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The impact of time between cognitive tasks on performance: Evidence from advanced placement exams

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ABSTRACT

Students are often required to perform several mental tasks in a short period of time, and their performance is likely to depend on how closely the tasks are scheduled. We examine this phenomenon in a particular context: Advanced Placement (AP) exams in the United States. We exploit variation in the AP exam schedule from year to year which results in a student who takes two exams in one year having more or less time between the exams than a student who takes the same two exams in a different year. We find evidence that more time between exams results in higher scores, particularly on the second exam, and that this effect varies across different types of students. Our estimates suggest that a student taking two exams ten days apart is 6–8% more likely to pass them both than a student taking the same exams only one day apart.

In educational settings, students are often faced with many projects and tasks that demand their attention. These competing demands require them to make careful trade-offs as to where they devote their time and energy, especially when they have two tasks scheduled close together. For physically demanding tasks, it is clear that the amount of time between them can significantly affect performance—running two consecutive miles is much harder than running two miles with a rest period in between. In fact after some physical events, such as ultra-marathons, athletes need several weeks of recuperation before they can return to peak performance (Chambers, Noakes, Lambert, & Lambert, 1998). However, it is less clear how time between cognitive tasks will affect performance. For example, imagine a student who must take two difficult exams a few days apart. Will her performance decrease because the exams are scheduled close together? Or is a one or two day separation enough to allow the student to prepare properly and return to peak mental acuity?

These questions are difficult to answer with observational data because the scheduling of tasks is endogenous.[1] A person who receives an assignment or volunteers to complete tasks that are scheduled close together may be very different from a person who does not. People may also organize their schedules to avoid having difficult tasks scheduled close together. Selection bias in both the types of tasks and the people who complete them can result in misleading conclusions about the importance of time between tasks on performance.

We identify the causal effect of time between cognitive tasks on performance by exploiting a novel natural experiment made possible by the timing of Advanced Placement (AP) exams. In May of each year, hundreds of thousands of high-school students in the United States take AP exams administered by the College Board. For most students, these exams are the culmination of a year of study in an AP course

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[1] These questions are difficult to answer in laboratory settings as well since the experiment would necessarily have to run multiple days and require large incentives to motivate survey participants.

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intended to be comparable to college-level work.[2] Each year the College Board fixes an exam schedule which applies to all students in the country, and we exploit the fact that this schedule changes from year to year. We analyze administrative data for a 10% sample of all AP exam takers in the United States between 1996 and 2001 who took exactly two exams in the same year. Our sample consists of thousands of students who took the same two AP exams but who differed in the amount of time between those exams. We use this exogenous variation in the time between exams to identify its causal impact on exam performance.

Our results indicate that performance significantly improves with more days between exams. Increasing the number of days between exams from 1 to 10 improves the combined point total on the two exams, which ranges from 2 to 10, by approximately 0.11–0.14 points (0.05–0.07 standard deviations) and the probability of passing both exams by 6–8%. Rather remarkably, within the range of our data this relationship is essentially linear, which means that increasing the time between exams from 1 to 3 days has a similar impact on performance as going from 8 to 10 days. The effects that we find are stronger for some subgroups (e.g. females and Asians) than for others. We also find that the estimates are driven almost entirely by an increase in performance on the second exam.

There are several potential underlying mechanism for the effects that we find including cognitive fatigue or differences in the ability of students to make use of last-minute preparation time. Our data are unable to fully distinguish between these underlying mechanisms, although they do provide some clues. In the final section, we discuss these mechanisms in more detail.

Our findings contribute to large bodies of work in psychology exploring cognitive fatigue, cognitive load, and memory recall.[3] Cognitive or mental fatigue has a rich tradition in psychology (e.g. Ebbinghaus, 1896–1897; Offner, 1911). Studies have focused on the impact of fatigue on the ability to process information (Sanders, 1998), on future effort (Meijman, 2000), and on mood fluctuations (Broadbent, 1979; Holding, 1983). Much of this work has focused on the impact of task length (e.g. total exam time) on average performance. For example, Ackerman and Kanfer (2009) provide a nice review. They argue that the evidence is inconclusive regarding the impact of exam length on performance and produce empirical results that actually find that performance can increase with exam length. Overall, the evidence suggests that while cognitive fatigue may not immediately hurt automated tasks, it can have a sharp impact on more complex tasks (Holding, 1983; Kuhl and Goschke, 1994).

Related to mental and cognitive fatigue is the literature on "cognitive load" and memory (see Paas, Renkl, & Sweller (2004) and Cepeda, Pashler, Vul, Wixted, and Rohrer (2006) for related reviews). Cognitive load theory is based on the idea that working memory is limited and that performance, reasoning, and learning degrades as the working memory fills up. How short and long-term memory works has been the study of hundreds of cognitive psychologists and a thorough review of this literature is beyond the scope of this paper. As we discuss in the conclusions section, we do not attempt to test a particular underlying mechanism or cognitive theory for our findings, but rather we focus on the overall impact of time between tasks on performance in the particular domain of AP test taking.

The paper is organized in the following way. In Section 1, we provide background information about the Advanced Placement exam program and discuss the data that we use in our study. In Section 2, we lay out our empirical strategy. We report our results in Section 3, and we conclude with a discussion of our findings and their broader implications in Section 4.

1. Advanced placement exams and data

In May of each year, Advanced Placement (AP) exams are administered to high-school students by the College Board (the same company that administers the SAT college admissions exam). For most students, these exams are the culmination of a year's worth of study in an AP course intended to be comparable to college-level work. In 2013, more than 2.2 million students took at least one AP exam, resulting in over 3.9 million total exams taken.[4] Exams are currently offered on 34 different subjects and include both multiple-choice and free-response sections. They are graded by college professors and other individuals with expertise in the subject who are employed and trained by the College Board. Each exam is given an integer score from 1 (lowest) to 5 (highest), with the cutoffs for each number determined freshly every year for each subject exam. Students are highly motivated to perform well on these exams for at least two reasons. First, high scores on AP exams are thought to impress college admissions committees. Of equal importance, many colleges and universities offer college credit for passing marks (a score of 3 or higher) on AP exams.

We obtained administrative data for a 10% random sample of all AP exam takers from 1996 through 2001.[5] We restrict the sample to students who took exactly two exams in the same year, which results in 238,138 AP exams taken by 119,069 students. Table 1 lists the AP exams taken by the students in our dataset, ordered by subject popularity. United States History, English Language, English Literature, and Calculus were the most popular exams. Very few students took Physics C: Electricity and Magnetism, French Language and Culture, or Latin.

Table 2 provides basic summary statistics for the students in our sample. More than 80% are high-school seniors. The average AP exam score for these seniors is lower than the average score for juniors and sophomores, suggesting that

[2] There are currently 33 exams, each covering a different subject area such as Calculus, Chemistry or European History.

[3] In economics, our paper relates to work by Coviello, Ichino, and Persico (2010) on multitasking. They show that Italian judges who were randomly assigned to work on several trials in parallel spent more time than if they did the trials one after the other. There is also work in behavioral economics that explores the impact that time-inconsistent preferences can have on performance when there are varying amounts of task separation (Ariely and Wertenbroch (2002) and see DellaVigna (2009) for a review of this literature)

[4] This information was obtained from the College Board's website on Oct. 25, 2013. http://media.collegeboard.com/digitalServices/pdf/research/2013/Number-of-Exams-per-Student-2013.pdf

[5] We thank the College Board for making these data available to us.