported grade point average (GPA), predicts the degree to which students engage in strategies related to retrieval and spacing. In particular, higher-achieving students (relative to lower-achieving students) are more likely to endorse retrieval practice (e.g., reporting that they test themselves over material they are learning), and are less likely to cram. Further, high-achievers appear to be more aware of the benefits of testing, and are also more likely than low-achievers to schedule their study sessions ahead of time. Thus, the general finding that students make poor choices in terms of study habits is tempered by the finding that a subset of students do appear to choose effective strategies. Individual differences, therefore, are an essential part of research on students' study behaviors.

Achievement Goals and Study Strategies

Although student achievement significantly predicts study strategies, achievement alone might not be sufficient to account for the full range of individual differences. In particular, the achievement *goals* that students hold can vary and influence their approaches to studying.

Achievement goals are generally defined in terms of competence, in particular, the reasons why individuals choose to engage in behaviors to demonstrate their competence (Meece, Anderman, & Anderman, 2006; Rawshorne & Elliot, 1999). In the academic context, competence can be reflected by performance (e.g., as measured on a specific test or activity, or overall GPA), with higher performance reflecting higher competence. Competence can also be reflected by intrapersonal mastery—how well students perform relative to their own perceived potential or expectations.

Achievement goals have also been defined in terms of valence, with a contrast between striving towards a positive outcome (i.e., approach) and avoiding a negative outcome (i.e., avoidance). As outlined by Elliot and McGregor (2001), this produces four distinct patterns of achievement goals: (a) Mastery-approach, as reflected in students who strive toward achieving a high grade to reinforce their personal sense of having mastered the material, (b) Performance-approach, as reflected in students who strive toward achieving the highest grade possible relative to their peers, (c) Mastery-avoidance, or perfectionistic students who aim to achieve a high grade by avoiding mistakes, and (d) Performance-avoidance, or students who are primarily interested in not failing the class. What differentiates these patterns is motivational, or why a particular outcome is important to a particular student.

Individual differences in achievement goals may account for differences in students' approaches to studying. Weissgerber, Reinhard, and Schindler (2016), for example, found that mastery goals predicted students' self-reported use of a combination of strategies known to boost

long-term learning, including retrieval practice, distributed practice, interleaving, generating answers, and inferring solutions to problems. Mastery goals have also been linked with increased metacognitive skills such as monitoring of one's own progress (Bernacki, Byrnes, & Cromley, 2012) and increased willingness to adjust one's approaches to studying (Wolters, 2004). Avoidance goals are known to be associated with less proactive approaches to studying (Bernacki et al., 2012) and a decreased tendency to establish a structured study routine (Elliot et al., 1999). Procrastination in particular has been associated with performance-avoidance goals (Wolters, 2004) and mastery-avoidance goals (Howell & Watson, 2007).

Academic achievement and achievement goals may be separable, such that even the highest performing students, if driven by avoidance goals, may engage in sub-optimal study behaviors. Though previous research has shown that student achievement is positively correlated with the use of effective study strategies (Hartwig & Dunlosky, 2012), this research has not systematically explored the potentially independent effects of academic achievement, and underlying achievement *goals*, on students' use of these strategies.

The Present Study

We collected data from students in an introductory biology course using an established survey designed to examine students' study habits and beliefs about learning (Hartwig & Dunlosky, 2012), and the Achievement Goals Questionnaire (AGQ), a widely-used measure of students' achievement goals (Elliot & MacGregor, 2001). Consistent with previous research, we expected that higher-achieving students would more likely endorse effective study strategies (particularly retrieval practice and distributed practice). Additionally, we examined the extent to which achievement goals independently predict endorsement of these strategies.

Method

Participants

We aimed for a sample size larger than that of previous studies (ranging from 300 in Morehead et al., 2016, to 472 in Kornell & Bjork, 2007) in order to provide enough power to replicate previous outcomes (e.g., Brandt et al., 2014; Somonsohn, 2015) and to detect effects of the added variable of achievement goals. As such, the survey was administered to 1039 undergraduate students enrolled in an introductory biology course at Iowa State University. The sample comprised students from three sections of the course over three semesters, with enrollments of 354, 308, and 377 in each section. A total of 931 students completed the survey (296 from Section 1, response rate = 84%; 288 from Section 2, response rate = 94%; and 347 from Section 3, response rate = 92%). Data were removed on a list-wise basis for any missing responses to the study habits or AGQ items (3% of the sample), resulting in data from 903 students entered into the analyses.

Students ranged in age from 18 to 45 (M = 19.52, SD = 2.01). Enrollment across the three sections included 52% freshmen, 27% sophomores, 17% juniors, and 4% seniors. In the sample, 48% of students were from science and engineering majors, 42% were in majors related to physical health and medicine, and 10% were from other majors or undeclared. Information on gender was available for two of the three sections and comprised 33% male, 66% female, and 1% indicating no response.

Materials and Procedure

Participants completed an adapted version of the Hartwig and Dunlosky (2012) survey measuring study habits, beliefs about learning, and GPA (see Appendix), along with the Achievement Goals Questionnaire (AGQ; Elliot & McGregor, 2001). Eleven of the items from Hartwig and Dunlosky's survey were used in their original form. Question 10 ("Which of the

following best describes your pattern of study? (a) I most often space out my study sessions over multiple days/weeks, or (b) I most often do my studying in one session before the test") was modified to include one additional response option ("I most often do my studying in a couple of sessions before the test") to measure students' tendencies to engage in what we refer to as "light cramming."[1] The survey was made available online during the last week of the semester and was introduced by the instructor via in-class and online announcements.

Results and Discussion

We conducted separate binomial and multinomial logistical regression analyses predicting students' responses on the survey questions as a function of self-reported GPA (measured on a 1-6 scale, consistent with Hartwig & Dunlosky, 2012) and achievement goals. A composite score was calculated for each of the four achievement goal constructs (Mastery-Approach, Mastery-Avoidance, Performance-Approach, Performance-Avoidance) by summing each students' responses to the three items corresponding to each construct (see Elliot & McGregor, 2001).

GPA and Achievement Goals as Predictors of Study Strategies

We first examined the relationship between student achievement and study strategies. Self-reported GPA was entered as a predictor of student endorsement of each of the strategies listed in Question 12 ("Which of the following study strategies do you use ***regularly***?"). Consistent with the results of Hartwig and Dunlosky (2012) and McAndrews et al. (2016), higher-performing students were more likely than lower-performing students to engage in self-testing, $\chi^2(1) = 17.19$, $\exp(B) = 1.33$, $p < .001$, $d = .26$, and were less likely to cram, $\chi^2(1) = 8.42$, $\exp(B) = .84$, $p < .01$, $d = .09$. High-performing students were also more likely to use diagrams,

charts, or pictures, $\chi^2(1) = 8.84$, exp(B) = 1.21, $p < .01$, $d = .10$, and to ask questions in class, $\chi^2(1) = 24.39$, exp(B) = 1.45, $p < .001$, $d = .20$.[2]

Next, scores on each of the four achievement goal constructs were entered into the model, along with GPA, to predict endorsement of each of the strategies listed in Question 12. These results are reported in Table 1. Although GPA still significantly predicted students' use of self-testing and whether students asked questions in class ($d = .17$), GPA did not independently predict cramming and diagram use. Instead, avoidance goals—independent of GPA—coincided with increased use of cramming. This was true for both performance-avoidance goals ($d = .02$) and mastery-avoidance goals ($d = .05$). Such a finding is consistent with previous research showing that avoidance goals—i.e., fear of receiving a low grade or of failing to meet one's own standards—coincide with increased procrastination on academic tasks (Howell & Watson, 2007; Wolters, 2004). This pattern was observed after controlling for GPA, suggesting that even high-performers, if driven by avoidance goals, may engage in non-optimal study behaviors like cramming.

As mentioned above, mastery goals coincide with a variety of approaches to studying (e.g., Wolters, 2004). Indeed, we found that mastery-approach goals predicted more frequent use of self-testing ($d = .03$), using diagrams, charts, or pictures ($d = .06$), using flashcards ($d = .03$), asking questions in class ($d = .05$), re-reading ($d = .06$), and studying with friends ($d = .03$). Mastery-approach goals also predicted less frequent use of cramming ($d = .08$). Performance-avoidance goals predicted more frequent use of self-testing ($d = .03$), but less frequent use of diagrams, charts, or pictures ($d = .03$), and less frequent use of re-reading ($d = .03$).

Scheduling, GPA, and Achievement Goals

We next examined the responses related to scheduling—Questions 2, 10, 8, and 9—as a function of GPA and achievement goals. These results are reported in Table 2. Question 2 ("How do you decide what to study next?") responses were consistent with previous research (Kornell & Bjork, 2007; Hartwig & Dunlosky, 2012) showing that the majority of students (58%) tend to study what is due soonest or overdue. Responses to Question 2 were predicted by GPA, $\chi^2(4) = 11.36$, $p < .05$, mastery-approach goals, $\chi^2(4) = 20.96$, $p < .001$, and performance-avoidance goals, $\chi^2(4) = 12.17$, $p < .05$. Students with higher GPAs were more likely to plan a study schedule ahead of time and study whatever they have scheduled rather than study what is due soonest or overdue ($d = .12$). Likewise, mastery-approach goals coincided with an increased tendency to plan a study schedule ahead of time ($d = .07$). Conversely, performance-avoidance goals coincided with the tendency to study what is due soonest or overdue rather than what is most interesting ($d = .07$). This is consistent with previous research showing that avoidance goals can be associated with less organized and less proactive approaches to studying (Bernacki et al., 2012; Elliot et al., 1999).

Responses to Question 10 ("Which of the following best describes your pattern of study?") indicated that few students (only 17%) report spacing out their study sessions. Also, few students (also only 17%) reported engaging in heavy cramming, whereas the majority of students (65%) reported engaging in "light cramming." Previous research using this question provided two response options—either space out study over multiple days/weeks, or study in a single session before the exam—and found a fairly even split between the proportion of students who space out their study (47%) and those who study in a single session before the exam (53%) (Hartwig & Dunlosky, 2012). In the current study, including a response option for "light cramming" resulted in a redistribution of these frequencies such that the majority of students

reported studying in a couple of sessions before the exam, rather than spacing their study over multiple days/weeks or studying in a single session. This finding is in accordance with a recent survey administered by Blasiman, Dunlosky, and Rawson (2017) showing that students tend to do most of their studying starting two days before the exam.

Table 2 also shows that students' responses to Question 10 were predicted by mastery-approach goals, $\chi^2(2) = 19.30$, $p < .001$ and performance-avoidance goals, $\chi^2(2) = 11.53$, $p < .01$. Consistent with the analyses reported earlier on cramming (see Question 12, Table 1), performance-avoidance goals coincided with increased use of heavy cramming ($d = .06$), whereas mastery-approach goals coincided with increased use of spacing relative to heavy cramming ($d = .09$) or light cramming ($d = .06$).

Finally, for Questions 8 and 9 ("What time of day do you most often do your studying?" and "During what time of day do you believe your studying is (or would be) most effective?"), students responded that they are more likely to study and be most effective in the evening (53% and 37%, respectively), consistent with previous responses to these items (Hartwig & Dunlosky, 2012). Responses to Question 8 were dependent upon performance-avoidance goals, $\chi^2(3) = 10.06$, $p < .05$, and marginally dependent upon performance-approach goals, $\chi^2(3) = 7.39$, $p = .06$. Performance-avoidance goals coincided with increased tendency to study in the afternoon ($d = .06$), evening ($d = .04$), and late night ($d = .06$) compared to the morning. Performance-approach goals coincided with increased tendency to study in the afternoon ($d = .04$) and evening ($d = .04$) compared to the morning. Responses to Question 9 did not depend on GPA or achievement goals.

Self-Testing, GPA, and Achievement Goals

The results for Question 6 ("If you quiz yourself while you study, (either using a quiz at the end of a chapter, or a practice quiz, or flashcards, or something else), why do you do so?") are presented in Table 3. As found in previous studies (e.g., Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; McAndrew et al., 2016; Yan et al., 2014), students more often reported using self-testing as a way to gauge their level of knowledge (46%), rather than as a way to potentiate learning (28%). Responses to this question depended upon mastery-approach goals, $\chi^2(3) = 15.25$, $p < .01$, which coincided with an increased tendency to use testing as a metacognitive tool rather than as a learning tool, $d = .04$.

Summary and Conclusions

The current data are consistent with previous research in showing that overall (1) testing, rereading, and cramming are commonly-reported study strategies (e.g., Hartwig & Dunlosky, 2012), (2) students tend to use self-testing as a way to gauge their knowledge rather than as a learning tool, and (3) students' approaches to studying are more influenced by impending deadlines than by a planned study schedule (Kornell & Bjork, 2007; Yan et al., 2014).

Further, we found that, similar to Hartwig and Dunlosky (2012) and McAndrews et al. (2016), high-achieving students were more likely to endorse strategies that have been demonstrated through empirical research to be effective. Particularly, students with higher self-reported GPAs were more likely to endorse self-testing, less likely to cram, and more likely to plan out their studying ahead of time.

Though self-testing was still significantly predicted by GPA after controlling for achievement goals, students' use of cramming was predicted more by their achievement goals than by achievement per se, such that avoidance goals (independent of GPA) coincided with increased use of cramming. Avoidance goals also predicted students' tendencies to be influenced

by impending deadlines, and to believe that late-night studying would be most effective. These patterns are all consistent with previous studies showing that avoidance goals coincide with less proactive and less organized approaches to studying (Bernacki et al., 2012; Elliot et al., 1999; Howell & Watson, 2007; Wolters, 2004). Thus, although student achievement can be a significant predictor of study behaviors, the current results show that the underlying reasons *why* students achieve could add important information that is not accounted for by achievement alone.[3]

These findings from a large, diverse sample add to the growing survey research—much of which has been based on students from psychology courses (e.g., Hartwig & Dunlosky, 2012; Kornell & Bjork; Morehead et al., 2016)—revealing the factors underlying students' study habits and beliefs about learning. Future research would benefit through further explorations of the role of individual differences in students' approaches to studying. Questions of particular interest include the development and persistence of these individual differences, how they coincide with effective approaches to studying, whether these approaches vary across different fields of study, and what roles they ultimately play in long-term academic success.

References

Bernacki, M. L., Byrnes, J. P., & Cromley, J. G. (2012). The effects of achievement goals and self-regulated learning behaviors on reading comprehension in technology-enhanced learning environments. *Contemporary Educational Psychology*, *37*(2), 148-161.

Blasiman, R. N., Dunlosky, J., & Rawson, K. A. (2017). The what, how much, and when of study strategies: Comparing intended versus actual study behaviour. *Memory*, *25(6),* 784–792. https://doi.org/10.1080/09658211.2016.1221974

Brandt, M. J., Ijzerman, H., Dijksterhuis, A., Farach, F. J., Geller, J., Giner-Sorolla, R… van t' Veer, A. (2014). The replication recipe: What makes for a convincing replication? *Journal of Experimental Social Psychology, 50,* 217-224.

Carpenter, S. K. (in press). Spacing effects in learning and memory. In J. T. Wixted & J. H. Byrne (Eds.), *Learning and memory: A comprehensive reference*. Academic Press.

Chinn, S. (2000). A simple method for converting an odds ratio to effect size for use in meta-analysis. *Statistics in Medicine, 19,* 3127-3131.

Elliot, A. J., & McGregor, H. A. (2001). A 2 x 2 achievement goal framework. *Journal of Personality & Social Psychology, 80,* 501-519.

Elliot, A. J., McGregor, H. A., & Gable, S. (1999). Achievement goals, study strategies, and exam performance: A mediational analysis. *Journal of Educational Psychology, 91*(3), 549-563.

Hartlep, K. L., & Forsyth, G. A. (2000). The effect of self-reference on learning and retention. *Teaching of Psychology*, *27*(4), 269-271.

Hartwig, M. K., & Dunlosky, J. (2012). Study strategies of college students: Are self-testing and scheduling related to achievement? *Psychonomic Bulletin & Review*, *19*(1), 126-134.

Howell, A. J., & Watson, D. C. (2007). Procrastination: Associations with achievement goal orientation and learning strategies. *Personality and Individual Differences*, *43*(1), 167-178.

Karpicke, J. D., Butler, A. C., & Roediger, H. L. III. (2009). Metacognitive strategies in student learning: Do students practice retrieval when they study on their own? *Memory*, *17*(4), 471-479.

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic Bulletin & Review*, *14*(2), 219-224.

Kornell, N., & Vaughn, K. E. (2016). How retrieval attempts affect learning: A review and synthesis. *Psychology of Learning and Motivation*, *65*, 183-215.

Kuncel, N. R., Credé, M., & Thomas, L. L. (2005). The validity of self-reported grade point averages, class ranks, and test scores: A meta-analysis and review of the literature. *Review of Educational Research*, *75*(1), 63-82.

McAndrew, M., Morrow, C. S., Atiyeh, L., & Pierre, G. C. (2016). Dental student study strategies: Are self-testing and scheduling related to academic performance? *Journal of Dental Education*, *80*(5), 542-552.

McCabe, J. (2011). Metacognitive awareness of learning strategies in undergraduates. *Memory & Cognition*, *39*(3), 462-476.

Meece, J. L., Anderman, E. M., & Anderman, L. H. (2006). Classroom goal structure, student motivation, and academic achievement. *Annual Review of Psychology, 57,* 487-503.

Morehead, K., Rhodes, M. G., & DeLozier, S. (2016). Instructor and student knowledge of study strategies. *Memory, 24,* 257-271.

Rawshorne, L. J., & Elliot, A. J. (1999). Achievement goals and intrinsic motivation: A meta-analytic review. *Personality & Social Psychology Review, 3,* 326-344.

Rowland, C. A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin*, *140*(6), 1432-1463.

Simonsohn, U. (2015). Small telescopes: Detectability and the evaluation of replication results. *Psychological Science, 26,* 559-569.

Susser, J. A., & McCabe, J. (2013). From the lab to the dorm room: Metacognitive awareness and use of spaced study. *Instructional Science*, *41*(2), 345-363.

Weissgerber, S., Reinhard, M. A., & Schindler, S. (2016). Study harder? The relationship of achievement goals to attitudes and self-reported use of desirable difficulties in self-regulated learning. *Journal of Psychological and Educational Research*, *24*(1), 42-60.

Wolters, C. A. (2004). Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology, 96*(2), 236-250.

Yan, V. X., Thai, K. P., & Bjork, R. A. (2014). Habits and beliefs that guide self-regulated learning: Do they vary with mindset? *Journal of Applied Research in Memory and Cognition*, *3*(3), 140-152.

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Appendix

Study habits survey questions and response percentages across five studies.

Questions	Response Options	Kornell & Bjork (2007)	Yan et al. (2014)	Hartwig & Dunlosky (2012)	McAndrew et al. (2016)	Current Study
1. Would you say that you study the way you do because a teacher (or teachers) taught you to study that way?	Yes	20%	36%	36%	14%	28%
	No	80%	64%	64%	84%	72%
2. How do you decide what to study next?	Whatever's due soonest/overdue	59%	61%	56%	67%	58%
	Whatever I haven't studied for the longest time	4%	4%	2%	3%	2%
	Whatever I find interesting	4%	8%	5%	4%	4%
	Whatever I feel like I'm doing the worst in	22%	20%	24%	11%	19%
	I plan my study schedule ahead of time, and I study whatever I've scheduled	11%	8%	13%	19%	17%
3. Do you usually return to course material to review it after a course has ended?	Yes	14%	41%	23%	14%	22%
	No	86%	59%	78%	83%	78%
4. All other things being equal, what do you study more for?	Essay/short answer exams	29%	38%	20%	13%	21%
	Multiple-choice exams	22%	17%	22%	38%	24%
	About the same	49%	45%	58%	49%	55%
5. When you study, do you typically read a textbook/article/other source material more than once?	Yes, I reread whole chapters/articles	16%	35%	19%	56%	15%
	Yes, I reread sections that I under-lined/highlighted/marked	60%	55%	64%	34%	52%
	Not usually	23%	10%	17%	10%	33%

6. If you quiz yourself while you study, (either using a quiz at the end of a chapter, or a practice quiz, or flashcards, or something else), why do you do so?	I learn more that way than I would through rereading	18%	15%	27%	30%	28%
	To figure out how well I have learned the information I'm studying	68%	62%	54%	55%	46%
	I find quizzing more enjoyable than reading	4%	6%	10%	9%	13%
	I usually do not quiz myself	9%	16%	9%	14%	13%
7. Imagine that in the course of studying, you become convinced that you know the answer to a certain question (e.g. the definition of a term in psychology). What would you do?	Make sure to study (or test yourself on) it again later	36%	36%	46%	39%	38%
	Put it aside and focus on other material	64%	63%	54%	59%	62%
8. What time of day do you most often do your studying?	Morning	N/A	N/A	<1%	28%	6%
	Afternoon	N/A	N/A	11%	27%	19%
	Evening	N/A	N/A	69%	47%	53%
	Late Night	N/A	N/A	20%	37%	22%
9. During what time of day do you believe your studying is (or would be) most effective?	Morning	N/A	N/A	15%	50%	21%
	Afternoon	N/A	N/A	27%	27%	33%
	Evening	N/A	N/A	50%	22%	37%
	Late Night	N/A	N/A	9%	19%	8%
10. Which of the following best describes your pattern of study?	I most often space out my study sessions over multiple days/weeks	N/A	N/A	47%	71%	17%
	I most often do my studying in a couple of sessions before the test	N/A	N/A	N/A	N/A	65%
	I most often do my studying in one session before the test	N/A	N/A	53%	30%	17%

11. What is your current college grade point average?	0.0–1.6	N/A	N/A	0%	1%	1%
	1.7–2.1	N/A	N/A	7%	0%	3%
	2.2–2.6	N/A	N/A	17%	3%	15%
	2.7–3.1	N/A	N/A	24%	30%	27%
	3.2–3.6	N/A	N/A	36%	45%	31%
	3.7–4.0	N/A	N/A	17%	18%	22%
12. Which of the following study strategies do you use **regularly**? (*Please check off all that apply.*)	Test yourself with questions or practice problems	N/A	46%	71%	80%	78%
	Use flashcards	N/A	40%	62%	17%	47%
	Recopy your notes	N/A	32%	33%	32%	38%
	Reread chapters, articles, notes, etc.	N/A	75%	66%	81%	62%
	Make outlines	N/A	30%	22%	44%	24%
	Underline or highlight while reading	N/A	59%	72%	54%	47%
	Make diagrams, charts, or pictures	N/A	20%	15%	41%	31%
	Study with friends	N/A	20%	50%	38%	46%
	“Cram” lots of information the night before the test	N/A	36%	66%	34%	64%
	Ask questions or verbally participate during class	N/A	N/A	37%	11%	20%
	Other (Please describe: _____)	N/A	N/A	6%	N/A	6%

Footnotes

[1] Discussions of distributed practice often make the distinction between spacing vs. massing (aka "cramming"). This classifies students into two categories that may inflate the estimated frequency associated with each. Including an option to reflect "light cramming" allows a more precise estimate of the proportion of students who truly distribute their study, vs. those who cram their study into a single session ("heavy crammers") or a couple of sessions ("light crammers").

[2] Estimates of *d* are based on Chinn's (2000) method for converting odds ratios to effect sizes.

[3] Like previous studies using the current survey, we used self-reported GPA as a proxy for student achievement. Although there is some concern about the construct validity of self-reported GPA (e.g., Kuncel, Credé, & Thomas, 2005), we were able to obtain transcripts from a subset of our sample ($n = 304$) and observed a strong positive relationship between actual GPA and self-reported GPA ($r = .91$, $p < .001$). Exam scores were also available for the entire sample, and we observed a strong positive relationship between average exam scores and self-reported GPA as well, $r = .64$, $p < .001$.

Table 1

Model Fits and Odds Ratios for GPA and Achievement Goals Predicting Study Strategies

			Performance		Mastery	
Strategy	χ^2	GPA	Approach	Avoidance	Approach	Avoidance
Test	39.81***	1.34***	1.02	1.06**	1.06*	1.02
Cram	51.97***	0.92	0.99	1.04*	0.87***	1.09***
Diagrams	35.61***	1.11	1.01	0.95**	1.10***	0.99
Flashcards	19.96**	0.92	0.99	1.03	1.05*	1.03
Questions	47.44***	1.35***	1.02	0.97	1.09**	1.03
Recopy	5.75	0.96	0.98	1.02	1.03	1.00
Reread	31.87***	0.94	1.02	0.95**	1.10***	1.01
Outlines	7.19	0.93	1.03	1.03	1.02	1.00
Underline	9.84	0.95	1.00	1.02	1.04	1.01
Friends	8.32	0.91	1.02	0.98	1.05*	0.99

Note: *$p < .05$; **$p < .01$; ***$p < .001$.

Table 2

Odds Ratios for Questions Examining Scheduling as a Function of GPA and Achievement Goals

			Performance		Mastery	
Response	Frequency	GPA	Approach	Avoidance	Approach	Avoidance
Question 2: How do you decide what to study next? (compared to "whatever's due soonest/overdue," 58% of responses)						
Longest time	2%	0.71	1.04	0.95	1.08	1.09
Interesting	4%	0.84	1.02	0.88**	0.94	1.00
Worst in	19%	0.96	0.97	1.00	1.01	1.00
Plan ahead	17%	1.24*	0.99	0.97	1.14***	0.97
Question 10: Which of the following best describes your pattern of study? (compared to "space out," 17% of responses)						
Light Cram	65%	1.01	1.00	1.03	0.90**	1.03
Heavy Cram	17%	0.96	0.99	1.11**	0.85***	1.01
Question 8: What time of day do you most often do your studying? (compared to "morning," 6% of responses)						
Afternoon	19%	0.89	1.07*	1.10**	0.93	1.00
Evening	53%	0.84	1.07*	1.07*	0.95	0.98
Late Night	22%	0.79	1.03	1.11**	0.92	1.04
Question 9: During what time of day do you believe your studying is (or would be) most effective? (compared to "morning," 21% of responses)						
Afternoon	33%	0.85	1.04	1.01	0.97	1.00
Evening	37%	0.89	1.03	1.03	0.97	0.97
Late Night	8%	0.84	1.03	1.01	1.01	1.01

Note: Frequency refers to the percentage of students who chose each response option. *$p < .05$; **$p < .01$; ***$p < .001$.

Table 3

Odds Ratios for Using Self-Testing as a Function of GPA and Achievement Goals

Response	Frequency	GPA	Performance		Mastery	
			Approach	Avoidance	Approach	Avoidance
Question 6: If you quiz yourself while you study, why do you do so? (compared to "I learn more that way," 28% of responses)						
How well I learned	46%	1.01	0.98	0.99	1.07*	0.97
More enjoyable	13%	0.89	1.02	0.98	0.97	1.00
I do not quiz myself	13%	0.88	0.97	0.96	0.97	0.95

Note: Frequency refers to the percentage of students who chose each response option. *$p < .05$; **$p < .01$; ***$p < .001$.