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Optimizing Learning in College: Tips From Cognitive Psychology

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Abstract
Every fall, thousands of college students begin their first college courses, often in large lecture settings. Many students, even those who work hard, flounder. What should students be doing differently? Drawing on research in cognitive psychology and our experience as educators, we provide suggestions about how students should approach taking a course in college. We discuss time management techniques, identify the ineffective study strategies students often use, and suggest more effective strategies based on research in the lab and the classroom. In particular, we advise students to space their study sessions on a topic and to quiz themselves, as well as using other active learning strategies while reading. Our goal was to provide a framework for students to succeed in college classes.

Keywords
learning techniques, memory, study strategies, metacognition, college success

Imagine a first-year college student (let's call him Mark) preparing for his first big mid-term examination. Mark studies hard: He stays up late the night before the test, highlighting his textbook and poring over his notes. A week later, Mark is surprised to find a big red C– on his examination. Mark's case is not unusual, especially in large introductory lecture courses where some students do not know how to prepare and to study for success in a college class.

Consider introductory psychology. Most students arrive with little idea of what psychology is about, but they are suddenly thrust into a rampage through a textbook with 15 chapters on 15 very different topics. The professor may cover perceptual illusions one week, classical conditioning the next week, and romantic relationships after that. The sheer number of technical concepts introduced each week demands study and concentration. How should students study and prepare for such a seemingly insurmountable amount of material? Every introductory college course—biology, economics, history, or physics—poses a similar challenge.

When college students are surveyed on how they study, many report relying on certain strategies such as highlighting (or underlining) as they read—upward of 80% of students report rereading their textbook and notes as their primary form of studying, often focusing on only the highlighted parts (Hartwig & Dunlosky, 2011; Karpicke, Butler, & Roediger, 2009). Despite the popularity of such strategies, research in cognitive and educational psychology suggests that they may consume considerable time without leading to durable learning (e.g., Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

The good news is that psychologists now better understand which study strategies are effective and which are not. For example, research has shown that students learn more when their studying is spaced apart in time rather than crammed into one long session (Carpenter, Cepeda, Rohrer, Kang, & Pashler, 2012) and that taking practice quizzes may be better than rereading the textbook (Roediger & Karpicke, 2006). Another effective strategy is to answer some questions about a topic before doing the reading rather than afterward (e.g., Richland, Kornell, & Kao, 2009). We discuss these techniques in more detail later.

Many of these strategies may seem counterproductive to both students and teachers. After all, quizzing and

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these other techniques take more effort and time and may even appear to slow learning. However, all the strategies noted in the previous paragraph encourage students to actively think about what they are learning and to do so in a deeper, more meaningful way. Students who use these strategies retain information longer and are better able to apply that knowledge to new problems (Dunlosky et al., 2013). Furthermore, research findings have suggested that one reason students struggle in classes is overconfidence: They may know less than they think they do (e.g., Hacker, Bol, Horgan, & Rakow, 2000) and may underestimate how quickly they will forget what they have learned (Koriat, Bjork, Sheffer, & Bar, 2004). The strategies described can help students to assess more accurately what they know and what they do not know and encourage a more active engagement with the material.

The aim of this article is to provide a brief tutorial in how to optimize learning in a college course. Most of the strategies are based on research, whereas a few (about organization, time management, and other factors) are based on our experience as educators and suggestions from time management books. We have provided select references in the text for readers who are interested in learning more about these techniques, and at the end of our article, we have listed several books for those who are interested in knowing more about the process of learning.

In choosing our suggestions, we assumed a motivated student, someone who genuinely wants to learn the material and receive a good grade. If you are motivated, then these strategies will help you to learn more in your classes. Although we have written this article for those of you taking introductory college courses, our advice also readily applies to other learning situations, including high school, medical school, and law school.

Starting the Semester

Students who struggle in school tend to make poor time management decisions, such as staying up late to study (Hartwig & Dunlosky, 2011; Weinstein, Lawrence, Tran, & Frye, 2013). Give yourself a head start by getting organized early in the semester and establishing a few key habits. (You likely know all of this already, but it is good to be reminded.)

Organize your time

For starters, go to the first day of class. The professor will hand out the syllabus, identify major assignments, and talk about course goals. Once you have the syllabus, read it carefully; these 5 to 10 pages will be your road map for the semester. Then, enter the examination days and due dates for major assignments for all of your classes into your calendar (this is also a good time to add extracurricular commitments like sporting events). Make it a habit to review the upcoming month once a week. Visualizing the chronological landscape of the semester will help you to see everything that you need to do and will alert you when you need to start studying early (e.g., if several assignments are due at the same time). Setting calendar reminders for the week before each exam and project (or for recurring tasks, like online quizzes) can prevent things from slipping through the cracks. If organization does not come easily to you, look into a time-management system (such as the *One Minute To-Do List* by Linenberger, 2014) or see if your school offers time-management workshops.

Buy or rent your books before the course

You must have them to get started. Some students prefer used books because they are a bit cheaper, which is fine, but be careful about books that are already highlighted: The book's previous owner may not have identified the important ideas, and paying attention to poor highlighting can hurt your understanding (Silvers-Gier, Kreiner, & Natz-Gonzalez, 2009).

Find a quiet place to study

If you are serious about studying and learning, eliminate distractions. Students often study with Facebook and e-mail competing for their attention while watching people come and go in a coffee shop. Research has shown that repeatedly switching attention among tasks makes learning less effective (e.g., Anderson & Fuller, 2010; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). Distractions such as listening to music or having a TV on in the background can make it more difficult to learn, even if you feel like it does not bother you (see Willingham, 2010a, for an overview of issues related to studying and technology). To help you focus while you study, start the habit of studying in a quiet place with social media turned off.

Preparing for Each Class

If the professor tells you to do the reading before class, do it! You will get much more out of class. Be careful, though, about how you do your reading. Many students seem to read as quickly as possible: "I need to get through my history reading so I can get to my psychology reading." This is understandable, but do not rush. Comprehension requires time—reading faster means you may remember less (what is known as a *speed–comprehension trade off*; see Rayner, Schotter, Masson, Potter, & Treiman, 2016). Your goal when reading should be to understand the

chapter, not just to finish it. So how can you get the most out of your reading?

As mentioned earlier, highlighting and underlining are popular, but research has shown that they usually do not help students to remember the material any better (Dunlosky et al., 2013). Instead, try one of the following research-supported tactics (Dunlosky et al., 2013; McDaniel & Callender, 2008). As you will see, these methods require you to think deeply about the material as you read and allow you to check what you learned.

Answer comprehension questions before you read the assigned chapter

It may seem counterintuitive to answer questions about topics you have not studied yet, but research suggests that answering questions about a topic before you start reading about it—even if you're just making educated guesses—may help you to remember more than if you did not answer any questions (e.g., Pressley, Tanenbaum, McDaniel, & Wood, 1990; Richland et al., 2009). Answering questions beforehand activates any related knowledge you have about the topic and makes it easier to connect new information to what you already know as you read.

Generate questions about the important points

If you are reading a section on cognitive dissonance, write down questions like, "What is cognitive dissonance?"; "What experimental techniques are used to study it?"; "What are two real-life examples that show cognitive dissonance at work?" Generating questions makes you think hard about the material and fosters comprehension (B. Wong, 1985). Additionally, answering questions such as "Why is this true?" or "What parts of this page are new to me?" will help you to learn because it connects what you are learning to what you already know (an approach called *elaboration*; see R. Wong, Lawson, & Keeves, 2002). More important, these questions will serve as a study guide for later.

Read, recite, and review

Some students like to write a summary or outline of a chapter as they read. However, research findings have been mixed regarding whether summarizing is effective. It works in some situations but not in others, and it almost always takes a long time (Dunlosky et al., 2013; McDaniel & Callender, 2008). As an alternative, try summarizing the chapter after reading it, recalling the big ideas from memory. Once you have done that, review the chapter, noting what you recalled and what you missed. This strategy, called the *read-recite-review method*, enhances what people remember when they read a text (McDaniel, Howard, & Einstein, 2009).

Recalling information from memory, as in the read-recite-review method, is one of the best ways to remember information, especially when you give yourself feedback for questions you missed. Even if you do not write a full summary when you test yourself, you can answer the questions that you wrote as you read, or try answering the end-of-chapter questions (they should be a lot easier this time!). Many newer textbooks also include online resources with interactive quizzes and other ways to test yourself. Be sure to check your answers and look up anything you missed.

Although these reading strategies take more effort at first (compared with highlighting or just reading), in the long term, you will both learn the material more quickly and know it better. Quizzing yourself after reading provides two benefits: It directly enhances your memory for what you just read, and it gives you a clear picture of the concepts on which you might need to spend more time (Roediger, Putnam, & Smith, 2011).

During Class

"Eighty percent of success is showing up" (Woody Allen, as cited in Safire, 2001, para. 11). Given this dictum, it is surprising how many students skip class. Not every professor is a bastion of wit and insight, but they are all experts in their fields, and you can learn from them. Class attendance is highly correlated with success in that class (e.g., Credé, Roch, & Kieszczynska, 2010). You won't learn if you're not in class.

Attend all your lectures

Some students skip class because they think the lecture duplicates what was covered in the textbook. This can be true to some extent, but it is actually a good thing. Successful learning requires thinking about an idea more than once. Reading about a concept at home and then hearing about it in class after a delay (ideally in a slightly different way) will make it much more likely that you will be able to remember that concept in the future (the *spacing effect*; Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). In particular, if the professor makes you think back to what you have read and explains it in a new way, you will learn much more (Benjamin & Ross, 2011). Of course, the professor may teach many ideas and concepts that are not in the text. Professors' remarks and activities in class rarely duplicate the book exactly and often are intentionally different from the text.

Leave your laptop at home

In lecture courses, the quality of notes that students take is correlated with (and probably causes) good performance in the course (Einstein, Morris, & Smith, 1985). However, you might want to leave your computer at home for several reasons. For one, you will avoid the distraction of the Internet and social media. Keep your phone in your pocket or bag, turned off, for the same reason (if you do bring your laptop, turn off your Wi-Fi). Evidence suggests that using social technologies in class is negatively correlated with college grade point averages (Junco, 2012). More important, multitasking with a laptop not only hampers your own learning but also can harm the learning of those around you (Sana, Weston, & Cepeda, 2013). This is probably why some professors ban laptops in their classrooms.

Write your notes instead of typing them

There is another reason to leave your computer at home. In a recent study, investigators studied whether students remembered more after taking notes by hand or by typing. Students who typed recorded more information than students who took notes by hand, but the students who took notes by hand were able to recall more information about the lecture than the students who took notes on the computer (Mueller & Oppenheimer, 2014). The problem is that when students take notes with a computer, they essentially type everything they hear without deep processing or understanding what they are typing. When students take notes by hand, they know they cannot write fast enough to keep up, so they process the material more thoughtfully and must decide what to put in their own words and how to do it. This reflective part of note taking appears to help beyond the benefits of being able to review more detailed notes in the future. Our advice here is based on a single study, but not using your computer has the other benefits we listed, too—you are less likely to be distracted.

Obtain slides before class

Finally, professors often use PowerPoint or Keynote slides and other visual aids in class. Our observation (not backed up by data) is that professors often present slides too quickly for the data to be well comprehended. If your professor uses slides, ask to receive copies of them to print out before class. Some professors do not like to provide copies, thinking that the practice discourages class attendance (although research suggests that this is not the case; Worthington & Levasseur, 2015). Teachers also worry (correctly) that many slides can be understood only if the student hears the accompanying lecture. So your professor may not give you the choice of having slides before the lecture. If this is the case, you might direct your instructor to a study by Marsh and Sink (2009). Their research showed that students learn more if they are given slides before class rather than after it; having the slides before class means students can take notes directly on the slides and not worry about copying the text that appears on the slides, giving them more time to think about the material and listen to the professor.

After Class

We suspect that most students put class out of their minds as they hustle to their next activity. This is natural. However, we strongly encourage you to come back to your classes later in the day. At a minimum, flesh out your lecture notes: Add any information you did not write down initially, and note any places where you did not understand something. Ideally, write these confusing points as questions (e.g., "What is the difference between classical conditioning and operant conditioning?"). If you have more time, you may want to try rewriting your notes from memory. Make sure to hit the main points that your professor covered in class and integrate those with the big ideas from the textbook. Synthesizing your notes in this way may broaden your understanding of the material and allow you to see how different ideas relate to one another. It also will help you to identify any areas you might need to work on (Mannes & Kintsch, 1987); you can bolster your knowledge of these areas by going back to the textbook. Reconstructing your notes and pinpointing specific areas to review will be a more efficient use of your time than going back and rereading whole chapters. Finally, try to answer the questions that you just wrote, along with any that you prepared from the day's reading (e.g., retrieval practice; Roediger & Karpicke, 2006). If you cannot answer a question, go back to the book and find the answer. Spending even 15 to 20 min reviewing the reading and class notes can help you consolidate the information you learned.

Of course, time management is critical here, because we are advocating that you review one day's work in the evening, in addition to preparing for the following day's assignments. However, the advantage is that by spacing your studying you will learn the material in less time than if you tried to cram all of your studying into the night before the test.

The advice provided in this section is based less on evidence than that in the other sections, for the good reason that researchers have not examined or attempted to manipulate activities after class to determine their effects. However, our observation as instructors is that the students who do the best in our courses often report these kinds of after-class activities.

Preparing for Tests

Every student knows that most studying occurs at the last minute (Hartwig & Dunlosky, 2011; Weinstein et al., 2013). When asked, students often say that they prepare for tests by rereading the assigned material in textbooks and their lecture notes, often focusing on what they had previously highlighted (Kornell & Bjork, 2007). Unfortunately, research suggests that cramming the night before the test and rereading are not the most effective ways to study. Instead, try to space your studying out over time and use more active study techniques, such as quizzing yourself.

Study each subject a little bit every day

One of the most powerful principles of effective learning is known as *spaced practice*, in which study of the same content is spaced out over time instead of crammed into one session (Carpenter et al., 2012). For learning over the long term, it is much better to study information repeatedly over time. Spacing your learning like this is a great tool because it does not take any more time than cramming, yet you learn more from each session. So start studying early in the semester and remember to cover something from each topic during each session. Even though it may feel like cramming works, it does not help with long-term retention (Roediger & Karpicke, 2006). Of course, it is natural to study more right before a big test, but you will have much greater success if you already know the material well from spaced study episodes.

One note about rereading: Many studies have shown that rereading a text (especially immediately after reading it the first time) does not help students to learn. Even when occurring after some delay, rereading is still less effective than other strategies such as self-testing or asking questions to yourself while you read (Callender & McDaniel, 2009; R. Wong et al., 2002). So limit your rereading to when you find you are confused about a particular topic when you tested yourself. If you are trying to make sure that you remember something for the test, you are better off quizzing yourself. If you do reread, do so at spaced intervals.

Study by quizzing yourself

Practice testing is one of the best study strategies you can use to prepare for an upcoming test. Research has shown clearly that answering a question correctly makes it easier to answer that question in the future—you actually learn when you take a test! In addition, answering questions identifies concepts that you need to review further (e.g., see Butler & Roediger, 2008). Using tests or quizzes as a learning tool is called *retrieval practice* because retrieving information from memory makes it easier to do so in the future—you are literally practicing recalling that information, just as you will need to do on the test. We've already mentioned a few ways you can take advantage of practice testing (e.g., the read-recite-review method), but here are a few others that can be useful when you are preparing for an exam.

First, start by answering the questions that you wrote while reading the text or reviewing your notes from class. Doing so will enhance your memory for the information that you retrieve and even for information that is related to the target information (Chan, 2009). Be sure to check your answers and look up anything that you got wrong. You also may want to finish a study session by writing a few more questions (focusing on concepts you find difficult). Then, when you start your next study session, you can begin by answering those questions. You do not need to write down your answers or say them out loud, so long as you force yourself to think through the answers (Putnam & Roediger, 2013; Smith, Roediger, & Karpicke, 2013).

Second, flashcards are a great and easy way to use retrieval practice. Many textbooks include a list of key terms; put these terms on flash cards and test yourself. Be sure to mentally retrieve the answer before turning over the card (rather than just looking at both sides) and to use a larger, rather than a smaller, stack of cards (Kornell, 2009). It is important to leave each card in the deck until you have recalled each term correctly three or four times. Students are often tempted to remove a card after recalling it correctly once, but defining the term correctly multiple times helps to solidify your memory (Karpicke & Roediger, 2008; Kornell & Bjork, 2008).

When you are practicing those terms, you might not want just to define the term but to elaborate on what you know about it. If *cognitive dissonance* is a key term, try explaining it (as to a friend), provide some examples as to how it is measured, or explain why it is important. Reflecting on a concept this way—elaborating the answer—often helps retention (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987).

Finally, studying in groups can be helpful because it makes it easy to quiz one another—just be careful to stay focused. One additional benefit of working in groups is that teaching something to someone else is also a great way to learn on your own (Nestojko, Bui, Kornell, & Bjork, 2014).

A few other test preparation tips

If you are unsure about the best way to schedule your study and retrieval practice, look into something called *successive relearning* (Rawson, Dunlosky, & Sciartelli, 2013). If you have to remember a lot of factual information for a test, then some mnemonic techniques may be useful in some situations (see Putnam, 2015). Mnemonics are specific memory improvement strategies like forming acronyms (e.g., remembering the Great Lakes through HOMES: Huron, Ontario, Michigan, Erie, and Superior). Other types of mnemonics, such as the method of loci, take a bit more time to use than acronyms but can help you to recall detailed sets of information and are especially useful for keeping things in order.

Preparing for a test using these strategies is doubtless harder and can sometimes take longer than merely rereading your notes and highlighting in your text. However, you will be rewarded with a stronger grasp on the material. You will retain the information much longer than if you just reread the information (Karpicke, 2012), and you will be well prepared for a final exam or more advanced courses.

The Final Exam

Many courses have cumulative final examinations. If you have studied using spaced practice and retrieval practice throughout the semester, you should be in good shape for the final because you used methods that produce durable learning. Because final exams cover a huge amount of information, be sure to begin studying far enough in advance to review all of the material. Again, use the questions that you created while studying and those from the book as a guide. Test yourself, review what you cannot retrieve, but be sure that when you retrieve and you think you have something right, it really is. Using the prior tests in the course can also help you to study. The night before your exam, get a good night's sleep to help consolidate your knowledge acquired during the day (e.g., Diekelmann & Born, 2010). Staying up all night cramming is usually ineffective.

Some General Tips

Students sometimes can fall into unhealthy lifestyles—having fun with friends can take precedence over studying. School should not be completely devoid of fun, but you need to protect your time to study. Put it first in your list of priorities, not near the bottom. Reward yourself with some fun after studying.

Proper exercise and sleep schedules are also critical. Set aside time to exercise. Most schools have a gym on campus, but you can also do it on your own. In addition to the health benefits of exercise, some research has shown that taking a 50-min walk can restore your ability to focus on a difficult task (Berman, Jonides, & Kaplan, 2008) and can boost creativity (Oppezzo & Schwartz, 2014). Finally, students often grumble (or brag) about how little they slept the night before. Some people may associate sacrificing hours of sleep with being studious, but the reality is that sleep deprivation can hurt your cognitive functioning without your being aware of it (e.g., becoming worse at paying attention and remembering things; Goel, Rao, Durmer, & Dinges, 2009; Pilcher & Walters, 1997). Most people need 7 to 8 hr per night. Sleep affects learning and memory by organizing and consolidating memories from the day (Diekelmann & Born, 2010; Rasch & Born, 2013), which can lead to better problem-solving ability and creativity (Verleger, Rose, Wagner, Yordanova, & Kolev, 2013). If that does not convince you, some studies have shown that sleep helps the brain remove certain proteins that build up and eventually contribute to the onset of Alzheimer's disease (Xie et al., 2013). We advocate that you study a lot using the techniques we have suggested, but be sure to get your sleep, too.

Closing Thoughts

Table 1 presents a summary of the most important ideas that we have presented here. You may find it useful to refer to it over the semester. One theme among all of these strategies is that successful learning requires actively engaging and thinking about the material. If you follow our suggestions, you should begin to see improvement in your courses. If you feel as though you have followed these strategies and are still struggling, you may need to find a way to spend more time studying. You also may want to reach out to the academic support services at your school, such as study sessions held by teaching assistants.

We have mainly addressed large lecture courses here but have skipped other important issues, such as writing a term paper (for advice on this score, see Sternberg & Sternberg, 2010). Courses come in many shapes and sizes and require many different forms of thinking, but you should be able to apply the principles covered here to new situations.

When we discuss research on learning and memory with different groups—explaining how testing can actually benefit learning more than rereading, for example—many people are surprised for two reasons. First, the advice seems so counterintuitive, because it just feels like reading is the way to go. The challenge here is that you cannot necessarily trust your judgment about what works and what does not (Bjork, Dunlosky, & Kornell, 2013). Rereading something can create the impression that you know it well because it seems familiar. However, that does not necessarily mean that you can retrieve that information when asked to write an essay about the topic. In short, rereading can lead to overconfidence about how well you will know the information in the future (e.g., Roediger & Karpicke, 2006). The strategies listed in Table 1 help to reduce that overconfidence.

Second, many people react with "Why wasn't I taught about this research in school? Why aren't there courses

Table 1. Summary of Strategies for Optimizing Learning in College

Space out your learning.

- Study for a little bit every day, rather than cramming in one long session.
- Start studying early, and touch on each topic during each study session.
- Reading before class and reviewing lecture notes after class will help consolidate what was covered in class.

Learn more by testing yourself.

- Instead of writing a chapter summary as you read, write down what you remember after you read, recalling the details from memory. Then, check to see how well you did (the read-recite-review method).
- Answer the "end-of-chapter" questions both before and after you read a chapter.
- Use flash cards to learn key vocabulary. Retrieve the idea from memory (before looking at the answer) and use a larger (rather than a smaller) stack of cards. Put answers you missed back in the deck at an early place and the ones you got right at the end. Finally, aim to recall each item correctly multiple times before taking a card out of the deck.
- Be skeptical about what you think you know—testing yourself can provide a better picture about which concepts you know well and which you might need to study further.

Get the most out of your class sessions.

- Attend every class session.
- Stay focused during class by leaving your laptop at home; you'll avoid distracting yourself and your classmates, and you may remember more by taking notes by hand.
- Ask your professor for a copy of any PowerPoint slides before class, so that you can take notes directly on the slide handout.

Be an active reader.

- Instead of speeding through your reading, slow down and aim for understanding.
- Ask yourself questions as you read, such as, "What did I learn on this page?" and "What on this page is new to me?"
- Finally, write some of your own questions about tricky concepts: "What is an example of *X* in real life?" or "How is Theory *X* different from Theory *Z*?"

Other general tips.

- Get organized early in the semester: Put major due dates and exams on your calendar, set reminders to get start studying early, and be sure to look at your calendar at least once a week so you can plan ahead.
- Get some exercise. Going for a 50-min walk in nature can enhance your ability to focus on difficult tasks.
- Sleep! Sleeping is critical for ensuring that memories are successfully stored in long-term memory.

on how to study in middle school?" This article is our attempt to help spread the word about this research that can have such a large impact in any learning endeavor. For those of you who seek further information, the following five books provide a wealth of information that go into much more detail about specific study strategies and the research behind them: Bain (2012); Brown, Roediger, and McDaniel (2014); Carey (2015); Mayer (2010); and Willingham (2010b).

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Introduction to the Special Section on Improving Research Practices: Thinking Deeply Across the Research Cycle

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The past 5 years have witnessed a profound shift in the way psychological scientists think about methods and practices. Whereas the prevailing sentiment was once a general contentment with the status quo, despite occasional rumblings from methodologists and statisticians (Cohen, 1992; Greenwald, 1975; Maxwell, 2004; Rosenthal, 1979), most psychologists now agree that we could do better. Our growing momentum has placed psychological science at the cutting edge of a broad movement to improve methods and practices across scientific disciplines. And as we move from debating whether we should change to investigating how best to do so, we are increasingly coming to grips with the fact that there are no magic bullet solutions.

Of course, as psychologists, we know that humans (including ourselves) often opt for cognitive shortcuts—that people tend to love a good heuristic, a simple decision rule, an easy answer (Chaiken & Ledgerwood, 2012; Kool, McGuire, Rosen, & Botvinick, 2010; Taylor, 1981). Yet we know, too, that oversimplified decision rules contributed to the problems with our methods and practices that we now face. For example, enshrining $p < .05$ as the ultimate arbiter of truth created the motivation to *p* hack. Heuristics about sample sizes allowed us to ignore power considerations. Bean-counting publications created an immense pressure to build long CVs. The single most important lesson we can draw from our past in this respect is that we need to think more carefully and more deeply about our methods and our data. Heuristics got us into this mess. Careful thinking will help get us out.

After all, science is hard, and reality is messy. These are complex issues we are tackling, and they deserve nuanced and thoughtful solutions. To that end, the May 2014 and November 2014 special sections in *Perspectives on Psychological Science* provided a toolbox of concrete strategies that researchers can use to think more carefully about their methods and to learn more from their data (Ledgerwood, 2014a, 2014b). The current special section hammers home the importance of thinking carefully at every stage of the research process, from selecting among possible research strategies, to analyzing our data, to aggregating across studies to build a more comprehensive picture of a given topic area.

The special section begins by asking how we can think carefully about optimizing our choice of research strategy. Of course, selecting any one research strategy necessarily involves tradeoffs (Brewer & Crano, 2014; Campbell, 1957; Finkel, Eastwick, & Reis, in press). For instance, increasing the sample size of a given study boosts the power of that study, but at the cost of decreasing the total number of studies that can be conducted (given a finite pool of resources such as time, money, and/or available participants). Miller and Ulrich (2016, this issue) propose a quantitative model that enables researchers to start weighing and integrating the costs and benefits of various research outcomes (true positives, false positives, true negatives, and false negatives) and to calculate an optimal sample size that maximizes what they call *total research payoff* across these study outcomes. Importantly, the model allows researchers to specify the value they place on different study outcomes so that the calculation of optimal sample size can be tailored to a specific researcher's values or to a particular research area (e.g., how important is it to this field at this time for true positives and true negatives to be correctly identified?). Using such a model also enables researchers to be explicit about the value they are placing on different study outcomes and the assumptions they are making about the effect size and base rate of true effects in a given research area. This kind of clarity helps reveal when conflicting recommendations about optimal research practices stem from variations in the starting assumptions of their proponents, allowing us to move

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