CUR Fellows Address

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Remembering to Perform Actions in the Future: Can Intentions Pop Into Mind?

I want to express my heartfelt thanks to the Council on Undergraduate Research (CUR) and to LI-COR Biosciences for the CUR Fellows award. I first became a councilor of CUR in 1990, and from the very beginning, the people associated CUR felt like kindred spirits. And it still feels that way. I love what CUR stands for and that is likely because undergraduate research was a transforming experience for me. Undergraduate research ignited a passion and excitement for learning, problem solving, and research that I treasure to this day—and one that I try to pass on to my students. I want to express my enduring thanks to my teachers who gave me that experience. I was fortunate to have mentors at both the undergraduate and graduate levels who not only cared deeply about their own research but who also were profoundly committed to my learning. So, thank you Burt Cohen at Lafayette College and Bill Battig at the University of Colorado. Briefly, I also want to mention what an honor it is to win this award with Tom Goodwin. He is well known as an outstanding teacher, mentor, scholar, and leader in CUR, and it is a high honor to be on the same program with him.

I will first define and describe my research area and try to convince you that it is an important topic. Then I will develop a theoretical debate in the area and describe one experiment that we have conducted to address this debate. A particularly appropriate feature of this experiment is that it was developed by an undergraduate student while she was conducting research with me.

What is Prospective Memory and How Do We Study It?

Prospective memory, which is a topic that has received relatively little research, is memory for activities to be performed in the future. Examples include remembering to turn off your cell phone during a lecture, remembering to give your friend Patty a message, and remembering to actually attach an attachment to an email message. It is often contrasted with retrospective memory, which is the type of memory that psychologists typically study. Retrospective memory is memory for past events, such as memory of the plot of a movie that you saw two weeks ago, memory for the content of a lecture that you heard last month, and memory for what you had for breakfast this morning.

Prospective memory is an interesting topic for many reasons. One is that there has been so little research on it, and yet is so important for everyday life. If you think about it even minimally, our lives are replete with prospective memory demands. For example, when I get up in the morning, I need to remember to take my vitamins, to make my lunch, to pack my book bag with the things that I will need at school, and to stuff my gym bag with the items that I will need later in the day. Then, I need to remember to put all those items in my car and later to bring them to my office. During the day, I need to remember to go to class (thankfully I have never forgotten that), make announcements in class (unfortunately I have forgotten those many times), and to attend various appointments and committee meetings throughout the day (regretfully, I have forgotten some of those too). And, at the end of the day, I may need to remember to meet my wife at an agreed upon time and location (I'm still married).

In an attempt to document the prevalence of prospective memory demands in everyday life, I have gotten in the habit of asking my students on the first day of class to write down the last thing they remember forgetting. I then classify their memory failures as either retrospective or prospective memory failures. So if someone wrote that she was at a party recently and temporarily forgot a person's name, I would classify that as a retrospective memory failure. By contrast, if someone wrote that he forgot to return a movie to the video store, I would classify that as a prospective memory failure. Regardless of whether I conduct this exercise with college-age students or older adults, it is always the case that the majority of the failures are prospective memory failures.

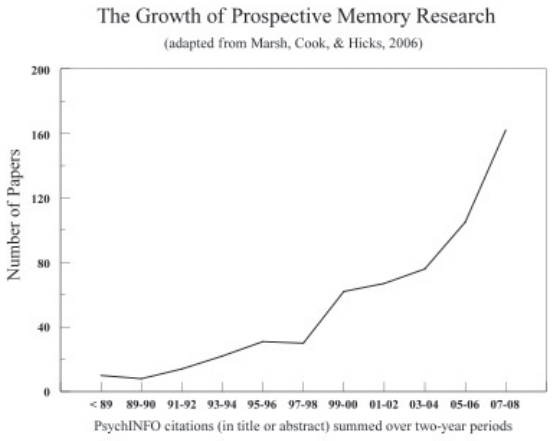
It is also the case that many of our most embarrassing failures involve prospective memory. You can probably

think of an embarrassing occasion on which you forgot to perform an intended action. My most embarrassing failure was forgetting my first department meeting as chair of the department. Although I was highly prepared for this meeting, a student called me down to the lab about 15 minutes before the department meeting began, and I got completely absorbed in solving the immediate problems there. It goes without saying that that failure of memory created an inauspicious start to my new leadership position!

Prospective memory failures can also have very serious consequences. As of 2008, more than 50 percent of Americans took prescription medications on a regular basis. And as you might imagine, older adults take more medication than any other age group. Because it is not unusual for older adults to take three, four, or five medications regularly, forgetting to take one's medication can have serious health consequences. Indeed, for older adults, this kind of forgetting can threaten independent living.

Despite the prevalence and importance of prospective memory for everyday life, there has been relatively little research in the field. As you can see in Figure 1, there was virtually no research prior to 1990—in stark contrast to the hundreds of thousands of studies that had been conducted on retrospective memory. There is steadily increasing interest in prospective memory, however, and empirical and theoretical papers on this topic are now regularly appearing in our best journals.

figure 1. The growth of research on prospective memory over the last 20 years.



To give you a concrete idea of how we study prospective memory in the laboratory, I will describe a typical paradigm. As can be seen in Figure 2, we first engage participants in what we call an *ongoing* task. For example, we might tell them that our central interest is in having them rate words for the ease with which they can be imaged. So, for this task, participants might be presented with words one at a time in the center of a computer screen and then be directed to rate each word on a 5-point scale, where 1 indicates *very difficult to image* (e.g., *truth*) and 5 indicates *very easy to image* (e.g., *chair*). Once participants understand this task and have had some practice with it, we tell them that we have an additional interest in their ability to remember to perform an action in the future and, specifically, that if they ever see a particular word (e.g., the word *rake*) in the context of the imagery-rating task, they should press a designated key. We then introduce a delay, during which the participants are asked to perform several other activities. After this delay, we reintroduce the ongoing imagery-rating task, and we do not remind them of the prospective memory task. The target word *rake* might occur three or four times among 400 or so imagery-rating trials, and our measure

Figure 2: A typical paradigm for studying prospective memory.

1. Present participants with instructions and practice trials for an ongoing task (e.g., imagery rating).
2. Present participants with the prospective memory instructions (e.g., "Press the *Q* key whenever you see the word *rake* in the context of the ongoing task").
3. A delay is introduced during which participants perform other activities (e.g., participants might perform other memory tasks and/or fill out demographics forms)
4. Reintroduce the ongoing task (imagery rating) without reminding participants of the prospective memory task.
5. The prospective memory target (*rake*) occurs several times in the ongoing task, and prospective memory performance is measured by the proportion of times participants remember to press the designated key when the target occurs.

of prospective remembering is the proportion of times out of four that participants remember to press the designated key when the target word *rake* occurs. To us, this is analogous to being busily engaged in the demands of life and yet having to remember to give your friend Patty a message when you see her.

Theories of Prospective Memory Retrieval

An important question is, what is different about prospective memory? In the typical retrospective-memory task, participants might be presented with a list of words to learn and then at some point the experimenter puts the participants in what we call a retrieval mode—that is, the experimenter asks them to start remembering the list of words that was presented earlier (Tulving, 1983). The experimenter might present participants with some cues to help them remember, but the critical feature is that the experimenter asks them to start remembering. As can be seen in the typical prospective-memory paradigm described in Figure 2, a central difference is that in testing prospective memory the experimenter does not put participants in a retrieval mode when the target word occurs. Thus, when the word *rake* occurs in the context of the imagery-rating task, no one reminds them to check their memory for what they were supposed to do when the word *rake* occurs. Instead, somehow, participants have to switch from analyzing how easy it is to image words to seeing the word *rake* as a cue for an action. So a central question in the prospective-memory literature is how does the cognitive system accomplish remembering when people are not specifically trying to remember at the time?

There are currently two major theories that address this question. One theory is that we remember to perform the intended action through monitoring processes (Smith 2003). The idea here is that when we form an intention, we initiate monitoring processes, which can sometimes feel like active and conscious monitoring and sometimes can occur unconsciously. Regardless of whether monitoring is conscious or not, the important assumptions in this theory are that monitoring always draws on a limited capacity of working memory resources and that monitoring is always *necessary* for prospective memory retrieval. Thus, if our monitoring lapses, we will forget.

My good friend and long-time colleague Mark McDaniel and I have proposed a very different theory, which we call the multiprocess theory (McDaniel and Einstein 2000; 2007). Because remembering to perform actions in the future is central to our lives, we believe that it is adaptive to have a flexible system that uses a variety of mechanisms to accomplish prospective remembering. We believe that if we relied exclusively on monitoring, then prospective memory retrieval would be too fragile. In particular, we believe that there are also spontaneous retrieval processes. By spontaneous retrieval processes, we mean that the occurrence of an appropriate cue can cause an intention to pop in to mind, even when we are not monitoring (i.e., when no resources are devoted to looking for the target).

Although we have developed a couple of theories about exactly how spontaneous retrieval can occur, one theory is that during planning, people form an association between the target cue (e.g., the target word *rake*) and the intended action (e.g., pressing the *Q* key). This association is stored in long-term memory and later, when the target cue is encountered, we believe that there is an associative system (very much like the hippocampal system described in Moscovitch 1994) that delivers the intended action to consciousness. The idea is that if someone has encoded the instructions well and if that person fully processes the cue at retrieval, the intention (*press the Q key*) should pop into awareness when the individual later processes the target word rake.

A Test of the Theories

The key difference between the monitoring and multiprocess theories is that the multiprocess theory assumes the existence of spontaneous retrieval processes, and the general goal of our research over the past few years has been to test for the existence of these kinds of retrieval processes. So how can we scientifically test whether a thought pops into awareness when a target word occurs? One might assume that you could use neuroimaging techniques to investigate this issue, but current neuroimaging methods require numerous trials and are unable to detect an occasional thought popping into mind. Being a

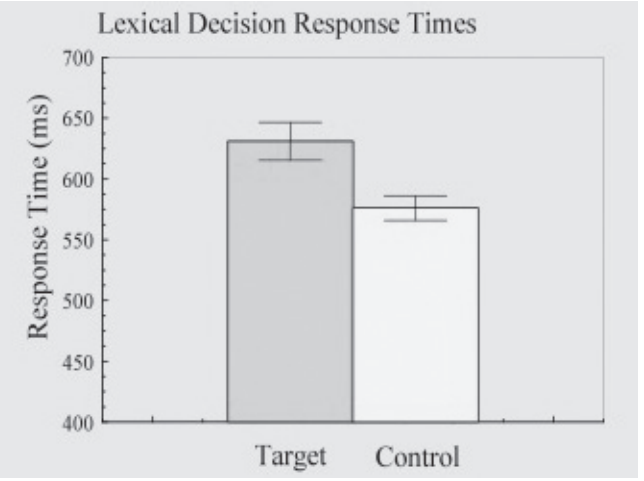
cognitive psychologist, I am interested in studying mental processes scientifically, and the way that we do that is to infer them from behavior. So in order to measure whether or not a thought can pop into awareness, we have to creatively design experimental conditions that enable us to make this inference.

Although we have developed several methods for inferring spontaneous retrieval processes, the most ingenious method was inspired by one of my undergraduate research students, Ruthann Thomas, who recently finished her PhD at the University of Toronto and now holds a post-doctoral position at Washington University in St. Louis. Her idea was to start the experiment with the typical first two steps of a prospective memory paradigm (see Figure 2) but then introduce a twist in the procedure. That is, she involved participants in an ongoing task, which was the image-rating task used in the example described earlier, and had them practice this task until they thoroughly understood it. Next, Ruthann gave participants prospective-memory instructions. Specifically, she told them that we had a secondary interest in their ability to remember to perform an action in the future, and that they should press the designated *Q* key whenever they saw the word *rake* during the image-rating task.

After being convinced that participants understood the instructions, she departed from the typical prospective-memory paradigm by purposely asking participants to suspend their intention to remember during an intervening *speed* task. The *speed* task was in actuality what we call a lexical-decision task. For this task, participants are presented with strings of letters in the middle of the computer screen and simply are asked to determine whether the letters form a word or not. Thus, if they see the letters *abtel* they would press the *no* key, whereas if they see the letters *table*, they would press the *yes* key. A critical feature of this task is that she told participants that our sole interest during this task was in their ability to perform this *speed* task as quickly and accurately as possible and to ignore all other intentions while they were performing it. Nonetheless, she presented the word *rake* during this speed task, as well as a word that was matched on all dimensions with the word *rake*.

As you might imagine, performance on this speed task is nearly perfect, and the interest is in the speed of responding. We believe that this experimental design provides a good test of the theories because participants should not have been monitoring during the speed task. Thus, according to monitoring theory, whenever the target word *rake* occurred, it should have gone by unnoticed. That is, it should have been processed like any other word and had very rapid response times. According to the multiprocess theory, however, presenting the word *rake* to participants in the context of the speed task, even though participants were not monitoring, should cause the prospective memory to pop into awareness, and this should slow down participants' speed of pressing the yes key to indicate that it is a word. Thus, according to the multiprocess theory, there should be slowing in response to the target word relative to matched control items. And, as can be seen in Figure 3, this is exactly what happened. Our interpretation of these results is that the target word *rake* was "loaded" in some sense so that whenever it occurred, it caused the intended action to be spontaneously retrieved and slowed down participants' speed of deciding that it was a word (Einstein et al. 2005; see also Scullin, Einstein, and McDaniel 2009). Thus, the pattern of results suggests the existence of spontaneous retrieval processes and supports the multiprocess theory.

Figure 3. Lexical decision response times (in milliseconds) to target- and matched-control items (from Einstein et al. 2005).



Improving Your Prospective Memory

I will close by describing a good strategy for helping you remember to perform actions in the future. The strategy is based on the research and theorizing of Peter Gollwitzer (Gollwitzer 1999), who is very interested in how to get people to follow through on their intentions. He believes that although people often form very strong intentions, they tend to form very general intentions, such as "I will take my blood pressure medication." Because he believes that the "the road to hell is paved with general intentions," he argues that people need to go beyond forming general intentions and instead create implementation intentions. These take the form of "when situation x arises, I will perform y." Thus, instead of saying "I will take my blood pressure medication," one should form the implementation intention "at breakfast in the morning, I will take my blood pressure medication." The idea here is that it is important to connect the intended action to a triggering cue. And, to the extent that you have formed a good encoding of this association, it is very likely that when having breakfast in the morning, the thought about taking one's medication will pop into mind. Gollwitzer believes that forming implementation intentions allows us to switch from using monitoring to relying on spontaneous retrieval processes. The evidence is compelling that implementation intentions help us remember to perform intended actions, and thus I encourage you to use them.

In closing, I once again want to thank CUR and LI-COR Biosciences for this wonderful award and for the opportunity to present you with a bit of background on prospective memory. I also want to thank the many undergraduate students who have contributed so creatively to our understanding of prospective memory and who have enriched my life.

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Dr. Gilles Einstein was born in Clermont-Ferrand, France, and moved to the United States when he was four. He received a B.A. from Lafayette College in 1972 and earned his Ph.D. from the University of Colorado in 1977. He has spent his entire professional academic career teaching and doing research at Furman University, where he is, according to a colleague, "… a master teacher, a creative, careful and prolific researcher, and one of the most popular faculty on our campus among students seeking research experience." He has published 6 books, 18 book chapters and 57 journal articles – most of these focusing on fundamental questions related to human memory. Along with a colleague (Dr. Mark McDaniel) Dr. Einstein has pioneered the study of "prospective memory" (remembering to perform some task in the future) and he has developed clever laboratory-based techniques that have become standards in

the field. Indeed, that method is now sometimes referred to in the literature as the Einstein-McDaniel procedure.

Dr. Einstein has, so far, included 31 undergraduate co-authors on his publications and 140 students have co-authored more than 100 conference presentations at national, regional and state scientific meetings. Dr. Einstein has received funding from NASA and the NIH totaling approximately $3.7 million and a significant portion of each grant has been set aside to support undergraduate research. Dr. Einstein writes: "In an age when one often reads about the wonders of distance learning, my core belief is that the ideal educational environment involves less distance between students and faculty." His teaching and his research with undergraduates are intended to "…foster inquisitiveness, healthy skepticism, independent thinking, and a lifelong zest for learning." Dr. Einstein's students become successful professionals. Thirty have earned (or will earn) their Ph.D. Another 22 have gone on to earn masters degrees, M.D. degrees or Law degrees. One of these former students writes: "In the course of our educational careers, many teachers will help shape our intellectual development and will contribute in small ways to our decisions about areas of study or career paths. More rarely, a teacher's impact is more dramatic, shaping the way we think, the way we approach and solve problems, the way we understand the world. In exceptional instances, a teacher's influence is so transforming that we are drawn to replicate that educational experience for others. Gilles Einstein has that kind of effect on students."

Dr. Einstein has received many awards and honors. Among them, he was awarded Furman University's "Meritorious Teaching Award" in 1985, in recognition of excellence in teaching courses in Psychology and Research Methods. For 14 years he chaired the Furman Advantage Program, which stimulates undergraduate summer research across all departments at the University. This program has grown and now annually supports 70 undergraduate research students and 95 interns. In the summer of 2006, Furman University selected him as their first winner of the South Carolina Independent Colleges and Universities Association "Excellence in Teaching Award".

Beyond Furman, Dr. Einstein has fostered undergraduate research on a national scale. Between 1990 and 1996, he served on the Board of Governors of the National Conference on Undergraduate Research. He also served on the editorial board of the Proceedings of the National Conference on Undergraduate Research *for 13 years. In 1992, he rallied psychologists throughout the country to plan for a new Psychology Division of CUR. Following his leadership, in 1993 CUR unanimously approved the addition of a Psychology Division to its ranks. All told, Dr. Einstein served as At-Large and Psychology CUR Councilor from 1990-1997.*

However, Dr. Einstein's most important accomplishments have been realized during one-on-one interactions with students. One who summarized why Dr. Einstein should be chosen for the CUR Fellows Award said it well: "Dr. Einstein inspires his students and gives them the aptitude and confidence to continue asking interesting research questions and searching for the answers. In this way, the scope of Dr. Einstein's impact in the field of psychological science is immeasurable."