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Short- and Long-Term Effects of Cumulative Finals on Student Learning

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Abstract

In two experiments, we examined the benefits of cumulative and noncumulative finals on students' short- and long-term course material retention. In Experiment 1, we examined results from course content exams administered immediately after course finals. Course sections including cumulative finals had higher content exam scores than sections with noncumulative finals. In Experiment 2, current and former students completed online versions of content exams up to 18 months after course completion. Students completing courses with cumulative finals retained more than students who took noncumulative finals. Introductory psychology students benefited more from cumulative finals than did upper-division course students. Based on our results, we suggest that instructors use cumulative finals to increase short- and long-term retention of course material.

Keywords

final exams, testing effect, student learning

Students often enter a course on the first day of class and look ahead in the syllabus to see if the course will end with a dreaded cumulative exam. At the beginning of each course, instructors must consider whether or not they will require a cumulative final. Unfortunately, there is little research indicating whether using a cumulative final exam format will improve student learning. In lieu of solid research evidence, professors often make their decisions about the use of cumulative exams based on heuristics from their personal preferences or student opinions. Although many students may not favor comprehensive finals, Wesp and Miele (2008) found that students' opinions about how much they enjoyed certain in-class activities correlated poorly with the students' actual exam performance, so more empirically derived evidence should drive our pedagogical thinking, rather than student opinions.

Several researchers have suggested that cumulative exams have the potential to improve student learning. For example, Petrowsky (1999) surveyed students' perceptions and found that the majority of students in a class with a cumulative final reported that, when compared to their behavior in courses without a cumulative final, they spent more time studying the material from previous chapters, that the cumulative exam helped them learn material that they had missed earlier in the semester, and felt that reviewing the previous class material helped to promote a fuller understanding of the course. Nevid and Mahon (2009) found that brief quizzes given at the beginning and end of a lecture focused student attention on important course material and resulted in improved memory for important information covered in a class meeting. Similarly, Szpunar, McDermott, and Roediger (2007) examined repeated testing of word lists and found that the expectation of being retested over material led to a continued processing of the material that improved performance on the final test as compared to when the expectation of being retested on material was not present. Even though Szpunar et al. (2007) did not use tests similar to the exams given in a course, they suggest that if one expects an upcoming test on material, this can influence how the material is processed.

Being tested on specific course topics on an exam earlier in the semester signals to students the importance of that information for course performance. Thus, the students should know which topics likely will appear on the cumulative final. Students then are able to review and relearn with the benefit of knowing what is important to the course instructor. In fact, Nevid and Lampman (2003) found that students showed greater retention of information that was signaled as important (i.e., highlighted in the text margins) as compared to information that was given no such designation. In addition, other researchers have found that repeated quizzing throughout the semester results in better scores on final exams as compared to the performance without repeated quizzing (e.g., Brosvic & Epstein, 2007; Landrum, 2007; McGuire & MacDonald, 2009).

These reported benefits of repeated quizzing nicely coincide with recent work within cognitive psychology examining the

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testing effect (e.g., Karpicke & Roediger, 2008; Roediger & Karpicke, 2006). Testing effect researchers suggest that participants taking a quiz or test on recently learned material will experience greater retention of material than if they studied that material repeatedly (i.e., reread and reviewed the material without testing or self-testing; e.g., Karpicke & Roediger, 2008). Karpicke and Roediger (2008) argue that the act of engaging memory retrieval processes as one completes a test leads to this superior retention. We believe that taking a cumulative final exam creates a similar retesting situation as what has been found in testing effect research. The memory retrieval needed in this repeated testing through a cumulative final will create more sustainable memories of the course material than if it were included on only one exam. Howard (2011), on the other hand, found that prior exposure to test materials (i.e., being quizzed on a question or simply reading the question), not exclusively prior testing itself, led to enhanced student performance. Regardless of the theoretical underpinnings of repeated testing or exposure, examining the potential practical value of cumulative exams is an important, and apparently unanswered, empirical question. To the best of our knowledge, our research is the first direct, empirical test of the short- and long-term retention benefits of cumulative final exams in comparison to noncumulative final exams.

Although researchers of the testing effect suggest that cumulative final exams should improve students' learning, one can find little direct evidence of the benefits of cumulative finals within the extant literature (however, see Lawrence, 2013). In most studies, researchers use cumulative exams as the criterion for learning within a class (i.e., as the dependent variable rather than an independent variable, e.g., Landrum, 2007). Other researchers test knowledge retention over brief periods of time (e.g., 30 min) within a lab setting (e.g., Szpunar, McDermott, & Roediger, 2007), but these experimental conditions are very dissimilar to the conditions encountered during a semester's worth of learning.

To address this gap in the pedagogical literature, we conducted two experiments. The first experiment focused on the basic question: Do students who have a cumulative final at the end of a semester score higher on a measure of class content knowledge than students who do not have a cumulative semester final? However, having students remember more course-related information at the end of a semester is only the beginning of what teachers hope to accomplish with cumulative exams. A loftier goal for teachers is that students completing cumulative exams will retain course-related information for a long period of time beyond the end of the semester. Unfortunately, some researchers suggest that students do not retain much content knowledge after completing their introductory courses (Rickard, Rogers, Ellis, & Beidleman, 1988; Spitzer, 1939; VanderStoep, Fagerlin, & Feenstra, 2000; however, see Scepansky & Carkenord, 2004, for dissenting conclusions) and that students experience this decay of knowledge relatively quickly after the semester ends (e.g., in less than 17 days; Bunce, VandenPlas, & Soulis, 2011). However, in the short term, Bunce, VandenPlas, and Soulis (2011) found that cumulative exams were one of several pedagogical techniques that may prevent the decay of student knowledge over the short term (i.e., 17 days).

Thus, our second experiment measured student retention for course material from zero to three semesters (i.e., 0–18 months) after course completion, comparing students who had completed courses utilizing cumulative exams with students who did not have cumulative exams in their classes. We hypothesized that students completing cumulative finals would retain more course-related material than would students completing noncumulative finals.

Finally, Landrum (2007) suggested the possibility of a differential advantage of cumulative testing for introductory students over advanced students. A few additional researchers indicate that novice students with the greatest amount of knowledge to gain (e.g., introductory students), and/or lower performing students may benefit more from repeated testing than do students who already have a firm knowledge base, such as students in upper-division courses (e.g., Landrum, 2007; Lawrence, 2013; Swanson, Holtzman, & Butler, 2010). Landrum (2007) found that students earning top, middle, and bottom grades improved their scores from initial quizzes to a cumulative final, but the effect was most notable for students scoring in the bottom third of the introductory course, indicating the effect of repeated testing was most noticeable for students with the most to learn. Therefore, in our second experiment, we also examined the potential differences between students from introductory psychology and upper-division courses. We hypothesized that introductory students would benefit more from cumulative finals than upper-division students, but that both groups would benefit.

Experiment 1

Method

Participants

All students enrolled in one of our core psychology courses (e.g., introductory psychology, research methods and statistics, abnormal psychology, social psychology, cognitive psychology, infant and child development, etc.) completed a content exam immediately after finishing their final exam, as part of our departmental assessment plan. Some of the course sections included a cumulative final exam; other sections included a noncumulative final exam due to instructor preferences. On average, there were 50 students enrolled in each of the sections of introductory psychology and 20–24 students in each of the upper-division courses. For our analyses, we used the class average performance on our content exams rather than individual student scores because students are allowed to submit their content exams anonymously. We should note that students have no extrinsic motivation to perform well on these content exams. Thus, the performance on these content exams may be lower than on exams in which performance is tied to student grades. However, the lack of extrinsic motivation to do well on

these exams is uniform across all course sections, regardless of course level or of final exam format.

Materials and Procedure

Experiment 1 involved Institutional Review Board (IRB)-approved archival use of data collected for faculty assessment purposes as part of our standard departmental procedures. We described the aims of this study at a department meeting, and faculty individually consented to the use of their de-identified evaluation data for the purposes of this study. Faculty members also indicated whether they used a cumulative or a noncumulative final for each course section. Our psychology department uses content exams as quantitative evidence of teaching effectiveness to measure if students are retaining the most important material taught in our courses by their instructors. These content exams were designed for introductory psychology and for each major content area course within psychology (e.g., research methods and statistics). The instructors of each course (e.g., all instructors who teach research methods and statistics) worked together to create the content exams. They agreed on the key concepts of their course and designed questions about those concepts. Instructors also agreed to refrain from using the exact questions contained on the content exams within their course unit exams. The content exam for introductory psychology contains 18 multiple-choice questions, while the content exams for other courses include 15 multiple-choice questions. These content exams are given at the end of each semester to evaluate how much of the essential content from each course the students learned during the semester.

A student's score on this assessment is not included in the student's grade for the course, but instead, a course section's average score on the content exam is used to evaluate the instructor at annual review. We tell the students that course content exams are only used to evaluate the instructors, not the students. Because this is program evaluation data of our teaching, we ask all students to complete the content exams at the end of each semester. We let them know that their content exam scores will remain confidential, that each student could choose to submit his or her content exam anonymously, and that the course instructor will not know how each student performs. Thus, we do not know whether performance on these course content exams is related to an individual student's performance on course assignments. All students present at their regularly scheduled final exam have submitted these content exams and many of them chose to submit their content exams anonymously. For each course, students are asked to complete the content exams immediately after submitting their final exams. That is, each student completes and submits his or her final exam, and then is given the content exam to complete. The students are allowed as much time as needed to complete the content exam, but most take 10–15 min to complete these exams. Given the archival nature of these data, and the fact that we cannot identify individual student scores, we used each course section's average content exam percentage correct score as our unit of measurement.

Table 1. Experiment 1: Descriptive Statistics for Exam Format by Course Level.

	Cumulative Exam			Noncumulative Exam		
Course level	*M*	*SD*	*n*	*M*	*SD*	*n*
Introductory	76.66	(4.01)	3	63.26	(6.82)	10
Upper division	82.60	(4.54)	10	72.19	(10.55)	15

Note. *M* = mean; *SD* = standard deviation. The *n* depicts the number of courses.

Average content exam scores were evaluated for 13 of the 14 sections of introductory psychology taught during the 2007–2008 academic year, and for 25 of the 26 sections of upper-division courses for which the department utilizes content exams. Of the introductory psychology sections, 3 included cumulative finals, while 10 did not. For the upper-division courses, 15 sections included cumulative finals and 10 did not. One introductory psychology section was not included in our analyses because of administration error (i.e., completed exams were misplaced by department administrators after the end of the semester). One upper-division section was not included in any analyses because the instructor did not provide consent for these course data to be included in the analyses.

Results and Discussion

Exploring the first question regarding impact of final exam format on student retention of course material immediately after completing the course, we performed a 2 (final exam format: cumulative vs. noncumulative) × 2 (course level: introductory psychology vs. upper division) analysis of variance using average course content exam percentage correct scores as our cases. We did not find an interaction between final exam format and course level ($F < 1$). However, we did find main effects of both final exam format and course level. That is, classes taking cumulative finals performed reliably better than classes who had noncumulative finals, $F(1, 34) = 14.63$, $\eta^2 = .23$, $p < .001$. In addition, upper-division classes had higher percentages correct than introductory psychology classes, $F(1, 34) = 5.707$, $\eta^2 = .09$, $p < .05$. See Table 1 for means and standard deviations for each cell.

Class averages comprised the available archival data, so Experiment 1 had less power than if we had been able to use individual student scores as our unit of measurement. Despite our small cell sizes, we believe the results from Experiment 1 clearly support the practice of using cumulative rather than noncumulative final exams in order to improve student retention of course material. In addition, we found that introductory psychology classes did not perform as well on course content exams as did upper-division classes, so we wondered if the relatively small cell sizes provided by our comparison across class averages may have prevented us from observing a potential interaction between final exam format and course level on content exam performance. Thus, in Experiment 2, we conducted a

larger study in which we invited former students from all of our courses that have content exams to participate. Furthermore, we contacted our potential participants zero to three semesters (i.e., 0–18 months) after course completion. By contacting former students some time after course completion, we were able to evaluate if the retention benefits afforded by taking cumulative finals persist well after course completion.

Experiment 2

Method

Participants

We invited students who completed either introductory psychology and/or an upper-division psychology course utilizing a content exam to complete an online course content exam. Across our three data collection phases, we e-mailed 4,732 survey invitations. We received a total of 450 completed online content exams; 335 of these were for introductory psychology and 115 were from upper-division psychology courses. We sent all e-mail invitations to students' official university e-mail addresses. We believe that this practice may have lead to our low survey completion rates. Students may have used other e-mail accounts as their primary e-mail source and may not check their university accounts frequently, especially over winter and summer breaks. When participants did submit surveys, they could do so anonymously or they could include identifying information in order to be entered into a drawing to win one of the three Apple iPod Touches® (for the first two data collection rounds) or in a drawing to win an Apple iPad® (last data collection round).

We cannot be certain of the number of unique survey respondents across the multiple content exams because participants had the option of submitting their online content exams anonymously. We did not feel that it was appropriate for us to require respondents to submit identifying information in order to participant in this experiment. We believe this for two reasons. First, because many of the potential participants were current students and all researchers on the project were faculty members, we did not want potential participants to feel coerced into participation. Second, we were concerned that because these surveys contained course-related materials, participants might feel that their performance could affect future grades within psychology courses. Unfortunately, because participants had the option of submitting their surveys anonymously, we cannot be certain if participants submitted surveys for specific courses (e.g., introductory psychology) during each of the three data collection waves. See Table 2 for a description of surveys submitted across the three waves of data collection in Experiment 2.

Table 2. Number of Surveys Submitted for Each Wave of Data Collection.

	Semester of Course Completion			
	Fall 2008	Spring 2009	Fall 2009	Spring 2010
Data collection wave				
July 2009	98			
January 2010	32	43	69	
June 2010	30	41	71	62

Note. We also indicate the number of surveys submitted for each course semester within each wave of data collection.

Materials

For Experiment 2, we converted our introductory psychology and upper-division course content exams into versions that could be administered online. We chose to administer these follow-up content exams online for two reasons. First, we wanted participants to complete the online content exams in a setting that was outside of their psychology courses. We did not want the participants to feel that their performance on the online content exam was associated with their course performance or grade in any way. Second, we wanted the ability to ask participants to complete these online content exams some time after course completion, which meant that many of the participants would graduate from the university in the interim. Thus, the only viable way to contact them and for them to complete the exams was via an online format. The online content exams included the same 18 (for introductory psychology) or 15 (all other courses) multiple-choice questions as were included in our end-of-semester content exams. Each course survey also included a question in which the participant indicated whether or not the final exam for that course was cumulative.

Procedure

We invited current and former psychology course students to complete online content exams for courses they had just completed the previous semester as well as courses they had completed up to three semesters earlier (i.e., the courses for which they completed content exams ended 0–18 months earlier). We did this in three waves of data collection. In the first wave, completed in July 2009, we contacted students who had completed a psychology course in the Fall 2008 semester. In the second wave, we contacted students in January 2010 and invited those students who had completed a psychology course in at least one of the last three semesters (i.e., completed the courses in Fall 2008, Spring 2009, and/or Fall 2009) to complete the online content exams. In the third and final wave, we contacted students in July 2010 and invited those students who had completed a psychology course in at least one of the last four semesters (i.e., completed the courses in Fall 2008, Spring 2009, Fall 2009, and/or Spring 2010) to complete the online content exam. Thus, students who completed one or more psychology courses in Fall 2008 were contacted in all three waves of data collection. If students completed more than one psychology course, they received multiple invitations, one for each psychology course completed. When potential

participants received the e-mail invitation, it clearly indicated for which class they were being asked to complete an online survey. This e-mail invitation also served as the basis for our informed consent process for the experiment, which indicated that participation was voluntary and allowed students to decide whether or not to participate.

The university's social and behavioral research IRB reviewed and approved this educational study, including our online survey data collection method utilizing a waiver of documentation of informed consent. At the end of the invitation e-mail, potential participants indicated if they chose to proceed with participation or to decline the invitation by clicking on one of the two hyperlinks that either took them to an online survey or to an online screen indicating our thanks for their consideration and our contact information for further questions that they may have. Again, see Table 2 for a breakdown of the surveys submitted within each wave of data collection.

When participants indicated that they wanted to participate in the study by clicking on the hyperlink within the e-mail consent documents, they were connected to the online survey on the university survey site (operated by Vovici®). This survey included optional demographic information (e.g., name, phone number, etc.), a section in which participants indicated all of the psychology courses they completed, and then the questions from the designated departmental content exam. Participants also indicated if the course for which they were completing a survey included a cumulative final.

The same e-mail invitation/consent process and online survey completion was conducted for the three data phases: July 2009, January 2010, and July 2010. With each data collection phase, more former students were contacted and more surveys were completed and submitted. By conducting multiple data collection phases, we were able to track the influence of time delay since course completion on the impact of cumulative versus noncumulative final exams.

Results and Discussion

We conducted analyses to address our three main questions regarding the longitudinal study—(1) Did participants completing courses with a cumulative final retain more information than did participants who had a noncumulative final? (2) If there was an information retention advantage for participants completing a cumulative final, did this advantage persist over time? and (3) Was the impact of a cumulative versus noncumulative final the same for both introductory psychology and upper-division courses?

To address these questions in Experiment 2, we performed a 2 (final exam format: cumulative vs. noncumulative) × 2 (course level: introductory vs. upper division) analysis of covariance (ANCOVA) with time lag as a covariate. For each participant, we calculated the number of months (or proportion of years) that had elapsed between the submission of the survey and the end of the corresponding course. For example, if a student submitted a survey in July 2009 for a course that ended in December 2008, that time lag was coded as 7 months or 0.5833 years. We did this instead of treating time lag as a categorical variable (i.e., number of semesters passed) because the number of months that pass between one semester to the next is not constant. For example, one semester passes between a course that ends in May and a survey submitted in the following January, while one semester also passes between a course ending in December and a survey completed in the following June. However, in the first case, 7 months have passed, while only 6 months have passed in the second case. Thus, we treated time lag as a continuous variable and used it as a covariate in our analyses.[1] From this ANCOVA, we found main effects of each of these factors, but no interactions. Those taking cumulative finals performed reliably better than those who had noncumulative finals, $F(1, 441) = 4.17$, $\eta^2 = .008$, $p = .042$. In addition, participants completing upper-division courses performed better than those participants completing introductory psychology, $F(1, 441) = 69.59$, $\eta^2 = .133$, $p < .001$, regardless of final exam type. Time lag also influenced survey performance with survey scores decreasing as the time between course completion and survey submission increases, $F(1, 441) = 13.06$, $\eta^2 = .025$, $\beta = -1.57$, $p < .001$.

Although we did not find an interaction between final exam format and course level, we conducted additional planned ANCOVAs separating out the performance of participants completing introductory psychology content exams and those completing upper-division course content exams. Based on Landrum (2007), we expected that students with more knowledge to gain (i.e., introductory psychology students) would benefit more from cumulative testing than would students with a prior existing knowledge base. For these analyses, we examined the effects of test type (cumulative vs. noncumulative) and time lag. Our separate analyses of introductory psychology surveys and upper-division surveys support Landrum's (2007) hypothesis. Specifically, for the introductory psychology surveys, we found main effects of final exam type, $F(1, 328) = 7.43$, $\eta^2 = .021$, $p < .001$, and time lag, $F(1, 328) = 13.45$, $\eta^2 = .038$, $\beta = -1.96$, $p < .001$, with participants completing cumulative final exams producing higher survey scores than participants completing noncumulative finals and participants' survey performance decreasing as the time lag since course completion increases. We did not find the same pattern of results for the upper-division course respondents. Specifically, we did not find a main effect of final exam format or time lag (all Fs < 1). See Table 3 for these outcomes. In Table 3, we present the results in terms of the number of semesters that elapsed between the time of course completion and survey submission. Thus, there are 4 time levels (0–3 semesters) instead of months or proportion of years between survey submission and course completion.

We suspect that the absence of a cumulative final advantage in survey performance for upper-division courses and the absence of a time lag effect on the upper-division courses may be due to the fact that most students in our upper-division courses are psychology majors. It is interesting to note that Scepansky and Carkenord (2004) found a similar pattern of results in which graduating psychology majors retained a

Table 3. Experiment 2: Descriptive Statistics for Exam Format by Course Level and Time Lag.

	Cumulative Exam			Noncumulative Exam		
Course level	*M*	*SD*	*n*	*M*	*SD*	*n*
Introductory (overall)	63.90	(19.00)	227	57.75	(18.21)	104
Zero semesters	69.14	(18.92)	74	65.97	(15.57)	32
One semester	62.87	(17.65)	95	53.70	(19.99)	48
Two semesters	57.65	(21.56)	45	55.13	(8.321)	13
Three semesters	63.25	(12.53)	13	54.55	(19.69)	11
Upper division (overall)	78.14	(13.88)	61	75.68	(16.89)	54
Zero semesters	80.75	(10.94)	18	76.19	(8.48)	7
One semester	78.28	(12.29)	31	74.21	(18.41)	38
Two semesters	75.24	(22.68)	7	79.99	(16.32)	7
Three semesters	71.99	(19.65)	5	86.67	(9.43)	2

Note. *M* = mean; *SD* = standard deviation. The *n* depicts the number of respondents.

surprising proportion of information from their research methods and quantitative methods courses. As a major in psychology, these students are exposed to similar concepts in several courses throughout their studies. In fact, the students completing the upper-division surveys three semesters after course completion had taken an average of 10.38 psychology courses and 16 of the 21 respondents were psychology majors (we know this because all of these upper-division test respondent submitted identifying information). Thus, in the time lag between completing a specific course and responding to our online course content exams, these students had repeated study and exposure to many of the concepts on the content exams. Not surprisingly, the impact of one cumulative final exam diminishes as compared to what we found with our introductory psychology survey respondents.

General Discussion

Regardless of type of course, students with cumulative finals did better on departmental content tests than students in courses with noncumulative exams, and this result was noticeable immediately after their final exam. Students in introductory psychology benefited more from cumulative exams than students in upper-division courses. Specifically, introductory students taking cumulative finals outperformed those taking noncumulative finals even 18 months (or three semesters) after course completion. Arguably, students in introductory psychology have the most to gain from taking a cumulative final exam because they are less likely, as compared to students taking upper-division courses, to have fully mastered the material, as Landrum (2007) suggested. The introductory psychology students completing cumulative finals get repeated exposure to the material on the exam. They are exposed to it during the time they initially learn and are tested on the material in the middle of the semester, and they are exposed to the material again at the end of the semester when taking the cumulative final exam. Upper-division students taking cumulative finals also are exposed to the exam material within the semester and, again, in the cumulative final. However, students taking upper-division courses have taken at least one, and likely more, previous psychology courses. Thus, the benefit of the additional exposure to course material that occurs when one completes a cumulative final is diminished relatively because they have been exposed to psychological concepts many times across courses.

Given that a single 3 or 4 credit course in introductory psychology is the required introductory experience to the major at 80% of institutions in the United States, and nearly all majors are required to begin with either the single course or a series of introductory courses (Stoloff et al., 2010), finding simple ways to improve learning outcomes in this foundational course is important. Courses within the major should build upon each other (Stoloff et al., 2010) and the evidence is that they do (e.g., Nathanson, Paulhus, & Williams, 2004; Sanders-Dewey & Zaleski, 2009; Tobin & Gebo, 2008). The diminished impact of a cumulative final in upper-division courses is reasonable if in fact the upper-division courses cover material initially introduced in introductory psychology and perhaps taught in other courses, as well. We believe the lessened effect of cumulative final exams in our upper-division courses may result from repeated exposures to material that naturally occurred as part of a well-developed curriculum, so this finding continues to support the importance of repeated exposure and study.

As a result of these findings, we believe using cumulative finals improves student learning, and we encourage instructors to utilize cumulative finals in their classes. We also encourage instructors to investigate and report other pedagogical strategies that enhance students' memory of course materials, because even in our optimal study condition (immediate content exam administration in upper-division courses with cumulative finals) students only answered 82% of the content exam items correctly. In the worst condition (18 month time lag for introductory psychology courses with noncumulative finals), students retained just over half of the most important information from introductory psychology.

Finding new ways to enhance student motivation to learn may improve pedagogical practice and content retention. Marrs, Sigler, and Hayes (2009) found that motivation was the most important discriminating variable between students earning the highest and lowest grades in introductory psychology. Further, Szpunar, McDermott, and Roediger (2007) suggest that awareness of an upcoming cumulative test can provide motivation for students to learn and retain course material. Brosvic and Epstein (2007) suggest that "postmortem" test reviews offer little benefit, as students may not be motivated to learn from the review, because that new learning will not affect their grades on an already completed test. However, if students anticipate a cumulative final in which content from previous exams may appear on an upcoming exam, they will feel motivated to learn from feedback about test item performance (Brosvic & Epstein, 2007). We believe that motivation to learn is improved when students are interested in what they are learning and have an incentive to learn the material (Marrs, Sigler, & Hayes, 2009). In turn, we believe that when students

realize they will have a cumulative final exam, they will be more motivated to learn course material and to solidify their understanding of the course material in their initial learning.

Reasonably then, students facing the specter of a cumulative final, on which performance might improve if they learn from their incorrect answers may well increase motivation to correct errors in learning. This may result in higher final exam scores and higher content exams scores. Most importantly, using cumulative final exams appears to increase retention of course content over both the short and, in some circumstances, the long term. We found evidence for an immediate benefit for cumulative final exams for both introductory psychology students and upper-division course students in Experiments 1 and 2. Furthermore, we saw the long-term (i.e., 1.5 years) knowledge retention benefit for cumulative final exams in students completing introductory psychology in Experiment 2. We believe that we did not find long-term knowledge retention benefits for students completing cumulative finals in the upper-division courses, because most of the students submitting these upper-division course exams were psychology majors. Thus, these students had taken several psychology courses in the time lag between course completion and the submission of our online content exams. Reasonably, the relative potency of a single cumulative exam diminishes as students are repeatedly exposed to a myriad of related topics in their psychology courses; however, the bottom line is that repeated opportunities to learn and be tested over key information benefits the students.

We know that many instructors may be reluctant to use cumulative finals because students tend to not like them. However, we urge instructors to keep in mind that students have little insight into the educational benefits of pedagogical practice (Wesp & Miele, 2008). Instructors can share with their students the benefits of cumulative final exams and emphasize the reason to take college courses is to learn information for the future. Furthermore, if more instructors adopt the use of cumulative final exams, then students will grow accustomed to them and fully expect them. This has been the case in our department.

In conclusion, the sum of the data presented across both our experiments supports the advantage of cumulative over noncumulative finals. As a result, we strongly recommend that instructors adopt the use of cumulative exams in their courses, especially in their introductory courses. Improved learning through cumulative exams not only benefits students but also has the potential to benefit the profession, by producing graduates who retain more of the information they acquire during training.

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Note

1. We also conducted a 2 (test type) × 2(course level) × 4 (number of semesters) analysis of variance. In this analysis, we again found a main effect of course level with the participants submitting upper-division course surveys scoring higher than participants submitting introductory psychology surveys, $F(1, 432) = 55.12$, $\eta^2 = .104$, $p < .001$. We also found a marginal effect of time lag, $F(3, 432) = 2.09$, $\eta^2 = .012$, $p = .101$. However, we did not find a significant effect of exam type on survey score in this analysis, $F(1, 432) = 1.88$, $\eta^2 = .004$, $p = .17$. Although there was a trend such that participants produced higher scores on the surveys if they had taken a cumulative final exam as compared to a noncumulative final. We suspect that this effect did not reach significance because, in this analysis, we collapsed the time lag measure into four categories, rather than treating it as a continuous variable. This decreased the power of the analysis and it introduced more degrees of freedom.

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