From Thought to Action: Effects of Process- Versus Outcome-Based Mental Simulations on Performance

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Mental simulations enhance the links between thought and action. The present research contrasted mental simulations that emphasize the process required to achieve a goal versus the outcome of goal achievement. For 5 to 7 days prior to a midterm examination, college freshmen mentally simulated either the process for doing well on the exam (good study habits) or simulated a desired outcome (getting a good grade) or both. A self-monitoring control condition was included. Results indicated that process simulation enhanced studying and improved grades; the latter effect was mediated by enhanced planning and reduced anxiety. Implications of process and outcome simulations for effective goal pursuit are discussed.

Taylor and Schneider (1989) proposed a cognitive analysis of coping that places mental simulation at the center of self-directed action. They suggested that mental simulation serves problem-solving functions and emotional regulation functions for turning imagined experience into action. Mental simulation may be defined as the imitative representation of real or hypothetical events. It includes rehearsals of likely future events (such as going over mentally the events that will occur during the day), replays of past events (such as going back over an argument with one's spouse to determine what went wrong), fantasies (such as imagining oneself as a lottery winner), or a combination of real and fantasy elements (such as replaying an argument but including what one should have said). Although mental simulation is central to entertaining the self, as through fantasies (e.g., Singer, 1972) and to maladaptive ruminative thought (e.g., Silver, Boon, & Stones, 1983)—it can be highly functional for effective self-regulation by providing an explicit vision of the future and enabling the person to construct a pathway for getting there (e.g., Markus & Nurius, 1986). In this way, mental simulation may enhance the links between thought and goal-directed action.

This may occur for several reasons. First, mental simulations make courses of action seem real or true. When individuals actively imagine future events (as opposed to reading or otherwise learning about them), they later express greater confidence that the events will actually occur (e.g., Anderson, 1983; Anderson & Sechler, 1986; Carroll, 1978; Gregory, Cialdini, & Carpenter, 1982; Hirt & Sherman, 1985; Kahneman & Tversky, 1982; Sherman, Zehner, Johnson, & Hirt, 1983). This effect of simulation on enhanced likelihood may create a state of readiness for action.

Second, imagining how events are going to take place provides information about those events, such as their sequence or causal relation to each other, and thus, simulation provides information rudimentary to planning (Miller, Galanter, & Pribram, 1960). Research by Hayes-Roth and Hayes-Roth (1979) demonstrated that simulation is an efficient and effective means both for deriving plans initially and for checking on their viability (see also Markman, Gavanski, Sherman, & McMullen, 1993). Thus, the information that can be derived from a mental simulation essentially provides a plan of action.

A third characteristic that may enhance links to action is that simulations produce emotional reactions and often intense ones (e.g., Wright & Mischel, 1982). For example, a growing literature on counterfactual reasoning suggests that the spontaneous or manipulated imagi-

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nation of nonfactual alternatives to reality can influence a wide range of emotional states, including regret, sympathy, and motivation (Gleicher et al., 1990; Johnson, 1986; Markman et al., 1993; Miller & McFarland, 1987). Imagining events can also have an impact on physiological responses, including heart rate, blood pressure, and electrodermal activity (Lyman, Bernardin, & Thomas, 1980; Sheikh & Kunzendorf, 1984). When simulations are recruited in the rehearsal of future behavior, the arousal and motivation necessary for action may be among the physiological states and emotions evoked (Locke & Latham, 1990).

Several areas of research are consistent with the hypothesis that mental simulation facilitates goal-directed behavior by strengthening the links between thought and action. A large literature on mental practice, much of it conducted in the context of athletics, shows how imagery or mental simulation can improve performance (Cratty, 1984; Nideffer, 1976; Orlick, Partington, & Salmela, 1983; Singer, 1972). Mental simulation is also incorporated into cognitive behavior therapies, especially relapse prevention techniques (Kazdin, 1986; Marlatt & Gordon, 1985). For example, Marlatt (Marlatt, 1978; Marlatt & Gordon, 1985) has reduced recidivism in alcoholics by incorporating simulation into cognitive coping skills: Alcoholics are instructed to imagine situations in which they might be tempted to drink and then rehearse how they can avoid giving in to that temptation (see also Brownell, Marlatt, Lichtenstein, & Wilson, 1986). Despite the fact that mental simulations appear to facilitate goal-directed behavior, little research has examined either the effects of different types of mental simulations on goal-directed behavior or the underlying processes whereby mental simulations affect goal-directed action.

Types of Mental Simulation

At least two types of mental simulations may be distinguished conceptually: outcome simulation and process simulation. Outcome simulation involves mental simulation as a goal rehearsal or goal-setting technique. This approach maintains that envisioning the outcome that one wants to achieve may facilitate efforts to achieve the goal or enhance perceptions of self-efficacy. Thus, for example, a student who imagines herself as a successful surgeon may be more likely to see the goal as within her reach and be more motivated to achieve her goal of becoming a surgeon than one who does not rehearse that vision. This approach espouses an "I can do it" effect of outcome simulation on goal pursuit and has been popularized in a variety of self-help techniques in goal-setting and time management (e.g., Lakein, 1973; Schwartz, 1983). This position has also been implicitly incorporated into Markus and Nurius's (1986) work on possible selves, which maintains that possible selves function as images of one's self in the future toward which a person may strive (Markus & Wurf, 1987; Ruvolo & Markus, 1992).

Research on mental practice embodies a second approach to mental simulation that emphasizes process (e.g., Cratty, 1984; Nideffer, 1976). From this perspective, the simulation of the process leading up to a desired outcome may enable a person to achieve his or her goal. According to this viewpoint, a student who wishes to become a surgeon would improve his or her chances by mentally simulating the steps he or she must go through to achieve that goal rather than envisioning him- or herself in the desired end state. Process simulations may enhance goal achievement by helping people construct viable and effective plans of action to reach their goals, ultimately prompting goal-directed actions.

The present research had several purposes. The first was to distinguish empirically between these two types of mental simulation and examine their effects on goal-directed behavior. To address these issues, we intervened in students' studying for a midterm examination to see which type of mental simulation—outcome simulation, process simulation, or both—would enhance studying and facilitate performance on the exam. A second purpose was to identify mediating processes by which these mental simulations might achieve these effects. Taylor and Schneider (1989) had predicted that the benefits of mental simulation on goal-directed action derive from effects on problem-solving activities such as planning and on emotional regulation. That is, simulating the steps to reach a goal provides information about the actions needed to attain the goal, such as their sequence or causal relation to each other. In addition, mental simulation may enhance the emotional or motivational states that facilitate action and may potentially decrease those that hinder action, such as anxiety or worry (Locke & Latham, 1990; Taylor & Schneider, 1989).

There are, however, several alternative theoretical positions that could account for the effects of mental simulation on goal-directed action. First, by virtue of yielding information about how to achieve a goal and/or by virtue of making the goal seem proximal, mental simulations may enhance perceptions of self-efficacy (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 and/or the desirability or value of a goal (Atkinson, 1964; Feather, 1982), thereby facilitating goal-directed behavior. Third, by making the goal and/or the steps to reach the goal salient, individuals may come to form intentions to initiate goal-directed action sequences. Finally, mental simulation may affect goal-directed behavior by changing the level at which individuals identify their actions (Vallacher & Wegner, 1985). Specifically, by making the goal salient, outcome simulation may lead people to identify their actions at a high level, whereas process simulation, which focuses on the individual steps to reach the goal, may lead people to identify their actions at lower levels. Lower level action is thought to facilitate performance on complex and difficult tasks (Wegner & Vallacher, 1986).

Based on this theoretical reasoning, we predicted that process simulation would enhance studying and exam performance through better planning and through effective emotional regulation (Taylor & Schneider, 1989). The simulation exercises were expected to have no effect on self-efficacy, outcome expectancy, outcome value, goal-related intentions, and action identification that could account for beneficial effects on performance.

METHOD

Participants

To fulfill a course requirement, 101 undergraduates (28 men and 73 women) participated in the study. Participants were enrolled in one of three introductory psychology classes that were offered in two consecutive terms and taught by three different instructors. The sample was 29.7% Anglo, 44.6% Asian, 10.9% Latino, 5.9% African American, and 8.9% other. Participants' age ranged from 18 to 28.

Procedure

Approximately 1 week before their midterm exam, participants were recruited to the lab and run in groups of one to three. Prior to the manipulation, they completed a brief questionnaire that assessed the amount of studying that they had already done for the class midterm exam. All participants were then given a daily calendar sheet and asked to indicate the days and hours that they planned to study for the exam and where and how they planned to study.

Because participants were run in groups of one to three, each group was randomly assigned to either (a) a control group, (b) a process-only or an outcome-only simulation group, or (c) a combined process and outcome simulation group (i.e., receiving both process and outcome simulation instructions).[1] Thus, in a 2 × 2 between-participants design, participants practiced a process simulation exercise (simulating the process of effective studying), an outcome simulation exercise (simulating discovery that one had achieved a high grade on the exam), both, or neither (for those in the self-monitoring control group).

Process simulation exercise. Participants in the process simulation group were instructed to mentally simulate themselves studying for the exam—that is, to visualize when, where, and how they might study for the exam to achieve a high grade on the exam. They read the following instructions:

> In this exercise, you will be asked to visualize yourself studying for the midterm in such a way that would lead you to obtain a high grade on the midterm. As of today and for the remaining days before the midterm, imagine how you would study to get a high grade on your Psychology midterm. It is very important that you see yourself actually studying and have that picture in your mind.

Outcome simulation exercise. Participants in the outcome simulation group were instructed to mentally simulate themselves attaining a high score on the exam—that is, to visualize themselves having completed the exam and finding out that they achieved a very high score on the exam. They read the following instructions:

> In this exercise, you will be asked to visualize yourself getting a high grade on your Psychology midterm and imagine how you would feel. It is very important that you see yourself actually getting a high grade on the Psychology midterm and have that picture in your mind.

Combined process and outcome simulation exercise. Those in the combined process and outcome simulation group were instructed to simulate both the process and the outcome.

Self-monitoring exercise. Those in the self-monitoring control group were instructed to monitor the amount of studying they did for each day before the exam and to record the number of hours studied each day.

Participants in the three simulation groups were instructed to perform their simulation exercise by reading the simulation script, following the instructions, rehearsing the simulation with their eyes closed, and then writing down the contents of their simulations on paper.

After the simulation manipulation (or the self-monitoring instructions), all participants read an information sheet that conveyed the informational content of both the process and the outcome simulation exercises but without the specific simulation instructions. This step was taken to avoid informational confounds in the simulation manipulations.

Dependent Measures

Time 1 assessments. After completing the mental exercise and reading the informational sheet, participants completed a questionnaire that assessed potential mediators. These assessments were on an interval scale of 1 (*not at all*) to 7 (*extremely*). *Planning* was assessed through three items: "To what extent have you figured out exactly how you might study for the exam?" on a scale of 1 (*I* *have no idea*) to 7 (*I have figured out exactly*); "To what extent do you have a plan for when, where, and how you might study for the exam?" on a scale of 1 (*I have no plan*) to 7 (*I have an exact plan*); and "At this point, do you feel that you have properly prepared for and organized the information and time that you will need for doing well on this exam?" on a scale of 1 (*not at all prepared*) to 7 (*fully prepared*). *Emotional impact* was assessed by three items asking them how anxious, worried, and confident they were about the exam. *Motivation* was assessed by three items: asking them how motivated they were to do a good job on the exam, to get a good grade on the exam, and to study for the exam. *Self-efficacy* (Bandura, 1986) was assessed by the items: "How confident are you that your abilities are up to the demands of this exam?" "How confident are you about being able to put in the work needed to do well on this exam?" and "How certain are you that you can make the effort needed to do well on this exam?" *Outcome expectancy* (see Locke & Latham, 1990) was assessed through the items: "How certain are you that your efforts will produce the outcome you are striving for?" and "How certain are you that your work will result in the grade you are seeking?" *Outcome value* was assessed by the questions "How important is it for you to attain this goal?" and "How valuable is this goal to you?" *Intentions to initiate goal-directed behavior* were assessed by asking participants to indicate when they intended to begin the activities leading to the goal and when they intended to begin studying for the exam. *Action identification* (Vallacher & Wegner, 1985) was assessed by asking participants to rate each of five descriptions as to how accurately it characterized what they would be doing on a scale of 1 (*not at all*) to 7 (*completely*). These descriptions began with low-level actions ("reading lecture notes and textbook" and "studying"), moved to middle-level actions ("improving my chances for a good grade"), and ended with high-level actions ("gaining knowledge in psychology" and "improving my general academic knowledge and skills"). The participants were also asked to indicate the grade they expected to receive and the grade for which they strove. With the exception of the action identification items, which were measured separately, the order of all other items was scrambled so as to minimize response bias.

Following the completion of the questionnaire, all participants were instructed to practice the mental exercise for 5 minutes each day for the remaining days before the exam and to record the number of hours that they studied for the exam. All participants were given a daily diary packet that contained sheets to record the hours studied. In addition, all participants were asked to record the content of their daily mental simulation. This was undertaken so we could identify if the mental simulation had changed form or if it had remained in substantially the same form during the intervening week.

Time 2 assessments. Participants were contacted by telephone at Time 2, the day before the exam. They answered the same items assessing potential mediators and also indicated the grade that they strove for on the exam and the grade they expect to receive.

Time 3 assessments. At Time 3, the day after the exam, participants were recontacted by phone and asked to report the content of their daily diary, including the day they began to study, the total hours studied, and the number of times they practiced the mental exercise. They were also asked how satisfied they were with the way they prepared for the exam, how satisfied they were with their performance on the exam, how helpful they found the mental exercise to be, and how likely they would be to use this technique to study for future exams on 7-point interval scales. They were then instructed to mail back the daily dairy in the stamped addressed envelope provided. Participants were then debriefed and given information on how to obtain a written report of the study's findings. Exam scores were obtained from the course instructors with participants' permission.

RESULTS

Of the 101 initial participants, 10 could not be contacted at Time 2, and 6 could not be contacted at Time 3. In addition, exam scores were not available for 8 of the participants. Because preliminary analyses revealed no discernible differences in the participants lost to follow-up, all participants were included in all data analyses for which they provided data. The number of times that participants reported doing the simulation or self-monitoring exercise ($M = 4.30$) did not differ among the four groups.

Students' daily diary logs were inspected to see if there were any systematic changes in the simulations over this time period either generally or as a function of experimental condition. The overwhelming majority of students reported that they had continued to perform the mental simulation as it had originally been taught to them, and there were no discernible trends generally or by condition to suggest that the mental simulations had systematically changed over the time period they were practiced.

Time 1 Assessments

The anxiety, worry, and confidence (reverse coded) measures were averaged to provide an index of emotional impact (Cronbach's alpha = .74). A two-way analysis of variance with process simulation (yes, no) and outcome simulation (yes, no) as the two independent variables revealed a significant main effect of process

TABLE 1: Mean Ratings of Potential Mediators at Time 1 as a Function of Process and Outcome Simulation

	Control	*Outcome*	*Process*	*Combined*
Emotional impact	4.16	4.56[a]	3.99	3.52[b]
Planning	4.88	4.81[a]	5.19	5.38[b]
Outcome expectancy	5.04	4.64	5.14	5.38
Action identification				
Reading materials	6.74	6.48[a]	6.82	6.89[b]
Studying	6.87	6.52	6.82	6.82
Getting a good grade	6.57	6.19	6.39	6.57
Gaining knowledge in psychology	6.35	6.00	6.43	6.46
Gaining general academic skills	6.04	5.67	6.00	6.11

NOTE: Measured on an interval scale of 1 (*not at all*) to 7 (*extremely*) for emotional impact; 1 (*have no plan*) to 7 (*have exact plan*) for planning; 1 (*not at all certain*) to 7 (*extremely certain*) for outcome expectancy; and 1 (*not at all*) to 7 (*completely*) for action identification. Means across each row not sharing a common superscript are significantly different from each other at .05 or greater.

simulation: Participants who simulated the process of studying for the exam reported less negative emotion than those who did not engage in process simulation, $F(1, 97) = 7.83$, $p < .006$. However, a significant two-way interaction, $F(1, 97) = 4.15$, $p < .04$, suggested that the impact of process simulation on reducing negative emotions was greater if the outcome was also envisioned. Means and the results of individual comparisons are represented in Table 1. The three motivation items were averaged to form an index of motivation (Cronbach's alpha = .76). Two-way ANOVA revealed no significant effects of the simulations on motivation at Time 1 (ps > .30).[2]

An index of planning was formed by averaging the three planning measures (Cronbach's alpha = .79). A significant main effect of process indicated that participants who engaged in process simulation reported having a clearer plan than participants who did not simulate the process of studying for the exam, $F(1, 97) = 5.22$, $p < .02$. Means are shown in Table 1. No effect of outcome simulation and no interaction were found (ps > .45).

The two outcome expectancy items were averaged for analysis (interitem correlation = .93). A main effect of process simulation on the outcome expectancy index was marginally significant, $F(1, 97) = 3.60$, $p < .06$, and suggested that process simulation participants were more certain of achieving their desired grade on the exam than those who did not simulate the process. Means are presented in Table 1.

The analysis of the action identification items revealed a significant main effect of process simulation on the lowest level action, that is, reading materials for the exam. Participants who simulated the process of studying for the exam identified more with this low-level action than those who did not simulate the process, $F(1, 97) = 5.37$, $p < .02$. No significant effects were observed for the other action identification items (ps > .15). Means are shown in Table 1.

Cronbach's alphas for the self-efficacy items, outcome value items, and behavioral intentions items were .81, .84, and .89, respectively. The items for each measure were averaged for analysis. There were no significant effects for self-efficacy, outcome value, and intentions to initiate goal-relevant behavior at Time 1 (ps > .15). In addition, no significant differences in the grade that participants strove for and the expected grade were found (ps > .35).

Time 2 Assessments

The same variables had been assessed the day before the exam by telephone interview. The index of emotional impact (Cronbach's alpha = .53) revealed no significant differences on negative emotions at Time 2. The three motivation measures were averaged to provide an index (Cronbach's alpha = .74). A significant two-way interaction for motivation emerged at Time 2, $F(1, 87) = 4.03$, $p < .05$. Motivation was low for process simulation participants except when it was combined with outcome simulation. As shown in Table 2, planned comparisons showed that the process-only group was significantly less motivated to study than the control group, $t(87) = 2.18$, $p < .04$. It is possible that process simulation participants were less motivated to study the day before the exam because they had already studied. In fact, this effect is largely eliminated when one covaries out the number of hours studied, $F(1, 86) = 2.73$, $p < .11$.

Cronbach's alphas for the planning items and outcome expectancy items were .78 and .88, respectively. The items for each measure were averaged for analysis. Although significant differences had been found at Time 1, no significant differences among conditions were found for planning and outcome expectancy at Time 2 (ps > .20).

In the analysis of the action identification items, a significant two-way interaction was found for the lowest level action ("reading"), $F(1, 87) = 4.63$, $p < .04$. As shown in Table 2, the outcome simulation group appeared to identify less with this low-level action. At the higher level action ("getting a good grade"), there was a significant two-way interaction, $F(1, 87) = 4.23$, $p < .04$. The outcome-only group appeared to identify less with this action as well.

Cronbach's alphas for the self-efficacy items, outcome value items, and intentions to initiate goal-relevant behavior items were .80, .84, and .84, respectively. The items for each measure were averaged for analysis. As had been true at Time 1, no significant differences

TABLE 2: Mean Ratings of Potential Mediators at Time 2 as a Function of Process and Outcome Simulation

	Control	*Outcome*	*Process*	*Combined*
Motivation	6.19[a]	5.89	5.67[b]	6.05
Action identification				
Reading materials	6.44	5.79	6.05	6.52
Studying	6.56	6.00	6.24	6.43
Getting a good grade	6.44	5.74	6.19	6.38
Gaining knowledge in psychology	6.33	5.58	6.29	6.38
Gaining general academic skills	5.61	5.58	5.81	5.76
Grade participants strove for	3.89	3.68	3.86	3.67

NOTE: Measured on an interval scale of 1 (*not at all*) to 7 (*extremely*) for motivation; 1 (*not at all*) to 7 (*completely*) for action identification; 0 (F) to 4 (A) for sought-after grade. Means across each row not sharing a common superscript are significantly different from each other at .05 or greater.

among conditions were found for self-efficacy, outcome value, and behavioral intentions at Time 2 ($ps > .15$).

In terms of the grade that participants strove for the day before the exam, there was a significant main effect of outcome simulation. As shown in Table 2, participants who simulated attaining a high grade on the exam strove for a lower grade the day before the exam compared to other participants, $F(1,87) = 4.39$, $p < .04$. As at Time 1, no significant differences were observed for expected grade ($ps > .35$).[3]

Time 3 Assessments

There was a highly significant main effect of process simulation on the number of hours that participants studied for the exam, $F(1,91) = 7.29$, $p < .008$. As shown in Table 3, participants who simulated the process of studying for the exam studied an average of 3 hours more than those who did not engage in process simulation. Planned comparisons revealed that both the process-only group and the combined group studied significantly more than the outcome-only group, $t(91) = 2.46$, $p < .02$, and $t(91) = 2.98$, $p < .004$, respectively. There was no effect of outcome simulation and no interaction ($ps > .15$).

The discrepancy between planned and actual hours studied was significantly smaller for process simulation participants ($M = -.27$) compared to other participants ($M = 4.79$), $F(1, 91) = 13.14$, $p < .001$. Means are presented in Table 3. Analyses of when participants began to study for the exam, satisfaction with the way they prepared for the exam, satisfaction with their performance on the exam, evaluation of the mental exercise as helpful to their exam preparation, and the likelihood of using the exercise to prepare for future exams revealed no significant differences among conditions ($ps > .15$).

TABLE 3: Total Hours Studied, Planned Minus Actual Hours Studied, and Exam Scores as a Function of Process and Outcome Simulation

	Control	*Outcome*	*Process*	*Combined*
Total hours studied	14.50[ab]	11.57[a]	16.07[b]	17.12[b]
Planned—Actual hours studied	4.59[a]	5.00[a]	.96[b]	–1.60[b]
Exam scores (%)	77.68	72.57[a]	80.60[b]	77.28
Exam scores—Class average (%)	3.85	–1.96[a]	6.60[b]	2.72

NOTE: Means across each row not sharing a common superscript are significantly different from each other at .05 or greater.

Exam Performance

As shown in Table 3, process simulation participants scored on average 3.5 percentage points higher on the exam ($M = 78.94$) than participants who did not simulate the process of studying for the exam ($M = 75.19$), $F(1, 89) = 2.89$, $p < .09$. A marginally significant main effect of outcome simulation was also observed, $F(1, 89) = 3.46$, $p < .07$. Participants who simulated the desired outcome received on average four points lower on the exam ($M = 75.13$) than those who did not engage in outcome simulation ($M = 79.23$). Planned comparisons revealed that the process-only group scored significantly higher ($M = 80.60$) than did the outcome-only group ($M = 72.57$), $t(89) = 2.52$, $p < .01$, as predicted.

Mediational Analyses

Possible mediators in the relationships between mental simulation and exam performance were investigated. Of the Time 1 variables that were affected by process simulation (emotional impact, planning, outcome expectancy, and action identification), only emotional impact and planning were significantly correlated with exam score ($r = -.27$, $p < .01$, and $r = .22$, $p < .05$, respectively). For the Time 2 variables, the only variable that was significantly affected by mental simulation and significantly correlated with exam score was the grade that participants strove for the day before the exam ($r = .28$, $p < .01$).

The mechanisms by which process simulation exerted its positive effect on exam performance and outcome simulation exerted its negative effect on exam performance were investigated using Structural Equation Modeling (SEM) analyses (Bentler, 1995). Only participants who provided data at all three time points were included in the analyses. For the path analyses, the following variables were included in the model: planning at Time 1, anxiety at Time 1, strove-for grade at Time 2, hours studied, exam score, process simulation (coded as 0 = no process simulation, 1 = process simulation), and outcome simulation (coded as 0 = no outcome simulation, 1 = outcome simulation). It was predicted that process simulation would enhance exam performance by facilitating better planning, and so the model included a path from process simulation to planning and a path from planning to exam score. In addition, the effect of process simulation on exam performance was also predicted to be mediated by emotion regulation. Hence, the model included a path from process simulation to anxiety and a path from anxiety to exam score. Although it was hypothesized that process simulation would increase studying, this effect was not expected to account for the improved exam performance; amount of studying was not significantly correlated with exam score ($r = .12$, $p < .15$). Thus, the model included a path from process simulation to hours studied without a path from hours studied to exam score. Hours studied was included in the model because it is considered an important outcome measure in its own right. Preliminary analyses showed that the grade participants strove for was significantly lowered by outcome simulation and significantly correlated with exam scores. Thus, two paths showing the mediated effect of outcome simulation on exam score through the grade that participants strove for were also included in the model. Other variables were not included in the model because they were not hypothesized to predict exam score, were not significantly correlated with exam score (ps > .10), and/or were not significantly affected by the manipulations (ps > .10).

Maximum likelihood estimators were used to calculate parameter estimates in the model. The independence model that tests the hypothesis that all variables are uncorrelated was rejected, $\chi^2(21, N = 91) = 83.86$, $p < .001$. To assess the fit of the model to the observed data and modeled covariance matrix, the chi-square statistic, the goodness-of-fit index (GFI), the comparative fit index (CFI), and the incremental fit index (IFI) were calculated. The small sample size in this study makes it appropriate to use these fit indexes in evaluating overall fit (Hoyle, 1995). There was a significant improvement in fit between the independence model and the hypothesized model, χ^2_{diff} (7, $N = 91$) = 36.02, $p < .001$. However, the significant chi-square statistic, $\chi^2(14, N = 91) = 47.84$, $p < .001$, and the fit indexes (GFI = .87, CFI = .46, IFI = .52) suggest that the proposed model did not adequately fit the data. Each relationship outlined in the proposed model was supported by a significant parameter estimate (betas ≥ .20 or betas ≤ –.20, ps < .05), with the exception of the hypothesized path from planning to exam score (beta = .05, $p > .50$).

To explore the possibility that planning (assessed at Time 1) may have enhanced exam performance indirectly through another variable (assessed at Time 2) such as the grade the student strove for, the hypothesized model was modified by deleting the path from planning to exam score and by adding a path from planning to strove-for grade. This post hoc modification of the model is justified, given that strove-for grade is the only Time 2 variable in the model that is significantly correlated with planning ($r = .46$, $p < .001$). The chi-square statistic and the fit indexes indicated that the modified model fit the data reasonably well, χ^2 (14, $N = 91$) = 26.46, $p < .02$, GFI = .93, CFI = .80, IFI = .82. Another indicator of the model's acceptable fit is the chi-square to degrees of freedom ratio (26.46/14 = 1.89). A model is considered acceptable if this ratio is less than 2 (Ullman, 1996). However, to develop a better fitting model, an additional modification was made on the basis of the Lagrange multiplier test. A path correlating the residuals associated with anxiety and planning (both assessed at Time 1) was added to the modified model. The chi-square test and the fit indexes indicated that the modified model with the correlated errors fit the data very well, $\chi^2(13, N = 91) = 16.82$, $p < .21$, GFI = .95, CFI = .94, IFI = .95, and was significantly improved with the addition of this path, χ^2_{diff} (1, $N = 91$), = 9.64, $p < .01$.

As displayed in Figure 1, each relationship in the modified model was supported by a significant standardized maximum likelihood parameter estimate. It appears that process simulation improved exam performance via two routes: (a) Process simulation reduced anxiety (beta = –.28, $p < .01$), which in turn enhanced exam performance (beta = –.21, $p < .05$), and (b) process simulation facilitated planning (beta = .24, $p < .05$), which in turn maintained aspiration level (i.e., strove-for grade) (beta = .45, $p < .001$). Aspiration level, in turn, enhanced exam performance (beta = .23, $p < .05$). The indirect (i.e., mediational) effect of process simulation on exam score was significant ($z = 2.17$, $p < .05$). The indirect effect of process simulation on strove-for grade via planning was significant ($z = 2.10$, $p < .05$), and the indirect effect of planning on exam performance via strove-for grade was also significant ($z = 2.09$, $p < .05$).

The negative coefficient for the path from outcome simulation to strove-for grade (beta = –.20, $p < .05$) is consistent with preliminary analyses that found lowered aspirations for outcome simulation participants. Because strove-for grade significantly predicted exam score, the negative effect of outcome simulation on the grade that participants strove for may have, in turn, accounted for the poorer exam performance. Analysis of the indirect effect of outcome simulation on exam performance was marginally significant ($z = 1.58$, $p < .12$).

Because post hoc modifications were made, the correlation between the hypothesized model estimates and the estimates from the modified model was calculated. The high correlation between the estimated parameters of the two models ($r = .99$, $p < .01$) indicates that the relationships among the parameters changed little as a result of the model modifications (Ullman, 1996). Generally, then, these results support the notion that the

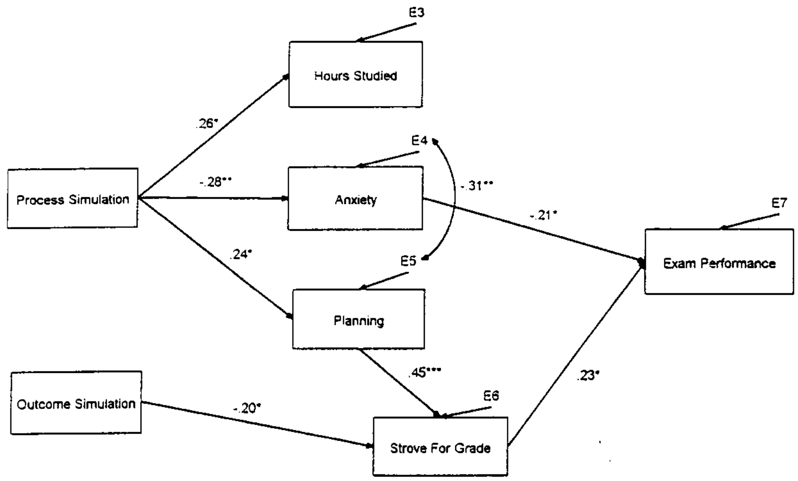

Figure 1 The modified model showing the mediational effects of process and outcome simulations on exam performance and the correlated residuals associated with anxiety and planning.
NOTE: Standardized path coefficients and significance levels of unstandardized path coefficients are shown.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

positive impact of process simulation on exam performance was mediated by reduced anxiety and enhanced planning (through the maintenance of participants' aspiration level).

GENERAL DISCUSSION

The results of the present research provide evidence for the facilitative effects of process simulation on goal-directed action and for the underlying theoretical model that guided the predictions. Specifically, students who envisioned the steps leading to successful goal achievement performed better on a midterm exam than those who had practiced outcome simulations, which focused them on the outcome they wanted to achieve. The beneficial effects of process simulation stemmed largely from its effects on problem-solving activities—specifically planning—and on the regulation of emotional states. In particular, process simulation participants reported having a detailed plan compared to participants in the other experimental conditions. Focusing on the process needed to achieve a goal also enhanced other problem-solving activities, specifically increasing the number of hours of study time participants devoted to preparation for their midterm. Process simulation also led to a decline in anxiety associated with the exam. Path analyses indicated that, as predicted, the positive effects of process simulation on exam performance were mediated by this reduction in negative emotions and by the better planning produced by the process simulation; in particular, enhanced planning maintained the grade that participants strove for, and their maintained aspiration level, in turn, enhanced performance.

Analyses of the mediators by which process simulation affected goal-directed action also ruled out several alternative explanations. Although process simulation increased outcome expectancy and low-level action identification, these variables did not account for process simulation participants' enhanced performance on the exam. Self-efficacy, enhanced subjective likelihood and value of the goal, and goal-related intentions also did not account for the beneficial effects of process simulation.

Process simulation increased study time, but these effects did not account for the effects of process simulation on exam performance. This lack of relation between studying time and performance may seem surprising. Measures of academic performance, such as exam grades, are only indirect assessments of how well a person has studied or how fully material has been mastered. In fact, other research has also found a low association between time spent studying and academic performance (e.g., Jenkins, 1931, reported a correlation of –.11) (see also O'Connor, Chassie, & Walther, 1980). As such, the effects of mental simulation on studying time could be construed as additional benefits of the mental simulation insofar as studying time may be more indicative of how thoroughly information has been learned, an indicator only roughly assessed by exam grade. Process simulation may have produced better exam performance through means other than length of time studying, such as by helping individuals study more effectively and efficiently, which are effects that may have been facilitated by planning and reduced anxiety.[4]

In addition, process simulation reduced the discrepancy between the number of hours that participants initially planned to study and the actual hours studied. Individuals who engaged in process simulation studied on average as initially planned, whereas those in the control and outcome simulation groups overestimated the amount of studying they would do. These results suggest that individuals in the control and outcome simulation groups exhibited the planning fallacy, that is, the overly optimistic assessment that one's own project will proceed as planned (Buehler, Griffin, & Ross, 1994; Kahneman & Tversky, 1979). Consistent with other research (Taylor & Armor, 1996), process simulation appears to reduce the planning fallacy.

Outcome Simulation

The outcome simulation perspective predicts that envisioning a desired outcome will help to bring about the desired goal. The self-help literature is replete with such advice (e.g., Dyer, 1989; Fanning, 1994; Lakein, 1973; Peale, 1982). However, the results suggest that envisioning the desired outcome did not prompt effective actions to bring about the desired goal. In fact, outcome simulation can have negative effects on goal-directed behavior. Oettingen (1995) reported similar results in a series of studies on the effects of positive fantasies (see also Hammond, Summers, & Deane, 1973, on the negative effects of outcome feedback). For example, Oettingen and Wadden (1991) found that positive fantasies interfered with goal attainment in a weight loss program. Oettingen (1995) suggested that positive fantasies reduce the likelihood of effective action because they produce anticipatory consummation of success and prevent a person from appreciating the effortful actions that are necessary for goal achievement (see also Mobilio, Burgess, & Gonzales, 1995). Consistent with this hypothesized account, outcome simulation participants reported studying 5 hours less, on average, than they had expected to, and they reported striving for a lower grade the day before the exam; reduced aspirations were found to mediate the negative effect of outcome simulation on exam performance.

Limitations of the Research

There are several limitations to this investigation that should be noted. It is tempting to conclude from this research that process simulation alone achieves beneficial effects on performance. However, even in the process simulation condition, the goal was clearly in mind (i.e., getting a high grade), despite the fact that it was not the explicit focus of the simulation exercise. Thus, the maximal advantage of mental simulation in bringing about effective action may be achieved by articulating a goal state clearly but then focusing primarily on the process for reaching it rather than by keeping the goal state clearly in mind throughout one's efforts.

It was also the case that, in the present research, simulations were enacted on multiple occasions rather than at a single point in time. Because mental simulation is used in this manner for planning (Hayes-Roth & Hayes-Roth, 1979; Scholnick & Friedman, 1987), this procedure was judged to approximate the ways in which mental simulations are realistically employed. Nonetheless, it is unclear what role repeated simulations serve in the maintenance of the effects. Examination of the students' logs revealed no systematic changes in the mental simulation over time, suggesting that its primary effect may have been to keep the focus on either the goal or the process for producing it (or both) in mind over the intervening week.

Future Research

Further research might profitably be directed to two issues. First, the findings of the present research shed light on the functions of mental simulations that are positive in content. The functions of mental rehearsals of potential impediments to goals also merit consideration. Several studies have found beneficial effects of negative outcome simulations, so long as these simulations are not accompanied by negative expectations (Noren & Cantor, 1986; Noren & Illingworth, 1993; Oettingen, 1995; Sherman, Skov, Hervitz, & Stock, 1981; Wurf & Markus, 1991). Thus, explicit evaluations of the self-regulatory functions of positive versus negative mental simulations focusing on the underlying processes whereby such effects occur may be a profitable direction for future research.

In addition, the types of tasks for which outcome versus process simulations may be useful merits research consideration. For example, which simulation is effective may depend on the complexity of the task for which one engages in mental simulation. Process simulations may be especially advantageous for complex tasks such as preparing for an exam, but outcome simulation may be beneficial under limited circumstances, such as when the pathway to a goal is simple and straightforward. Establishing the generality of the findings to other task domains is also an important domain for future studies. Research from our laboratory suggests that process simulation as opposed to outcome simulations may help people cope more effectively with stressful events (Rivkin & Taylor, 1996) and may help reduce the planning fallacy (Taylor & Armor, 1996).

CONCLUSION

> The will to win is not nearly as important as the will to prepare to win.
>
> —Anonymous

Social cognition researchers in the pragmatic tradition have increasingly identified the ways in which thought is linked to action. The present research on mental simulation is very much a part of that pragmatic tradition. Overall, the results have implications for how individuals may mentally prepare for future events, bridge the gap between thought and action, and enhance the likelihood of reaching a desired goal. Common wisdom and considerable research have suggested that an "I can do it" strategy of envisioning a desired outcome can have a self-fulfilling effect on goal attainment. However, the current research does not support this belief. The results of the present research suggest that a more successful strategy for goal attainment may be to answer the mundane question "How can I do it?" and then to mentally rehearse that strategy. Such a strategy may most effectively manage emotions and elicit effective problem-solving activities such as planning for the successful pursuit of a goal.

NOTES

1. The reason for this random assignment scheme is that, due to the different lengths of the mental exercise instructions, we were not able to run all groups simultaneously. Participants who were randomly assigned to the second group (i.e., assigned to the process-only or outcome-only simulation) were then randomly assigned to receive either the process simulation instructions or the outcome simulation instructions. The instructions for these two experimental groups were similar in length and, therefore, allowed participants in these groups to be run simultaneously.

2. Three-way analyses of variance revealed significant main effects of gender for self-efficacy and anxiety at Time 1, $F(1, 93) = 3.97$, $p < .05$, and $F(1, 93) = 4.47$, $p < .04$, respectively. Immediately after performing the first simulation (or self-monitoring) exercise 1 week before the exam, male participants rated themselves higher in self-efficacy (M = 5.71) and reported less anxiety (M = 3.67) than did female participants (M = 5.26 and M = 4.19). Significant main effects of gender were also obtained for anxiety, motivation, and outcome value at Time 2, $F(1, 83) = 8.28$, $p < .005$; $F(1, 89) = 5.54$, $p < .03$; and $F(1, 83)$-24.86, $p <$ 001, respectively. On the day before the exam, male participants reported lower anxiety (M = 3.44), lower motivation (M = 5.53), and lower outcome value (M = 5.20) than did female participants (M = 4.31, M = 6.02, and M = 6.32). A significant three-way interaction for self-efficacy at Time 1 suggested that, whereas female participants reported higher self-efficacy in the combined simulation condition, male participants reported lower self-efficacy in the combined simulation condition than in either the outcome-only or process-only simulation condition, $F(1, 93) = 4.50$, $p < .04$. In addition, a significant three-way interaction for expected grade at Time 1 suggested that male participants in either the outcome-only or process-only simulation group expected higher grades than did males in the other groups. However, female participants expected slightly higher grades when in the self-monitoring control group than in the simulation groups, $F(1, 93) = 5.85$, $p < .03$.

3. In addition, three-way analyses of variance with process simulation (yes, no) and outcome simulation (yes, no) as the two between-participants independent variables and time (Time 1, Time 2) as the repeated measure were conducted for the Time 1 and Time 2 variables. These analyses revealed significant main effects of time for the planning index, the lowest level action identification item ("reading"), the middle-level action identification item ("getting a good grade"), and the grade participants strove for, $F(1, 87) = 20.34$, $p < .001$; $F(1, 87) = 23.86$, $p < .001$; $F(1, 87) = 8.88$, $p < .01$; and $F(1, 87) = 8.23$, $p < .01$, respectively. In general, planning increased while the two action identification items and the grade participants strove for decreased from Time 1 to Time 2. In addition, a significant outcome by time interaction revealed that the outcome group decreased their striving-for grade from Time 1 to Time 2, $F(1, 87) = 4.71$, $p < .05$. No significant effects were found for other variables (ps > .15).

4. Because participants were recruited from three different psychology classes, we also analyzed how each group performed with respect to the class average by subtracting the participant's exam score from the appropriate class mean. The results were virtually identical. There was a marginally significant effect of process, $F(1, 89) = 2.96$, $p < .09$. As shown in Table 3, process simulation participants scored higher (M = 4.66) than did participants in other conditions (M = 1.01). A significant effect of outcome, $F(1, 89) = 4.96$, $p < .03$, showed that those that did not engage in outcome simulation scored higher (M = 5.32) than did outcome simulation participants (M = .58). Tukey HSD post-hoc comparisons reveal a significant difference between the process-only group (M = 6.60) and the outcome-only group (M = –1.96), $t(89) = 2.81$, $p < .05$.

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