Harnessing the Imagination

Mental Simulation, Self-Regulation, and Coping

Shelley E. Taylor, Lien B. Pham, Inna D. Rivkin, and David A. Armor
University of California, Los Angeles

Mental simulation provides a window on the future by enabling people to envision possibilities and develop plans for bringing those possibilities about. In moving oneself from a current situation toward an envisioned future one, the anticipation and management of emotions and the initiation and maintenance of problem-solving activities are fundamental tasks. In the program of research described in this article, mental simulation of the process for reaching a goal or of the dynamics of an unfolding stressful event produced progress in achieving those goals or resolving those events. Envisioning successful completion of a goal or resolution of a stressor—recommendations derived from the self-help literature—did not. Discussion centers on the characteristics of effective and ineffective mental simulations and their relation to self-regulatory processes.

Of the many skills that humans possess, one of the most intriguing is the process by which we envision the future and then regulate our behavior and emotions so as to bring it about. The ability to imagine future events has been explored in virtually every area of psychology. Developmental psychologists have studied children's symbolic capacities to imagine future events and the ways in which they use those skills to set goals, make plans, fantasize, and play (Singer, 1972). Cognitive psychologists have studied how people deploy their mental resources for efficiently and effectively managing a range of cognitive tasks (Davies & Stone, 1995), including problem solving (e.g., Klein & Crandall, 1992) and planning (Hayes-Roth & Hayes-Roth, 1979). Clinicians have helped clients imagine potentially problematic future situations they will encounter to rehearse skills for managing those situations successfully (e.g., Brownell, Marlatt, Lichtenstein, & Wilson, 1986; Marlatt, 1978). Personality psychologists have studied how people's visions of themselves in the future guide their current self-conceptions and actions (Markus & Nurius, 1986). Social psychologists have studied counterfactual reasoning and its role in the evocation of emotional states and in the regulation of future behavior (e.g., Kahneman & Miller, 1986; Markman, Gavanski, Sherman, & McMullen, 1993).

The task of imagining the future and creating a means for getting there has been addressed in particular in social cognition and in health psychology. In so doing, these two largely disparate fields have nonetheless identified the same fundamental parameters. Social cognition researchers studying self-regulation have noted that the management of affect and the initiation and maintenance of problem-solving activities are fundamental to moving oneself from a current situation toward an envisioned future one (Fiske & Taylor, 1991). Similarly, stress and coping researchers, such as Lazarus and Folkman (1984), have maintained that people overcome the stressful circumstances of their environments through the initiation of problem-solving activities and the regulation of their emotional states, thereby creating a less stressful future.

Because no one, however prescient, can see into the future, people use the imagination for this task. By imagining how things are likely to be or, alternatively, how one wants them to be, one achieves some ability to comprehend what the future will be like. What do we mean by the imagination? On the one hand, the term may be used very generally to refer to the ability to conjure up images, stories, and projections of things not currently present and the use of those projections for entertaining the self, planning for the future, and performing other basic tasks of self-regulation. On the other hand, the term imagination may be used quite specifically to refer to the mental activities that people engage in when they want to get from a current point in time and place to a subsequent one, having accomplished something in between.

Editor's note. Articles based on APA award addresses are given special consideration in the American Psychologist's editorial selection process. A version of this article was originally presented as part of an Award for Distinguished Scientific Contributions address at the 105th Annual Convention of the American Psychological Association, Chicago, IL, August 1997. Shelley E. Taylor was the award recipient.

Author's note. Shelley E. Taylor, Lien B. Pham, Inna D. Rivkin, and David A. Armor, Department of Psychology, University of California, Los Angeles.

This research was supported by a grant from the National Science Foundation (SBR-9507642). Lien B. Pham was supported by a National Science Foundation Graduate Fellowship, and Inna D. Rivkin was supported by a Jacob K. Javits Fellowship.

Correspondence concerning this article should be addressed to Shelley E. Taylor, Department of Psychology, 1283 Franz Hall, University of California, Los Angeles, CA 90095-1563. Electronic mail may be sent to taylors@psych.ucla.edu.
Mental simulation is the imitative representation of some event or series of events (Taylor & Schneider, 1989). It may involve the replay of events that have already happened, such as running back through an argument one had with a colleague to figure out where the conversation went wrong. It may involve the cognitive construction of hypothetical scenarios, such as deciding how to confront a procrastinating graduate student. It can involve fantasies, such as the imagined sexual exploits that often pull people to sleep, and it can involve mixtures of real and hypothetical events, such as replaying an argument and inserting what you should have said into the dialogue (Taylor & Schneider, 1989). Mental simulation can be useful for envisioning the future because it addresses the two fundamental tasks of self-regulation and coping, namely the management of affect or emotional states and the ability to plan and solve problems. Specifically, there are certain intrinsic characteristics of mental simulations that make them useful for envisioning the future and for engaging the problem-solving and emotional regulation skills so vital to effective self-regulation.

Characteristics of Mental Simulations

Mental simulations make events seem real. When people run through a set of events in their minds and imagine them in concrete and specific form, it often makes those events seem true. For example, anticipating an idyllic vacation of lying on a beach, swimming, sailing, and snorkeling may make the experience seem so real that it propels a person into the sometimes lengthy and tedious process of making the vacation plans. Considerable research also supports this point. At least nine empirical investigations have demonstrated that when people imagine hypothetical events and are subsequently asked to rate the likelihood of those events, they are more likely to believe the events will actually occur following mental simulation than following other cognitive activities that have focused on those hypothetical events (e.g., Anderson, 1983; Anderson & Sechler, 1986; Carroll, 1978; Gregory, Cialdini, & Carpenter, 1982; Hirt & Sherman, 1985; Sherman, Skov, Hervitz, & Stock, 1981; see Koehler, 1991, for a review). In an engaging demonstration of this effect, Gregory and his colleagues (Gregory et al., 1982, Study 4) contacted homeowners about subscribing to a cable television service. Some of the homeowners were asked to imagine that they had cable and to envision the benefits it would bring them. Other homeowners were given a persuasive communication that described the advantages of subscribing to cable. Subsequently, participants were contacted to see whether they would be interested in purchasing cable. Those who had mentally simulated owning cable were more likely to want to subscribe than were those who had merely read about its advantages.

An important reason why mental simulations make events seem true is that they tend to obey the constraints of reality. This important point was noted by Kahneman and Miller (1986), who observed that, although mental simulations are imaginary, they are typically not magical. Even an entertaining fantasy about acquiring great wealth typically begins with an unexpected inheritance or winning a lottery rather than with a large cloud opening up and dumping the money in the front yard or some other impossible event. Because mental simulations are typically constrained by what is plausible, they are useful for anticipating the future inasmuch as imagined plans of action are unlikely to rely on improbable or fantastic steps along the way.

Mental simulations give rise to problem-solving activities. Typically, people simulate in concrete form by creating highly specific settings and behaviors that often have a video-like flow. As such, mental simulations as representations match the way social reality occurs. Simulations are at the same level of specificity as social interaction, and they bring in information about social settings, social roles, and specific people. Simulations involve a sequence of successive interdependent actions causally linked to each other, just as real situations do, and the organization of action that one imposes on one's mental simulations can, in turn, yield a plan. Research on mundane planning by Hayes-Roth and Hayes-Roth (1979) has shown that imagining how events are going to take place provides information about those events. As one envisions taking one's clothes to the cleaners, the mental pictures that are created may lead one to see opportunities that might otherwise have been missed: the shoe repair store across the street, where one's boots can be resoled, and the grocery store, where one can pick up the last remaining items for dinner. Thus, there is emergent information relevant to problem-solving activities in mental simulation.

Experts have long recognized the important role that mental simulation can play in solving problems. For example, Peter Lynch, the legendary investment adviser for the multibillion-dollar Fidelity Magellan Fund, provided entertaining accounts of the scenarios he mentally generated for making decisions about what stocks to buy (Lynch, 1989). For example, when Lynch's wife, Carolyn, brought home a pair of L'Eggs panty hose that she bought in the supermarket, Lynch was able to see the needs this product would meet. Envisioning the increasing numbers of working mothers who needed panty hose, but who had very little time, led him to recognize that trips to the supermarket would be far more frequent than trips to the department store. A panty hose product they could pop into the grocery cart with the cereal and coffee seemed to be a wonderful idea and led Lynch to make a very timely investment.

The problem-solving activities of other experts, such as the commanders of elite fire-fighting units and Desert Storm tacticians, have been studied for the important role that mental simulation plays in developing solutions to
difficult problems. One example illustrates how a tactical action officer successfully averted a major diplomatic catastrophe in the Middle East:

During the Iran–Iraq war, a Tactical Action Officer (TAO) in charge of Air Defense for a Navy Battle Group was asked by one of the cruisers for permission to shoot down a threatening aircraft. The target was unidentified, coming from the direction of an Iranian airport, did not generate IFF [Identification–Friend or Foe] signals, was flying at a low altitude, and was heading straight towards the cruiser. Moreover, it failed to respond to radio warnings. In short, it fit the Rules of Engagement—Fire or Foe [decide] signals, was flying at a low altitude, and was heading straight towards the cruiser. The Officer generated a mental simulation involving helicopters from other ships in the Battle Group that had become lost. He directed aircraft to the area for visual identification. His suspicions were correct—it was a British helicopter that had lost its way. (Klein & Crandall, 1992, p. 25)

As this example clearly shows, the flexibility of mental simulation and the capacity it provides for trying out several solutions to a problem can be an effective problem-solving method in circumstances that call for a rapid solution to a unique set of circumstances.

A major consequence of mental simulation is the evocation of emotional states and their potential control. Imagining a scenario does not produce a dry cognitive representation but rather evokes emotions, often strong ones. Researchers who manipulate positive and negative affect, for example, have made extensive use of mental simulations as one of the most effective manipulations of affective states (e.g., Larsen & Ketelaar, 1991; Morrow & Nolen-Hoeksema, 1990; Strack, Schwarz, & Gschneider, 1985; Wright & Mischel, 1982). By leading people to mentally replay one of the saddest or, alternatively, one of the happiest events of their lives, researchers can reliably evoke positive or negative emotional states. Moreover, the resulting emotions often produce low-level physiological changes, such as alterations in heart rate, blood pressure, and electrodermal activity, suggesting that the physiological underpinnings of these emotional states are activated as well, albeit in modest form (e.g., Lyman, Bernardin, & Thomas, 1980; see also Strack et al., 1985).

An important, and we would argue vital, function of simulations is that they produce links to action by virtue of the self-regulatory activities they evoke. At least two lines of research illustrate this link. The first is a large literature from sport psychology on mental practice, much of it with elite athletes (Cratty, 1984; Neideffer, 1976; Orlick, Partington, & Salmela, 1983). Mental practice refers to using mental imagery or simulation to improve performance. For example, golfer Jack Nicklaus reported on his legendary method for winning golf tournaments:

Before every shot I go to the movies inside my head. Here is what I see. First, I see the ball where I want it to finish, nice and white and sitting up high on the bright green grass. Then, I see the ball going there; its path and trajectory and even its behavior on landing. The next scene shows me making the kind of swing that will turn the previous image into reality. These home movies are a key to my concentration and to my positive approach to every shot. (Nicklaus, 1976, p. 45)

Comments from numerous athletes, including Olympians and professionals, are similar. Most athletes say that they can actually feel the muscle twinges associated with their actions as they imagine themselves executing a dive, a jump in skating, a service in tennis, and a variety of other skills (Orlick & Partington, 1986). Meta-analyses of mental practice effects have shown that these efforts are not misplaced. Although physical practice is superior to mental practice of a motor skill, mental practice produces superior learning compared with no practice at all, and the combination of mental and physical practice appears to be maximally effective for honing skills and making progress (Feltz & Landers, 1983).

Research from cognitive–behavior therapy also illustrates the importance of mental simulation for producing links to action. In particular, the relapse-prevention techniques developed by Marlatt and others (e.g., Brownell et al., 1986; Marlatt & Gordon, 1985) show how important mental rehearsal of high-risk-for-relapse situations can be to the ability to maintain abstinence from such health-compromising behaviors as smoking and excessive drinking. For example, a man trying to overcome a drinking problem may mentally rehearse exactly how he will handle Superbowl Sunday with his friends so that he can refrain from drinking or can engage in placebo drinking during the afternoon. Through such rehearsals, people can develop and refine the specific coping skills they need to use to avoid temptations in the future.

Types of Mental Simulation

Not all mental simulations are equally effective for helping people regulate their behavior. Indeed, some mental simulations actually interfere with self-regulation, for instance, by substituting a fantasy of success for progress toward a goal (Oettingen, 1995) or in the case of painful ruminations that plague many people suffering from depression or reacting to trauma (Horowitz, 1976; Silver, Boon, & Stones, 1983). Consequently, the imagination is not intrinsically beneficial for self-regulation but must be actively harnessed to be effective for this purpose. The sport psychology literature and the relapse-prevention literature illustrate a particular type of mental simulation that has been found to be effective in leading to behavior change. The critical component of this successful use of mental simulation is an emphasis on simulating the process needed for reaching a goal. According to this
process-simulation viewpoint, one sets a goal and then actively mentally rehearses the steps one needs to go through to reach it, which leads to appropriate changes in behavior, increasing the likelihood that the goal will be obtained. The student who wishes to be a successful psychologist, for example, would, according to this approach, increase his or her chances for so doing by mentally simulating the process of going through the steps he or she would need to get there, such as applying to graduate school, conducting research, writing papers, attending conferences, networking, and the like.

Why should simulation of the process needed for reaching a goal be an effective way of regulating behavior? Essentially, this prediction can be derived from the characteristics of mental simulations noted earlier. Rehearsal of the process needed to reach an envisioned end state forces one to identify and organize the steps involved in the activities needed to get there, which, in turn, yields a plan. At the same time as one is mentally walking through these activities, the emotions that will be involved may be evoked, at least in a modest state, such that one can anticipate what these emotional states will be and develop some degree of control over them.

A contrasting point of view, however, put forth largely by the self-help literature, argues for a quite different form of mental simulation for the achievement of personal goals. This approach, termed outcome simulation, maintains that actively focusing on the outcome to be achieved will help to bring it about. According to this approach, a student who wants to be a famous psychologist will be more likely to achieve that goal if he or she envisions himself or herself already in this role.

Outcome simulation for goal achievement has been promulgated by a number of self-help writers (e.g., Dyer, 1989; Fanning, 1994; Lakein, 1973; Peale, 1982). For example, in his book Visualization for Change, Patrick Fanning (1994) urged readers to focus on the outcomes that attainment of their vocational and financial goals will bring:

See yourself enjoying favorite activities in your new-found leisure, running, dancing, swimming, or whatever you would like to do. See yourself surrounded by loved ones and friends, popular and relaxed, having a good time. . . . See yourself wearing new stylish clothes, driving a new car, playing with a new tennis racquet, or skiing on new skis. (p. 21)

Author Norman Vincent Peale (1982) put forth a similar point of view:

Hold the image of yourself succeeding, visualize it so vividly, that when the desired success comes, it seems to be merely echoing a reality that has already existed in your mind. (p. 15)

Despite the widespread recommendation of outcome simulation for goal achievement, the self-help literature has not, for the most part, articulated a formal process model whereby a focus on a desired outcome would enable a person to achieve it. Drawing on the distinction made earlier between emotional regulation and problem-solving activities, one might predict that outcome simulations would be effective in engaging emotional responses that help people muster the motivation to achieve their goals. For example, imagining the revenues that will be generated by a successful first book may propel a novice writer into the daily grind of writing. However, in the absence of a specific plan to help direct this motivation into particular goal-appropriate behaviors, it is questionable whether outcome simulations would bring about the beneficial changes they have been expected to have.

Our research program of the last few years has centered on an examination of these different types of mental simulations and their effects on behavioral self-regulation and goal achievement. In so doing, the distinction between problem-solving activities and emotional regulation has been fundamental to our thinking. We maintain that process simulations effectively address the two main tasks of self-regulation, namely, enlisting problem-solving activities, such as planning, and regulating emotional states. For these reasons, we predicted that process simulation would be superior to outcome simulation in regulating behavior and in controlling emotions in response to stressful events.

Preparing for Examinations

Our first study (Pham & Taylor, 1997) was an intervention with introductory psychology students at the University of California, Los Angeles, who were studying for their first midterm examination. Seventy-seven students in the introductory course were recruited five to seven days before their midterm for a study on coping with exams. Participants were brought into the laboratory for training in mental simulations, which they were then instructed to use on their own for the five to seven days preceding the exam.

Participants in the process-simulation condition were told to visualize themselves studying for the exam in a way that would lead them to obtain a grade of A. They were told how important it was to actually see themselves studying and to hold this picture in their minds. They were given some sample details they might draw on, such as visualizing themselves sitting at their desks, on their beds, or at the library, and studying the chapters, going over the lecture notes, eliminating distractions such as turning off the television or stereo, and declining a friend’s offer to go out. After learning the simulation, they rehearsed it in the lab and then were told to do this for each of the days before the exam for five minutes each day, keeping a record of when they practiced it.

Participants in the outcome-simulation condition were told to imagine themselves having gotten a grade of A on the exam. They were told to see themselves standing in front of the glass case where the midterm exam grades are posted, holding their breath, moving their gaze horizontally to find their score, learning that they had received an A, beaming with joy, and feeling confident and proud. The two interventions were matched
in terms of length and amount of detail. Students in the outcome-simulation condition learned the simulation, mentally rehearsed the experience in the laboratory, and, like the process-simulation participants, were instructed to perform it for five minutes each day before the exam. Participants in a control condition simply monitored their studying over the same period prior to the exam.

Subsequent to receiving these instructions, all participants completed a brief questionnaire measuring anxiety, worry, confidence with respect to the exam, and motivation to study, as well as their expected grade and the grade they were striving for. The night before the exam, all participants were recontacted by phone and asked the same questions. At that time, they were also asked to report the number of hours they had studied, when they had started studying, and the number of times they had read each chapter. Their grades were then obtained from the midterm list.

The results indicated that students who had simulated the process of studying for the exam during the week prior to their midterm benefited from this mental simulation. Compared with participants in the control group, those using the process simulation began studying earlier and spent more hours studying for the exam. They also added nearly eight points to their exam score relative to the control group.1

In contrast, students who practiced the outcome simulation of focusing on the achievement they hoped to obtain were not, for the most part, benefited by the outcome simulation. There were negligible nonsignificant effects on how much they studied for the exam, and they added only two points to their score relative to the control group (see Table 1).

In a second study (Pham & Taylor, in press) using the same procedure, we examined the potential mediators of mental simulations on performance. We hypothesized that the mental simulation involving process improved exam performance by enabling the students to regulate their emotions successfully, such as anxiety or concern about the exam, and by yielding a plan for helping the students organize their thoughts and materials. There are, however, at least four alternative theoretical viewpoints that could account for beneficial effects of mental simulation on performance. First, mental simulations may enhance feelings of self-efficacy by virtue of making a goal seem proximal or by yielding information about how to achieve a goal (Bandura, 1986; Locke & Latham, 1990). Such perceptions may, in turn, lead to enhanced striving and superior performance. Second, mental simulation may enhance the subjective likelihood or value of a goal or both (Atkinson, 1958; Feather, 1982), facilitating motivation and constructive progress. Third, mental simulations may make goals or the steps to reach goals salient, thus prompting intentions to initiate goal-directed actions (cf. Gollwitzer, 1993). Finally, mental simulation may affect goal-directed behavior by changing the level at which individuals identify their actions (Vallacher & Wegner, 1985). Specifically, process simulations may focus people on the individual steps needed to reach a goal, and this kind of lower level action identification is thought to facilitate performance on complex and difficult tasks (Wegner & Vallacher, 1986).

The second study paralleled the methods of the first study and enlisted 101 undergraduate participants facing an introductory psychology midterm examination. Three changes were made in the procedures. Participants simulated getting a high grade, rather than getting an A, because an A was not a realistic goal for many of the students. Second, all participants received a Study Hints Sheet that combined the content of both mental simulations so as to equalize information between the groups. Third, participants completed a questionnaire with items assessing potential mediators, including planning (e.g., "To what extent do you have a plan for when, where, and how you might study for the exam?"); emotional impact (e.g., "How anxious are you about the exam?"); self-efficacy (e.g., "How confident are you that your abilities are up to the demands of this exam?"); subjective likelihood and value (e.g., "How certain are you that your efforts will produce the outcome you are striving for?"); and action identification (e.g., items ranging from low-level actions such as "reading lecture notes and textbook," to midlevel actions such as "improving my chances for a good grade," to high-level actions such as "gaining knowledge in psychology"). Each of these mediators was assessed with at least three items, and scale alphas were within conventional levels of acceptance.

The results of the second study revealed a beneficial effect of process simulation on the total hours studied.

---

**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Process Simulation</th>
<th>Outcome Simulation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days of study</td>
<td>5.20(_a)</td>
<td>4.11(_{ab})</td>
<td>3.20(_b)</td>
</tr>
<tr>
<td>Number of hours of study</td>
<td>14.05</td>
<td>12.39</td>
<td>10.20</td>
</tr>
<tr>
<td>Exam grades (%)(_a)</td>
<td>73.18</td>
<td>67.61</td>
<td>65.28</td>
</tr>
</tbody>
</table>

*Note.* Data are from Pham and Taylor (1997). Means in the same row not sharing a common subscript are significantly different from each other at *p* < .05 (Tukey's HSD).

*The average score of students not participating in the experiment was 68.29%.

---

1 The original investigation (Pham & Taylor, 1997) included a fourth condition that combined the process and outcome simulation. Analyses of variance indicated that the main effects of process simulation, as compared with outcome simulation, on number of days of study, number of hours of study, and exam grades were all significant at *p* < .01.
such that those who rehearsed the process studied more. Process-simulation participants also did somewhat better on the exam, whereas outcome-simulation participants did somewhat worse, compared with the control group (see Table 2).

To assess mediation, we examined which variables were affected by the independent variable of mental simulation and which were correlated with the dependent variable of exam performance. Only two of the proposed mediators met these criteria, namely, anxiety and planning. Self-efficacy, subjective likelihood and value, behavioral intentions, and action identification were all unrelated to exam performance. At the second time point, the night before the exam, the only variable that was significantly correlated with exam performance was the grade participants strove for. Accordingly, structural equation modeling analyses were conducted (Bentler, 1995) to examine whether a reasonable model of mediation could be obtained.

This analysis indicated that the conceptual model that guided the research fits the analysis of beneficial effects of mental simulation on performance well. The process simulation improved examination performance by two routes. First, it reduced anxiety, the emotional regulation component, which in turn enhanced performance. Second, it facilitated planning, the problem-solving component, which maintained aspiration level, namely, the grade that the student strove for, which in turn enhanced exam performance. Conventional measures of fit show this to be an adequate model (see Pham & Taylor, in press).

What is responsible for the adverse effects of simulating a desired outcome on grades? It appears that students who practiced the outcome simulation rehearsed the joy they would experience over the high grade but failed to study more and so, over time, they reduced their level of aspiration, thus producing a detrimental effect on performance. This pattern of results is not without precedent in the self-regulation literature. Specifically, recent research by Oettingen suggests that positive fantasies and daydreams may undermine future achievements because they imply anticipatory consummation of success (Oettingen, 1995). Like Oettingen's fantasies, outcome simulations may make people feel good in the present without providing a basis for achievement in the future.

In summary, then, these studies provide support both for predictions regarding the superiority of process simulation over outcome simulation in the effective self-regulation of behavior and also for the mediational processes that were proposed for why these effects would occur, namely, the beneficial effects of process simulation on active problem solving and emotional regulation.

### The Planning Fallacy

We sought to extend these findings beyond the domain of exam performance in a third investigation (Taylor & Armor, 1997) and to provide a more stringent test of the predictions by applying them to a known self-regulatory dysfunction, namely, the planning fallacy. The planning fallacy (Buehler, Griffin, & Ross, 1994; Kahneman & Tversky, 1979) refers to the fact that people invariably underestimate the resources, such as time and money, that will be required to finish a project and overestimate how easily it can be done. It is embodied in the experience of anyone who has been involved in a construction project. An example of this phenomenon noted by Buehler et al. (1994) is the Sydney Opera House, which in 1957 was initially expected to be completed by 1963 at a cost of $7 million. In fact, a greatly downscaled version was completed in 1973 at a cost of $102 million. More recent examples include the Channel connecting England and France, the Denver Airport, and the Los Angeles subway system.

The planning fallacy also exists on the individual level, embodied in the daily to-do list that many people create in a fit of unrealistic optimism at the beginning of the day only to find that most of their expectations remain unmet at the end of the day. Academicians habitually take home a briefcase full of work to do over the weekend and bring most of it back again on Monday. Individual plans appear to be as vulnerable to the planning fallacy as are group projects.

Buehler et al. (1994) examined the planning fallacy with respect to students expecting to complete school projects. These students showed remarkably unrealistic optimism with respect to their anticipated completion dates. In four studies, Buehler et al. found that only approximately one third of the students they surveyed finished the projects by their predicted completion time. The planning fallacy appears to be more acute in Califor-

### Table 2

**Effects of Mental Simulation on Exam Performance**

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th>Process Simulation</th>
<th>Outcome Simulation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of hours of study</td>
<td>16.07, a</td>
<td>11.57, b</td>
<td>14.50, a,b</td>
</tr>
<tr>
<td></td>
<td>Exam grades (%)</td>
<td>80.60, a</td>
<td>72.57, b</td>
<td>77.68, a,b</td>
</tr>
</tbody>
</table>

Note. Data are from Pham and Taylor (in press). Means in the same row not sharing a common subscript are significantly different from each other at p < .05 (Tukey's HSD).

---

1 In Study 1, the outcome simulation of receiving an A maintained aspiration level (Pham & Taylor, 1997), but when the focus of the outcome simulation was changed to receiving a high grade in Study 2 (Pham & Taylor, in press), aspiration level declined over time. This difference in the manipulation appears to account for the fact that, in Study 1, outcome simulations had negligible effects on performance, but in Study 2, outcome simulations produced detrimental effects on performance.
nia. In a recent investigation using similar procedures (Taylor & Armor, 1997), we found that only 14% of students completed their projects by the time they said they would. Most intriguing, students were typically highly confident that they would complete the project as estimated. Although the planning fallacy is humorous testimony to unrealistic optimism, it is also expensive and resource-consuming, and so helping people find ways to regulate their goal-directed behavior more successfully is essential. Accordingly, we undertook an investigation (Taylor & Armor, 1997) of the planning fallacy using our distinction between process simulations and outcome simulations to see if process simulations would enable people to bring their problem-solving and emotional-regulation skills to bear on the timely completion of a project.

Eighty-four students designated a school-related project that had to be completed during the subsequent week. They were told to pick a project that would require some time and effort, such as a lab report or a short paper, and were asked to make initial predictions about when they would begin and when they would complete their projects. One group of participants was trained in a process simulation. Specifically, they were told to envision themselves gathering together the materials or resources they would need for the completion of the project, to see themselves getting organized, and to envision themselves beginning to work on the project. The guidelines were deliberately left quite general so as to accommodate a wide variety of individual projects. A second group of students was asked to perform an outcome simulation each day. They were asked to imagine that their project was completed and to envision how pleased they would be with the final result. They were told to envision themselves looking over the final product, packing it up, and taking it to class, confident that they had done well. After learning the mental simulations in the lab, the students in these two simulation conditions were told to rehearse the simulations for five minutes each day during the subsequent week. Students in a self-monitoring control condition simply recorded their progress on the assignment each day. One week later, students completed a questionnaire indicating when they had begun their project, when they had finished their project, and how long it had taken them.

We first ascertained whether the planning fallacy asserts itself in the form of procrastination, that is, in not beginning on time, or in the form of not finishing on time, or both. The evidence suggests that it is both. Only 21% of the students began their projects by the time they expected to, and only 30% of the students finished their projects by the time they expected to. These patterns were importantly moderated by the experimental manipulation of mental simulation. The control condition performed the most poorly: Only 14% began their projects when they expected to and only 14% finished them when they expected to. The process-simulation group, however, fared somewhat better. As Table 3 indicates, they were more likely to start by the time they said they would, and they were significantly more likely to finish by the time they said they would. The outcome-simulation group also experienced beneficial effects, although they were more muted.

The process simulation enabled many of the students to muster their planning and problem-solving skills for the timely completion of their project. Did it also have an effect on their affective self-regulation? Potentially, by focusing students directly on problem-solving activities, process simulation might undermine the pleasurable affect that could be experienced in the context of successfully pursuing a project. This was apparently not the case, and in fact, there is some evidence for the opposite conclusion. Students who practiced the process simulation found the assignment significantly easier relative to the students in the outcome-simulation and control conditions, who thought the assignment was slightly harder than they had expected. Although the exact reasons for this difference are unknown, it is likely that, because planning and problem-solving activities emerge from process simulations, they gave the students a jump start with respect to the project as compared with the other experimental condition.

In summary, a known dysfunction of self-regulation, namely, the planning fallacy, can be ameliorated through mental simulation. Although the effects of the process simulation were fairly modest (enabling 41% to complete their projects on time), this was nonetheless significantly better than the 14% who finished on time without the benefit of mental-simulation exercises.

The process by which these benefits were obtained merits comment. Most researchers have assumed that the problems embodied in the planning fallacy can best be addressed by making people more realistic about their timetables and the impediments they may face (e.g., Buehler et al., 1994; cf. Weinstein, 1996). Others (e.g., Armor & Taylor, in press), however, have argued that inducing such realism raises the risks of undermining emotional regulation, namely, the optimism that fuels both the planning fallacy and constructive progress. Note that the process simulation achieves its effects not by inducing a sense of realism but by getting people to
regulate their behavior in such a way as to bring it in line with original expectations. In this way, the process simulation may reduce the degree of planning fallacy without undermining the unrealistic optimism that initially fueled it.

**Mental Simulation and Coping**

Among the literature that gave rise to the theoretical position described in this article is research on stress and coping (Taylor & Schneider, 1989). As noted earlier, coping is judged to be effective to the degree that it engages appropriate problem-solving activities and is successful in regulating emotions in the face of stress (Lazarus & Folkman, 1984). To this point, however, the tie-ins of our research program with the stress and coping literature have been largely indirect. In a fourth study, (Rivkin & Taylor, 1998), we explicitly tied mental simulation to the tasks of problem solving and emotional regulation in the context of stressful events.

The point of departure for this research was Pennebaker's work on emotional disclosure. Over the past 15 years, Pennebaker and his associates have compiled an impressive program of research to suggest that, when people are given an opportunity to express their thoughts and feelings with respect to a traumatic event, they show beneficial psychological and health effects (e.g., Pennebaker, 1988; Pennebaker & Beall, 1986; Pennebaker, Kiecolt-Glaser, & Glaser, 1988; Pennebaker & O'Heeren, 1984). In a typical study, participants are brought into the laboratory on each of several successive days to write or talk about a past trauma, and their emotions and physical symptoms are assessed both immediately following the intervention and several months later. The typical finding of such investigations is that, although the immediate effects of writing about a trauma on emotional regulation may be negative, over time they are beneficial, and immune changes and health-center visits parallel these beneficial effects.

We reasoned that people may obtain some of these same benefits by means of mental simulation. Because mental simulations enable people to replay events, to process them in detail, to express the emotions evoked by these events, and to focus on different aspects of an event, they may well produce the same beneficial effects that writing or talking about a stressful event can produce. The study described here departed in two potentially significant ways from the typical studies that Pennebaker and his associates have undertaken. First, and obviously, we used mental simulation as our intervention instead of writing or talking about events. Second, instead of using traumatic events from the past, we used ongoing stressful events. This change was made in an effort to identify effects of mental simulation on both problem-solving activities and emotional regulation. Traumatic events in the past are typically amenable primarily to emotional regulation; no amount of problem solving or planning will affect the outcome in the present because the events have already occurred. By contrast, for ongoing stressful events, both problem-solving activities and emotional regulation may be required for effective coping (cf. Lazarus & Folkman, 1984), and mental simulations that focus people on their ongoing stressful events may evoke both kinds of activities.

Seventy-seven college students were brought into the laboratory and asked to designate a stressful event that was going on in their lives. They were given examples they might draw on, including academic stressors as well as interpersonal ones. Following the designation of the stressful event, one group of participants focused on the unfolding event and practiced a mental simulation patterned after instructions developed by Pennebaker and Beall (1986). Specifically, they were asked to visualize how the problem arose, what happened step-by-step, the actions they undertook, the circumstances surrounding the event, and the feelings they experienced. A second group of students completed an outcome simulation. These participants were asked to picture the problem beginning to resolve itself, to imagine their relief that the problem was no longer bothering them, and to experience satisfaction in having dealt successfully with the problem. A control group of participants completed the same questionnaires as the other groups but did not perform a mental simulation. Following the laboratory session and again one week later, participants completed scales to assess their emotional responses to the stressful event and the coping activities they planned to use (at Time 1) or had actually used (at Time 2) to deal with the problem. Emotional responses were assessed by self-ratings, and coping strategies were assessed with the COPE (Carver, Scheier, & Weintraub, 1989).

The students who had mentally simulated the ongoing stressful event through the intervention patterned after Pennebaker and Beall's (1986) study reported more positive affect relative to the outcome-simulation and the control groups immediately after performing the simulation. One week later, the trend toward more positive affect remained, and, in addition, participants reported that they had used more emotion-focused coping, specifically positive reinterpretation and the use of social support for emotional solace, compared with participants in the outcome-simulation and the control conditions (see Table 4). The intervention, then, succeeded in evoking coping directed to the management of emotional states, and it reduced negative affect, as has been found with previous writing interventions by Pennebaker and his associates (e.g., Pennebaker & Beall, 1986).

The intervention uncovered significant changes in problem-solving activities as well. Participants who focused on the ongoing stressful event reported one week
later that they had used more active coping and had sought more instrumental social support relative to the outcome-simulation and control groups. The outcome simulation, which had led participants to envision the successful resolution of the stressful event, had no significant impact on the intended or reported use of active coping strategies or on the seeking of instrumental social support relative to the control condition (see Table 5). When people are coping with ongoing stressful events, then, mental simulations that focus on the unfolding processes surrounding those events can have not only emotional regulation benefits, as Pennebaker and his colleagues have previously found, but also problem-solving benefits, as these findings on active coping and the use of instrumental social support indicate.

The students had been asked to describe the particular stressful event they chose, and serendipitously, those events split evenly into academic problems, which were initially perceived as quite controllable, and interpersonal problems, which were initially seen as less controllable. Typically, research has found that controllable problems are especially amenable to problem-solving activities relative to emotion regulation strategies, whereas uncontrolled problems are more amenable to emotional regulation relative to active coping strategies (Forsythe & Compass, 1987; McCrae, 1984; Vitaliano et al., 1990). Internal analyses based on the type of problem produced an intriguing pattern. Interpersonal stressors came to be seen as amenable to active coping strategies following the use of the process mental simulation. The reverse was true for academic problems: Mentally rehearsing the academic stressor and what they had done to deal with it led participants to perceive that emotional regulation strategies, specifically, acceptance, could help with the management of the academic stressful event as well.

These patterns fit well with our guiding conceptual framework, which maintains that mental simulations can have beneficial effects on self-regulation when they enable people to regulate their emotions effectively and engage their problem-solving strategies. The results suggest, too, that the type of intervention developed by Pennebaker and his associates may be fruitfully extended beyond the past traumatic events their work has previously explored. In particular, stressors that are ongoing may also be amenable to these kinds of interventions, either through writing about, talking about, or mentally simulating the events in question. In so doing, our investigations suggest, both problem-solving benefits and emotional regulation benefits may be achieved.

### Conclusions

The work just described has its joint origins in social cognition research on self-regulation and in health psychology research on stress and coping. These literatures are fundamentally related in suggesting the importance of two basic self-regulatory tasks, namely, the management of affect and the initiation and maintenance of problem-solving activities. As the social cognition literature on self-regulation makes clear, problem-solving activities and emotional regulation are essential for the performance of basic daily activities and for the active pursuit of chosen goals. As the stress and coping literature makes clear, these tasks are essential for coping effectively with inevitable stressful circumstances. Our research program suggests that mental simulation is a process that can be actively harnessed for this beneficial self-regulation and that both the activation of emotional states and the generation of plans and other problem-solving activities are reliably engaged by certain types of mental simulations.

Nonetheless, mental simulation is not an intrinsically beneficial process. As noted, a number of research...
ers have written about the painful consequences of rumi-
native thought and its ability to perpetuate the reality of
stressful events on which people might better achieve
closure (Nolen-Hoeksema, Morrow, & Fredrickson, 1993; Silver et al., 1983). Our research program has
identified outcome simulations as another type of mental
simulation that appears to have few benefits and can even
be maladaptive. In so doing, it provides an indictment of
the processes by which these tasks are accomplished and, in
particular, on the ways by which they are accomplished
most successfully. Mental simulation is a window on the
future that helps people perform these tasks effectively.
When used appropriately, it can enable a person to man-
age the basic tasks of life, namely, the regulation of emo-
tional states and the effective use of planning and prob-
lem-solving capabilities for combating stress, regulating
daily activities effectively, and achieving personal goals.

REFERENCES

imagining behavioral scripts on personal intentions. Journal of Per-
sonality and Social Psychology, 45, 293–305.

Anderson, C. A., & Sechler, E. S. (1986). Effects of explanation and
counterexplanation on the development and use of social theories.

outcome expectancies and self-regulation. In M. P. Zanna (Ed.), Ad-
vances in experimental social psychology (Vol. 30). New York: Aca-
demic Press.

vation in terms of motives, expectancies, and incentives. In J. W.
Atkinson (Ed.), Motives in fantasy, action, and society (pp. 288–

Bandura, A. (1986). Social foundations of thought and action: A social-

cino, CA: Multivariate Software.

Browne, K. D., Mariatt, G. A., Lichtenstein, E., & Wilson, G. T.
(1986). Understanding and preventing relapse. American Psycholo-
ist, 41, 765–782.

Buchler, R., Griffin, D., & Ross, M. (1994). Exploring the "planning
fallacy": Why people underestimate their task completion times.

Carroll, J. S. (1978). The effect of imagining an event on expectations
for the event: An interpretation in terms of the availability heuristic.
Journal of Experimental Social Psychology, 14, 88–96.

ing strategies: A theoretically based approach. Journal of Personality
and Social Psychology, 56, 267–283.

Ithaca, NY: Mouvement.


Dyer, W. W. (1989). You'll see it when you believe it: A way to your

Fanning, P. (1994). Visualization for change (2nd ed.). Oakland, CA:
Berkeley Books.

Feather, N. T. (Ed.). (1982). Expectations and actions: Expectancy-

on motor skill learning and performance: A meta-analysis. Journal of


praisals of stressful events and coping: Testing the goodness of fit


vant scenarios as mediators of likelihood estimates and compliance:
Does imagining make it so? Journal of Personality and Social Psy-
chology, 43, 89–99.

Hayes-Roth, B., & Hayes-Roth, F. (1979). A cognitive model of plan-

Hirt, E. R., & Sherman, S. J. (1985). The role of prior knowledge in
explaining hypothetical events. Journal of Experimental Social
Psychology, 21, 519–543.


to its alternatives. Psychological Review, 93, 126–153.

Kahneman, D., & Tversky, A. (1979). Intuitive prediction: Biases and
corrective procedures. TIMS Studies in Management Science, 12,
313–327.

problem solving and decision making. In J. M. Flach, P. A. Han-
cock, J. K. Cerd, & K. I. Vicente (Eds.), An ecological approach
to human machine systems II: Local applications. Hillsdale, NJ:
Erlbaum.

Koehler, D. J. (1991). Explanation, imagination, and confidence in judg-

April 1998 • American Psychologist