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Resting on Laurels: The Effects of Discrete Progress Markers as Subgoals on Task Performance and Preferences

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This article investigates the influence of progress certainty and discrete progress markers (DPMs) on performance and preferences. The authors suggest that the effects of DPMs depend on whether progress certainty is high or low. When the distance to the goal is uncertain, DPMs can help reduce uncertainty and thus improve performance and increase preference. However, when the distance to the goal is certain, DPMs may generate complacency, sway motivation away from the end goal, and decrease performance in the task, as well as its appeal. Therefore, the addition of more information, feedback, or progress indicators may not always improve task performance and preference for the task. The authors validate these claims in 4 experiments.

Keywords: progress information, effort, uncertainty, task partitioning, goals

Much of human activity aims to achieve ends or goals (e.g., climbing mountains, saving money, solving math problems, running a marathon). Although the path to such achievement is not always rewarding in and of itself, people often embark on those paths because they lead to the reward of goal attainment. For example, in mountain climbing, many mountaineers report that the daily experience is miserable but that reaching the peak provides meaning and satisfaction (see Loewenstein, 1999). Because reaching such goals may be difficult, people often adopt subgoals that break the overall task into smaller, more manageable parts (Newell & Simon, 1972). For example, when trying to solve a mechanics problem in physics, a student may first search and summarize the forces acting on the system (Catrambone, 1998).

In this article, we investigate the effect of a special type of subgoal on overall performance in a task. In particular, we examine the effect of subgoals that are meant to signify progress toward an end. In general, any task can be characterized by the amount of progress information it embodies, defined here as external feedback about the distance to an end—or the degree of progress toward completion. The actual amount of progress information in a task lies on the continuum between complete progress uncertainty and complete progress certainty. Examples of tasks with high progress certainty include traveling with a global positioning system or paying a mortgage; in these cases, the person knows the exact distance from the goal. Examples of tasks with low progress certainty include courting a potential romantic partner or working on a research paper; in these cases, the person can sense progress, but the distance to the goal may be unclear. In this work, we look at tasks in which the amount of progress or the distance to the goal can be measured by a single monotonic dimension. We later discuss the potential implications and limitations when trying to extend our findings to more complex situations.

In addition to the amount of progress information, tasks can be characterized by another important attribute, namely, the frequency of progress indication, which ranges between complete discreteness (e.g., an indication of progress in the middle of the task) and complete continuity (e.g., exact continuous indication of distance to the end). The frequency attribute of progress information is central to our thesis because we suggest that when progress information is discrete enough,[1] it may acquire another role and serve as a natural subgoal. We base this claim on evidence from research into problem solving that has suggested people tend to form solution procedures that consist of steps (i.e., subgoals), often tied to structural features of the problem environment (Anazi & Simon, 1979; Catrambone, 1998; Newell & Simon, 1972; Singley & Anderson, 1989). For example, solving the famous Tower of Hanoi problem, one might treat the moving of each set of discs (subtower) resting on top of the focal disc to be moved as a subgoal on the way to moving the entire tower to the other peg. Moreover, such research has shown that breaking tasks into steps can reduce the difficulty and complexity of a solution and provide additional intrinsic rewards on achieving each step.

The amount of progress information and its frequency influence performance in several ways. The effect of progress certainty (i.e., the ability to know the distance to the goal) on performance is relatively straightforward and pertains to its influence on motivation, which may be defined as the driving force of directed activity or "something that causes a person to act" ("Motivation," 2002). In general, motivation increases as the distance to the goal decreases,

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[1] At high levels of frequency, progress information is less likely to serve as a subgoal. In this work, we use two extreme cases of highly separable (i.e., low frequency) and highly continuous (i.e., high frequency) indications of progress information.

which is termed the *goal-gradient* effect (Hull, 1932, 1934; Kivetz, Urminsky, & Zheng, 2005; See, Heath, & Fox, 2006). Given a problem and a level of effort, progress is a direct signal of the ease or difficulty of the task. That is, the lesser the difficulty, the lower the likelihood of aborting and trying a different route (Newell & Simon, 1972). Therefore, when the task requires solving a problem, greater progress certainty should result in increased effort directed toward the goal (Newell & Simon, 1972). As such, any signals that provide information about a diminishing distance to the reward likely increase overall performance (Locke & Latham, 1990; Pervin, 1989). A general hypothesis is thus that performance should be higher when progress is more apparent, that is, when progress certainty is higher.

To analyze the effects of the frequency of progress indication, we focus on two extreme cases: continuous progress indication and discrete progress markers (DPMs). Continuous progress information, by definition, generates progress certainty and yields the above-mentioned predicted improvement in performance. In contrast, DPMs provide knowledge about the exact distance from the goal only at specific points along the task (e.g., one-half completed). Because DPMs provide progress information, they decrease uncertainty about the distance to the goal. Although conceptually DPMs are just a subset of a continuous stream of progress information, there are theoretical reasons to suspect they may have additional behavioral influences. In particular, DPMs may serve as "mere subgoals," or artificial landmarks that represent "levels of performance that are not accompanied by an external reward" (Heath, Larrick, & Wu, 1999, p. 80). As mentioned previously, these structural features provide natural breaks in the flow of task completion and are thus likely to be adopted as subgoals (Anazi & Simon, 1979; Catrambone, 1998; Newell & Simon, 1972; Singley & Anderson, 1989). As subgoals, DPMs can reduce the difficulty and complexity of a solution, providing intrinsic rewards on their achievement. However, providing artificial landmarks, such as "You have reached 50% of your exercise goal," also may have negative effects. In this work, we focus on two such negative influences: complacency caused by the mere achievement of the subgoal and motivational distraction from the ultimate goal.

The premise of our current work rests on the notion that the conjunction of progress certainty and DPMs may generate counterintuitive results. Simply put, if DPMs have both positive and negative effects, the net effect of adding DPMs may be negative. This negative effect might emerge when a progress indication already is present because of ample progress certainty, which renders the motivational benefit accorded by the DPMs through their provision of such an indication redundant. Our main hypothesis in this work is that DPMs have a positive effect on performance with progress uncertainty but may have a negative effect with progress certainty. Note that because this prediction relies on the sum of two opposing forces (one of which depends on the perceived progress information), we can make only a relative (i.e., interactive) prediction as opposed to an absolute claim that adding DPMs always will have a negative effect under progress certainty. We describe the theoretical support for our hypotheses next and follow with four experiments that test this prediction.

The "Dark Side" of Subgoals

Progress toward a goal, and in particular the achievement of subtasks on the way to goal attainment, is both motivating and rewarding (Brunstein, 1993; Locke & Latham, 1990; Newell & Simon, 1972; Pervin, 1989; Soman & Shi, 2003). However, other effects emerge from attaining subgoals or reaching markers on the way to achieving a goal that may be less beneficial to the overall attainment of the goal itself. Although these negative consequences are not mutually exclusive, it may be helpful to categorize them into two groups. One group comprises those consequences when the subgoal replaces the overall goal as the center of reference, and the second group consists of those caused by a motivational distraction or interference of the subgoal with the overarching goal. We discuss these two theoretical accounts next.

Subgoals as Substations

A goal is a reference value by its very definition, allowing a person to assess success or failure, a particular level of achievement, or a relative position on some dimension (Carver & Scheier, 1998). It is the focal point of directed activity (Newell & Simon, 1972). The idea of looking at goals as reference points suggests that the motivational effect of a goal changes in a manner similar to the shape of the value function in prospect theory (Kahneman & Tversky, 1979). In other words, the goal gradient becomes steeper as one approaches goal attainment (i.e., a convex function) and then becomes less steep as the goal is reached (i.e., a concave function); the level of motivation is captured by the slope of the function (Heath et al., 1999). Moreover, this effect is true for each subgoal in a task. In simple terms, approaching a subgoal may motivate activity toward the subgoal, but as soon as the subgoal is reached, overall motivation and performance level should decrease, creating a state of complacency. The net effect of the subgoal thus depends on the magnitude of two opposing forces: motivation and complacency. When the two forces are present, the complacency period may "win," in which case a subgoal may lead to an overall decrease in performance.

Notably, this prediction is consistent with "goals as reference points" theory (Heath et al., 1999), which suggests that a focus on the reference point in the domain of gains may decrease motivation. For example, consider a marathon runner who is approaching a well-marked halfway point in the course. Seeing the halfway point getting nearer and nearer may increase motivation, in line with most predictions (Heath et al., 1999). However, after reaching the halfway point, the runner might feel some sense of elation and achievement, congratulating herself for coming this far. This may be especially true if she planned a challenging time goal and succeeded.[2] She then might dwell on this achievement long enough to lose focus on the real goal of the run and consequently, unintentionally, decrease her level of effort. On balance, the decrease in effort may be greater than the initial increase toward the subgoal of the halfway point. In this case, the runner might have been better off without seeing the half-distance mark altogether. Note that this effect also can be captured by the goal-stack model (Newell & Simon, 1972) if the goal-stack operation is not

[2] More on planning in our General Discussion.

instantaneous; that is, if completion of the subgoal causes the previous goal to take the focal position only after some delay, we can expect a lapse in directed activity and a decrease in performance.

Negative consequences of progress information, such as DPMs, are not intuitive. In measuring theories about the effects of subgoals, Heath and colleagues (1999) found that participants believe that a runner who partitions the total distance by setting progress markers is more likely to run the complete distance than is a runner who does not, presumably because of the motivating effects of DPMs. However, such lay theories about the effects of DPMs may fail to take into account the negative influence of the partition and thus overestimate the positive impact of DPMs. We investigate people's ability to predict complacency and the negative effects of DPMs in our pilot study.

Subgoals as Goal Distracters

Humans are not alone in their pursuit of goals; most classical research on motivation and end rewards focuses on animals and their actions to attain food or water. The basic phenomenon uncovered by such research reveals that the closer an organism is to its goal, the greater is its motivation to achieve that goal (Hull, 1932, 1934). Researchers also have revealed great similarities in human behavior (Kivetz et al., 2005; See et al., 2006), though research that examines discrete feedback rather than continuous feedback about progress toward the goal has produced results that deviate from this basic pattern. In particular, research in which animals receive DPMs has indicated that they may decrease both performance (e.g., rate at which pigeons peck a lever to obtain food) and preferences (i.e., likelihood of animals choosing the same path in the future). For example, Duncan and Fantino (1972) provided pigeons with signals in the form of light indicators as they got closer to a goal to receive a pellet of food. The overall task length remained constant, but the number of lights used differed across conditions (i.e., two or three equally spaced light indicators). In contrast to the general belief about the beneficial impact of progress markers, the pigeons significantly underperformed when they received more DPMs (i.e., they pecked at a slower rate, which caused longer delays in receiving food rewards) and significantly preferred the task with fewer (or no) DPMs when they could choose between conditions.

In the case of more complex agents pursuing more complex goals, a related theory also exists. According to models of limited cognitive resources, different goals may compete for attentional resources (Kruglanski et al., 2002; Shah & Kruglanski, 2002). Similarly, means for attaining a goal, such as subgoals, may draw attention away from the ultimate goal (Kruglanski et al., 2002). In the domain of cognitive problem solving, goal management has been modeled as a stack (Newell & Simon, 1972), such that when a subgoal may aid in the solution of the task, the previous focal goal gets put aside, in a stack; only when the current subgoal has been either completed or deemed unreachable will the previous end be drawn from the stack and become the goal of directed activity. Thus, in cases in which goals (subgoals) are not rewarding in and of themselves, we might find a decrease in overall motivation, because they may distract attention from the end itself. Consistent with the straightforward implications of a goal-stack model, we posit that while goals remain in the stack, they have little power to direct activity.

A recent development in the study of goal pursuit dynamics revealed that progress toward a goal may inhibit goal-congruent behavior in favor of facilitating progress toward a competing goal (Fishbach & Dhar, 2005). In other words, feedback about progress toward a goal causes it to be replaced with a competing goal that rests atop the goal stack. Fishbach and Dhar (2005) further distinguished between goal commitment activities and goal progress signals and found that progress signals cause participants to balance their goal activities and decrease effort toward the focal goal. This distinction has particular importance for our work, because DPMs by definition indicate goal progress, and if participants entertain some other goal (e.g., resource preservation), reaching a DPM would cause them to decrease their effort and performance. According to Fishbach and Dhar (2005), DPMs may decrease performance toward the ultimate goal of the task in complex cognitive tasks because progress toward a goal might trigger the replacement of the current goal with the goal in the stack.

In summary, subgoals and DPMs in particular may increase motivation and improve performance because they simplify the task and indicate progress toward an end (i.e., increase progress certainty). We expect this positive effect to be very prevalent when progress indication is otherwise lacking (i.e., progress uncertainty) but weaker when ample progress indication already is present in the task (i.e., progress certainty). In the latter case, the negative implications of subgoals should loom larger than do their positive influences. We therefore predict an interaction between the level of progress information toward the ultimate goal and the presence of DPMs. In other words, DPMs can be either positive or negative, depending on the level of progress certainty.

This prediction stands in opposition to the hypothetical results of Heath and colleagues (1999) and suggests that people may hold erroneous beliefs about the effects of DPMs. Therefore, prior to our main experiments, we conducted a pilot study aimed to replicate Heath and colleagues' (1999) results in a context similar to our experimental environments, which enables us to compare the beliefs directly with actual behavior. We then describe four experiments that test this thesis. Implicitly manipulating both DPMs and progress uncertainty, Experiment 1 investigates the influence of progress information on participants' effort and willingness to repeat the task. Experiment 2 replicates the main results of Experiment 1 and tests whether the distraction of attention can be an alternative account for our results. Experiment 3 extends the investigation by using explicit manipulations of both DPMs and progress certainty in a more complex task involving accuracy as well as effort. Finally, Experiment 4 extends the results further to a longer, more realistic task. We conclude with a discussion of the results, the interplay between motivation and cognition, and the implications and limitations of the current investigation.

Pilot Study: Metacognition About DPMs

In comparing our predictions with the intuition experiments (i.e., asking people how they would behave) that Heath and colleagues (1999) reported, we find a puzzle. Participants in their experiments seemed to predict only positive influences of DPMs, suggesting that if our theoretical predictions hold, people have erroneous theories about DPMs. Because their experiments differ from ours, in that they featured intuition studies using a different context, we first ensure that their findings will hold in an intuition study in our experimental context. This study conceptually replicates the experimental manipulations we describe for Experiment 1 and asks participants to predict behavior.

Method

Sixty graduate students participated in the study as part of a course requirement. We told participants about four antique dealers who needed to walk to an auction house because their cars had malfunctioned. The auction house received daily fresh stock to sell, such that the earlier the antique dealers arrived, the higher was the likelihood that they would receive more items and thus a larger profit. The four antique dealers appeared in different progress certainty and DPM conditions (see Figure 1). In the uncertainty condition without DPMs (A in Figure 1), the dealer had no indication about the distance to the auction house. In the uncertainty condition with DPMs (B in Figure 1), the road was divided into quarters by three major intersections, so that the dealer could tell in which quarter of the path he was walking. In the certainty condition without DPMs (C in Figure 1), the road offered clear distance signs, and in the certainty condition with DPMs (D in Figure 1), the road to the auction house both offered distance signs and crossed the three major intersections. This fourth condition was the crucial one, because it featured both types of information. Participants estimated the walking speed of the dealers at 1/16 intervals, assuming 4 miles per hour (mph) is the average speed at which an antique dealer walks.

Results and Discussion

We regressed the prediction results, depicted in Figure 2, on the indicator variables for continuous progress information, DPMs, and their interactions. Throughout the article we use dichotomous coding (–1, 1) for binary variables to facilitate interpretations of the interactions that are similar to analysis of variance (Irwin & McClelland, 2001). In line with past results, people predicted an overall positive effect of DPMs ($B = 0.242$), $t(56) = 3.89$, $p < .001$; and no significant effect of progress certainty ($B = 0.064$), $t(56) = 1.03$, $p = .309$. More important to our current investigation, participants did not predict an interaction of DPMs and progress certainty ($B = -0.015$), $t(56) = 0.17$, *ns*. In summary, people seem to believe that more information is better, especially in the form of DPMs, whereas we propose that providing DPMs in a certain environment may yield negative effects.

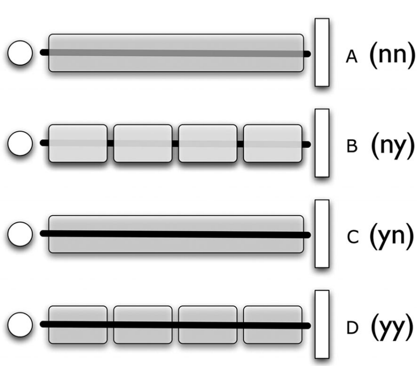

Figure 1. Schematic illustration of the antique dealers and gold-mining games. The black horizontal lines represent the visible path, and the shaded horizontal lines represent the parts of the path in which the gold miner or antique dealer is invisible to the participant. The first letter in the naming of the conditions refers to the level of continuous feedback (*y* or *n*), and the second letter refers to the existence of progress markers (*y* or *n*).

Experiment 1: Gold Mining

To test our basic interactive prediction with actual behavior, we begin by manipulating the two central constructs in our account: progress uncertainty and DPMs. We predicted that progress uncertainty should have an overall negative impact on performance but that DPMs would have an interactive effect, such that their influence would be positive when progress information is unavailable (high uncertainty) but negative when progress information is available (low uncertainty). This interaction may attenuate the overall positive impact of progress certainty and in some cases lead to an overall negative effect of DPMs.

Method

Participants. One hundred ninety-six participants, mostly college students from the northeast United States, were recruited through advertisements and public announcements. We randomly assigned participants to one of four progress–information conditions and, before allowing them to begin the task, familiarized them with the graphical interface for the condition to which they had been assigned. At the end of the experiment, participants received between $0.11 and $36.00, depending on their performance on a computerized task.

Task. A computer game called "gold miner" was created for the experiment. In this game, participants must press the *z* and *m* keys alternatively to move a "gold miner" (a small red circle that starts at the leftmost corner of the screen) toward the "gold mine" (a blue rectangle at the rightmost side of the screen). Each *z–m* pair moves the miner one step. As we subsequently describe, the image of the terrain over which the gold miner travels differed among the conditions (Figure 1). We informed participants that they would earn money when their gold miner reached the mine and that their reward would increase when the gold miner reached the mine faster. Unbeknownst to the participants, the actual length of each trial was 243 steps, which took participants 1 min on average to traverse. After participants reached the gold mine, we informed them of their reward and presented them with a choice of either participating in another trial or terminating their participation in the study and receiving their cumulative earnings up to that point. The reward magnitude for each trial was a linear function of the time each trial took, determined by subtracting 2.2 times the number of seconds from 155 to obtain the number of cents gained or lost (i.e., very poor performance could yield a negative amount). There were no limits on the time or number of trials that participants could play, and the overall payoff to each participant equaled the sum of their individual trial rewards.

Design. The experiment used a 2 (progress certainty vs. progress uncertainty) × 2 (DPMs: present or absent) between-participants design. We manipulated progress certainty according to participants' ability to see the exact location of the gold miner on the screen. Thus, the gold miner walked either on a bridge, such that the gold miner was visible at any moment, or in a tunnel, such that participants could see the gold miner only entering or exiting.

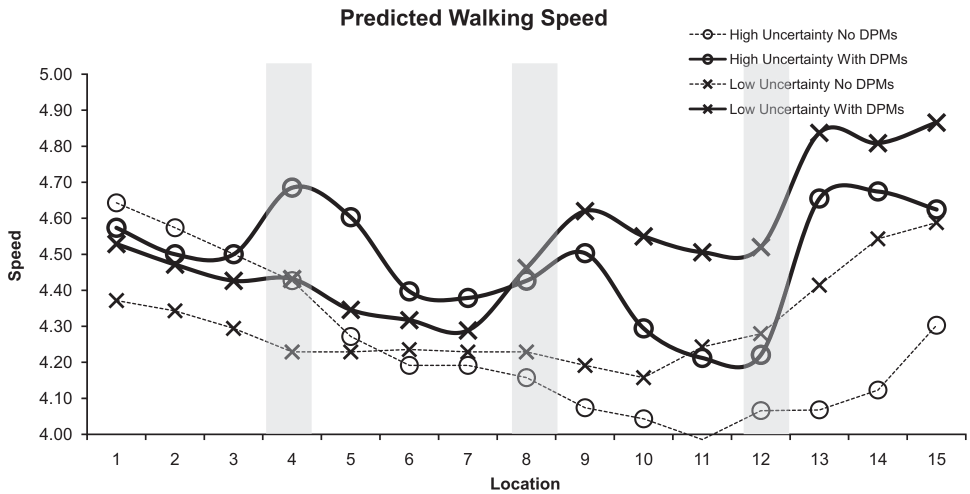

Figure 2. Predicted walking speed (miles per hour) in the four conditions. DPM = discrete progress marker.

We manipulated DPMs by dividing the path to the gold mine into four quarters, explained as either four bridges or four tunnels depending on the level of progress certainty (see Figure 1). In the uncertainty condition without DPMs (A in Figure 1), participants received no information about their distance from the gold mine (described as one long tunnel). In the uncertainty condition with DPMs (B in Figure 1), the task consisted of quarters, so that participants could see only when they had completed each quarter of the path (described as four tunnels).[3] In the certainty condition without DPMs (C in Figure 1), participants could see how much progress they had made at any point (clear background). Finally, in the certainty condition with DPMs (D in Figure 1), participants could see how much progress they had made at any point as well as when they had completed each quarter of the path (described as four bridges that the gold miner must traverse). Again, this fourth condition represented the crucial one because it offered both types of information.

Dependent measures. The main dependent measure was performance (effort), which we measured by the amount of time each participant needed to complete a trial. As an additional measure, we used the momentary effort, that is, the rate at which participants clicked the two keys during any given time period. Finally, we measured preference for the task, as indicated by the number of trials each participant chose to play.

Results

Each participant completed as many trials as he or she chose, for a total of 819 trials across all participants. The results we report reveal the same pattern for each individual trial (e.g., first, second) and for the aggregate data. Thus, we present the results for the aggregated data, followed by a similar analysis of only the first trial for each participant. We regressed the time that participants needed to complete each trial on the DPMs, progress certainty, and their interaction (see Table 1, top half).[4] Consistent with the goal-gradient hypothesis, the analysis revealed a main effect of progress uncertainty on task completion time ($B = 1.41$), $t(815) = 4.63$, $p < .0001$. That is, participants took longer to complete the task under progress uncertainty. However, DPMs in and of themselves had no main effect on performance ($B = 0.19$), $t(815) = 0.63$, *ns*. Most important for the purpose of the current experiment, the interaction between progress certainty and level of DPMs was significant ($B = –2.14$), $t(815) = 7.02$, $p < .0001$, such that DPMs decreased performance under progress certainty but increased performance under uncertainty. An analysis of the simple effects confirmed the predicted contrast: Providing DPMs to participants improved their performance when progress was uncertain ($B = –3.899$), $t(343) = 4.15$, $p < .0001$; but decreased performance (i.e., increased task completion time) when progress was certain ($B = 4.668$), $t(472) = 6.02$, $p < .0001$.

To exclude any possible effect created by multiple trials within participants, we conducted a similar analysis with the first trial from each participant. This analysis (Table 1, top half, in parentheses) revealed a similar pattern: a main effect of progress uncertainty, by which performance decreases ($B = 2.37$), $t(191) = 2.94$, $p = .004$; and no main effect for DPMs on performance ($B = –3.19$), $t(191) = 0.4$, *ns*. Again, the most important result for the purpose of this experiment was the negative and significant interaction between progress certainty and level of DPMs ($B = –2.28$), $t(191) = 2.83$, $p = .005$.

To obtain a proxy for the effects of progress certainty and DPMs on participants' preferences for the task (i.e., choice to repeat the task), we regressed the number of trials that participants played in

[3] A pretest indicated that participants could not predict when their gold miner would emerge from a tunnel, which suggests a state of progress uncertainty in the tunnel conditions.

[4] A more extensive model that controls for individual differences (random effects) and learning between trials showed no difference in terms of the effect of the trial number on performance across conditions (i.e., interactions between trial number and conditions were virtually nonexistent); the expected positive relation occurred between trial numbers and performance ($B = –0.26$), $t(194) = 6.95$, $p < .0001$, which could be due to selection or learning. In addition, we find a nonsignificant effect for uncertainty ($B = 0.99$), $t(194) = 1.77$, $p = .076$; no effect of DPMs ($B = –0.74$), $t(194) = 1.33$, $p = .18$; and a significant interaction between DPMs and uncertainty ($B = –1.51$), $t(194) = 2.69$, $p = .007$. Thus, we display the more parsimonious model.

Table 1
Experiment 1: Average Trial Length (in Seconds) and Average Number of Trials Repeated

	Progress certainty	
Progress marker	Uncertain	Certain
Average trial length		
None	57.6 (68.5)	50.5 (54.9)
Quarter	53.7 (59.1)	55.2 (58.9)
Average number of trials repeated		
None	3.81	6.12
Quarter	5.58	4.21

Note. Results in parentheses are first-trial averages.

each condition (Table 1, bottom half) on certainty, DPMs, and their interaction. We also attempted to control for the effect of their previous payoff on their preference to repeat the task by adding each participant's time (payoff) for the previous trial. The analysis revealed a negative effect of progress uncertainty ($B = -0.45$), $t(627) = 1.91$, $p = .057$; and a nonsignificant effect of DPMs ($B = 0.387$), $t(627) = 1.67$, $p = .095$. That is, progress uncertainty slightly decreased the number of trials that participants chose to play, whereas DPMs slightly increased them. More important, the analysis revealed a significant interaction between uncertainty and DPMs ($B = 1.15$), $t(627) = 4.85$, $p < .0001$, replicating the performance results. When progress was uncertain, participants chose to undertake more additional trials in the condition with DPMs than in the condition without DPMs. In contrast, when progress was certain, participants chose to play more trials in the condition without DPMs than in the condition with DPMs. We also found a main effect of performance in the previous trial on performance in the current trial ($B = -0.33$), $t(627) = 11.95$, $p < .0001$; that is, the shorter (more money) a participant took in the previous trial, the greater was his or her likelihood to play the next trial. However, as we mentioned previously, this additional control did not change the nature of the results.

The results also allowed for an analysis of the momentary effort, as captured by participants' key pressing rate (presses per second). In support of our predictions, participants reacted to the DPMs in different ways in the two progress marker conditions. Participants in the uncertainty condition with DPMs regained some vigor after each marker, whereas those in the certainty condition with DPMs did not. In addition, the results showed that participants began with vigor and then slowed down, which made the effects of the DPMs more prominent as the task progressed (Figure 3).

The mean percentage increase in speed around the DPMs was three times as large with progress uncertainty (1.48%) compared with that of progress certainty (0.57%). Regressing the momentary acceleration in the area of the DPMs on the level of certainty confirms the significance of this difference ($B = 0.99$), $t(16) = 3.62$, $p = .002$. No such effects appeared in the two conditions without DPM. This result supports the idea that participants who reach a marker under progress uncertainty increase their effort more than they do under progress certainty; Figure 4 depicts the acceleration or deceleration (rate of change in clicking speed, logged to enable unbiased comparisons of accelerations and decelerations) at each point during the task. Although participants greatly accelerated in response to the DPMs when progress was uncertain, they did so to a far lesser extent when progress was certain. Moreover, participants decelerated after reaching the first two DPMs, which is consistent with our theoretical account of the negative aspects of DPMs and the points at which they loom larger than the positive aspects of DPMs. We thus find evidence for both sources of negative influences of DPMs. The lower average speed along the path in the certainty plus DPMs condition suggests an overall lower motivation and supports the motivational distraction account (Figure 3); the differential effects of DPMs support the reference-based complacency account (Figure 4). Although there may be advantages to mere achievements, they may be relatively outweighed by the lack of focus on the ultimate goal.

Discussion

The results of Experiment 1 confirm our predictions. Progress uncertainty decreases performance and the likelihood that the task will be repeated. More important, we find that DPMs increase performance when progress information is unavailable but decrease performance when progress information is available. We

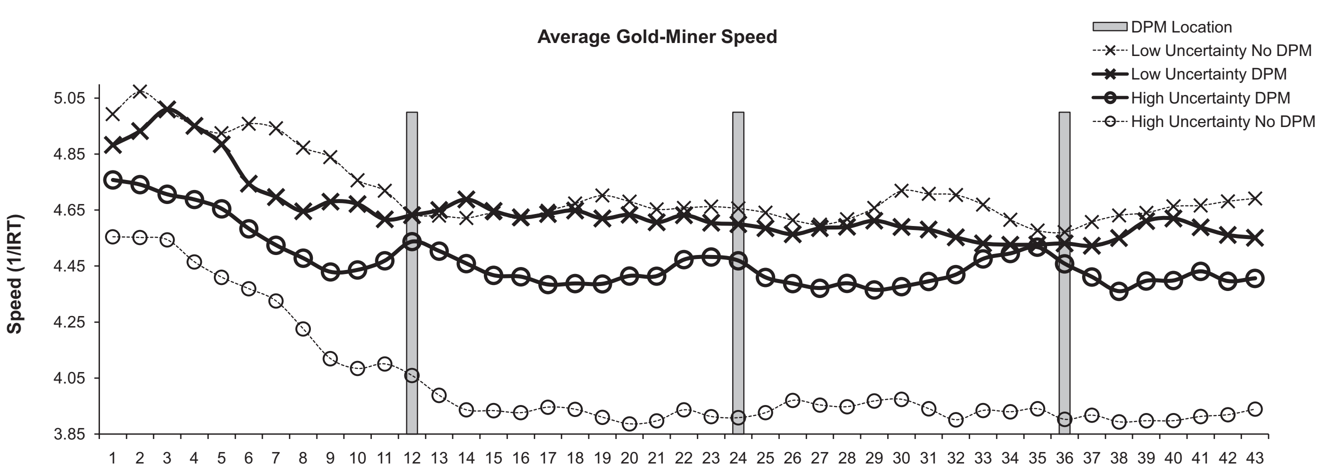

Figure 3. Gold miner momentary speeds (smoothed) in the four conditions. DPM = discrete progress marker.

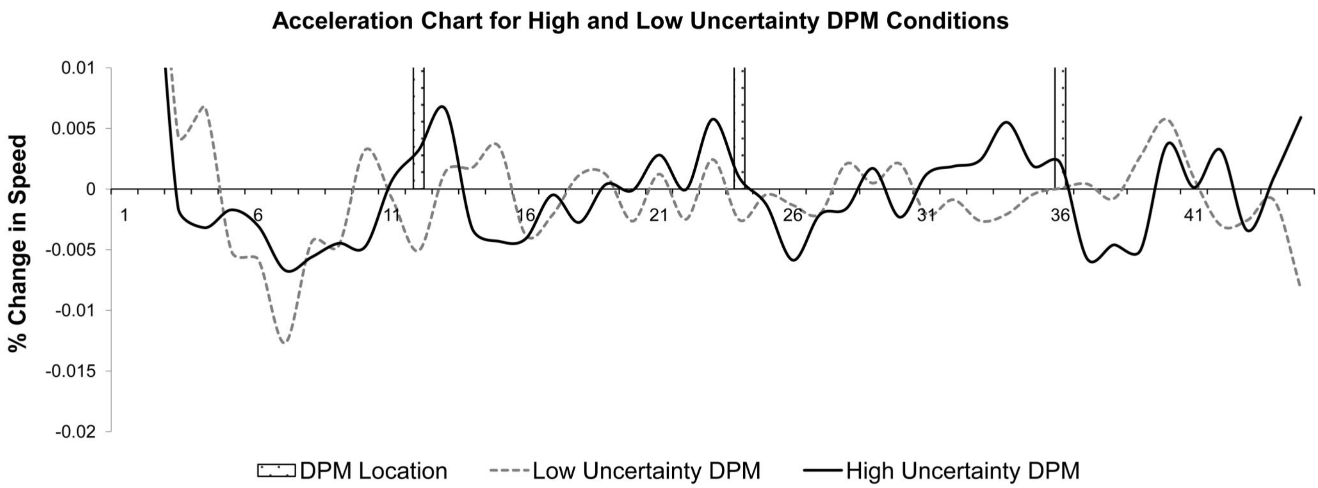

Figure 4. Acceleration/deceleration in the discrete progress marker (DPM) conditions with high and low progress uncertainty (log ratios displayed). Speed measured in pixels per second.

find the same result when we compare the likelihood of repeating the task. Thus, we find evidence in support of the predicted interaction between DPMs and overall progress uncertainty in both our performance measure and our preference measure. Note that the latter measure represents a proxy for the overall appeal of the task (after we control for prior payment). In addition, DPMs significantly decrease the overall appeal of the task when progress is certain, in additional support for the idea that DPMs decrease the average motivation associated with the task by defocusing motivation from the end reward (Fishbach & Dhar, 2005; Kruglanski et al., 2002; Newell & Simon, 1972).

We predict this interaction between DPM and the level of progress certainty because participants may consider progress markers as subgoals. As such, DPMs shift motivational attention away from the end goal, and when they do little to simplify the task or increase motivation, they reduce the overall appeal of the task. The analysis of momentary effort provides additional support for this effect; that is, DPMs increase momentary effort much more when progress is uncertain than when it is certain. The results also confirm Heath and colleagues' (1999) predictions that motivation around a goal conforms to the shape of the prospect theory value function (Kahneman & Tversky, 1979). We thus find evidence for both complacency and a decrease in overall motivation toward the task.

An alternative account we must address before continuing our investigation of the effects of DPMs relates to attention distraction. If the DPMs in the progress certainty plus DPM condition distract attention from the task or the goal, performance should deteriorate in the same basic way. This alternative account suggests that the effect of the DPMs occurs at the level of attention as opposed to our account which centers at the level of directed activity. To test whether the effect of DPMs is caused by attention shifting away from the task at hand, or by the deeper goal distraction that we posit, we designed Experiment 2. In this experiment, we replicate two important conditions from Experiment 1 but add a third condition with a subtle attention distraction occurring at the same progress points as the DPMs. If the attention story holds, we should observe deterioration in performance, but if our motivational account holds, we should not.

Experiment 2: Solar Eclipse

Method

Participants. Two hundred ninety-one participants, belonging to an online participant pool, participated in the experiment and were paid according to their performance.

Task. We used the same general setup as in the gold miner experiment, with a few modifications. We replicated the open road condition (i.e., progress certainty), in which the gold miner is visible every step of the way, as well as the bridges condition (i.e., progress certainty plus DPMs), in which the road to the gold mine is divided into five equal-length background colors (rather than four in Experiment 1) and the gold miner is clearly visible all the way to the gold mine but also clearly passes each one-fifth marker. The main modification to these two conditions included an image of the sun in the background. We then created a third condition, the "eclipse" condition, based on the open road condition. Unlike DPMs, in this condition, the distraction points were not an integral part of the road and did not implicitly represent progress. To create this distraction, after each fifth of the task (equivalent to a change in background color in the bridges condition), the image of the sun in the background expanded, turned from yellow to orange, exploded, and then returned to its original state. Each participant became familiar with the graphical interface appropriate for his or her condition prior to beginning the game. The game consisted of 200 steps between the starting point and the gold mine.

Design. The experiment consisted of three conditions (progress certainty, progress certainty plus DPMs, progress certainty plus distraction) in a between-participants design. We created the DPMs, as in the previous experiment, by varying the background colors of the five bridges, and we implemented distraction with the solar eclipse graphic.

Dependent measures. The main dependent measure was overall performance (i.e., amount of time participants took to reach the gold mine). We also measured several post-task items, including participants' ratings of task difficulty (10-point scale: 10 = *very difficult* and 1 = *not difficult*); estimations of how many times the sun eclipsed (open response question); and, for participants in the bridges condition, the extent to which the background colors of the bridges helped or hurt their performance (5-point scale: 1 means the bridges *hurt* performance, 3 was *neutral,* and 5 meant the bridges *helped* performance).

Results

The main result replicated Experiment 1 because participants in the certainty plus DPM condition performed worse (M = 57.3 s, SE = 2.05) than did their counterparts who did not receive DPMs (M = 52.5 s, SE = 1.16), $t(189) = 3.64$, $p < .001$. More important to our current investigation, we found no effect of the attentional distraction on performance because performance in the certainty plus distraction condition (M = 52.7 s, SE = 1.55) did not differ from performance in the condition without distraction, $t(192) = 0.09$, $p = .924$; but was markedly better than the condition with DPMs, $t(198) = 3.79$, $p < .001$. This was despite participants clearly noticing and recalling the attentional distraction (they saw a mean of 4.89 eclipses).[5] We can thus infer that participants in the distraction condition attend to the eclipse but that this distraction does not hurt their performance, and therefore, distraction is unlikely to be the reason for the reduced performance caused by the DPMs in the progress certainty condition. We also did not find any evidence for differences in the perceived task difficulty among conditions. Participants rated both the DPM condition ($M = 3.54$, $SE = 0.23$) and the distraction condition ($M = 4.2$, $SE = 0.70$) as easy as the certainty condition ($M = 3.91$, $SE = 0.23$), without significant differences either in comparison with each other or in an absolute sense. Finally, participants in the certainty plus DPM condition indicated that the bridges neither helped nor hurt their performance ($M = 2.98$, $SE = 0.07$).

Discussion

Experiment 2 replicated the negative effect of DPMs under progress certainty with different participants, five as opposed to four DPMs, and a slightly different incentive scheme. Creating a manipulation that distracts participants' attention, but not their goal directedness, also enabled us to disentangle two potential explanations for the effects of DPMs. We found no decrease in performance when the distraction occurred at the level of attention, even though it was clear participants paid attention to those distracters. Therefore, the effect of DPMs on performance in the task likely stems from motivation as opposed to attention, similar to Fishbach and Dhar's (2005) finding that only the indication of progress toward the goal, not level of commitment, prompts participants to shift their resources and try to balance competing goals.

Experiments 1 and 2 together demonstrate that human participants react to DPMs not unlike the way pigeons do. That is, when DPMs appear in an environment that contains certainty about progress, where one knows the distance to the goal, performance decreases, as does the tendency to repeat the task. However, these two experiments may be limited in three different ways. First, Experiments 1 and 2 used a task that requires sheer effort but little or no other skills. Will the results generalize to more complex tasks that involve accuracy and strategy rather than sheer physical effort? Second, Experiments 1 and 2 manipulated certainty and DPMs implicitly by manipulating constant progress feedback and changing the background colors of the road to the gold mine. Would the pattern of results remain, even if DPMs and progress certainty were provided explicitly? Third, we termed the moderator that we manipulate, that is, the ability to observe the distance to the goal, *progress certainty.* Would explicitly manipulating certainty about progress interact with the effect of DPMs, as we predict? To answer these questions, we created a task that required both effort and accuracy and provided participants explicit cues relating to progress, specifically, a frequent cue indicating the exact percentage completed and an infrequent (DPM) cue that provides a numeric indication of the task stage. We varied the presence or absence of these cues in accordance with the condition participants were in.

Experiment 3: Target Practice

Method

Participants. One hundred seventy participants, mostly college students from the Boston area, were recruited through advertisements and public announcements to participate in an eye–hand coordination laboratory study. Participants were compensated on the basis of their performance.

Task. We created a computer game called "target practice." The elements of the game consisted of a blue dot, which participants controlled with keyboard arrows, and a large red circle that moved slowly in random directions on the screen. The participants' goal was to center the blue dot in the red circle and maintain that position for as long as possible while the red circle continued to move. Keeping the dot centered in the moving circle sometimes required not moving it (if correctly positioned) for several seconds. Thus, the task required accuracy and strategy in addition to the effort of moving the dot. Every second the dot remained centered, a red signal at the upper right-hand corner of the screen flashed, and participants advanced one step closer to the game's end. Participants were informed that the faster they reached the end, the greater their reward would be. Unbeknownst to participants, the game consisted of 100 such steps. At the end of each game, participants reviewed the running sum of their earnings and were asked whether they wanted to play again, up to a maximum of 10 trials. Finally, prior to beginning the game, participants became familiar with the graphical interface corresponding to the condition to which they were assigned.

Design. The experiment consisted of six conditions in a 2 (DPM: available vs. not available) × 3 (level of progress certainty: certainty, low certainty, and uncertainty) between-participants design. We manipulated the progress markers by instructing participants that the game consisted of five stages and by displaying an indication of the current stage of the game (i.e., Stages 1–5). To manipulate progress certainty, we varied the information about percentage of the task completed. The certainty condition displayed the exact percentage completed (from 0% to 100%).

[5] Participants in the other conditions recalled seeing an eclipse significantly fewer times ($M = 0.39$, $SE = 0.08$), $t(192) = 6.42$, $p < .001$.

Because the game consisted of 100 steps, the percentages signified exact progress in the game. In the low-certainty conditions, no progress information appeared, but participants had been told that the game had a constant length. The uncertainty conditions were similar to the low-certainty condition, but the actual length of each game (and that of each of the five stages) was probabilistic (though with the same expected length of 20 steps per stage and 100 steps per game). We designed this manipulation of progress uncertainty to remove participants' ability to predict the length of each trial and thereby provide a different test of the progress certainty concept, in a sense making it extremely hard to know the distance to the goal.

Dependent measures. The main dependent measure was overall performance (i.e., amount of time participants spent on each game). In this game, we could not measure momentary effort by the rate at which participants clicked the keys because a more accurate response sometimes required fewer keystrokes. An additional measure we considered is the preference for the task, as indicated by the number of trials that each participant chose to play.

Results

Participants completed a total of 873 games across the six conditions. The average time for each game and the average number of games played appear in Table 2. As in Experiment 1, the effect of adding DPMs to the task depended on their relative information value (Table 2), as supported by the significant interaction between the availability of DPMs and progress certainty, $F(2, 867) = 5.62$, $p = .004$. The pattern of results implied that when DPMs are added to the certainty condition, performance decreased (time increased), $F(1, 314) = 9.99$, $p = .002$; but when DPMs appeared in the uncertainty condition, performance increased, $F(1, 555) = 5.32$, $p = .022$. In summary, as in Experiment 1, DPMs increased performance with progress uncertainty but decreased performance when they appeared in the progress certainty condition.

The number of trials that participants chose to play followed a pattern similar to that of Experiment 1. When participants experienced greater uncertainty about progress, DPMs increased their preference for the task, but when they had certainty, DPMs decreased their preference. In the intermediate condition, DPMs had no effect on the number of games played, as verified by an analysis of variance that revealed no main effect for DPMs or certainty but a significant interaction, $F(2, 163) = 3.43$, $p = .035$. Again, we find that the valance of the effect of DPMs depends on overall certainty about progress.

Table 2
Experiment 3: Average Trial Length (in Seconds) and Average Number of Trials Repeated

Condition	Mean time	Performance improvement	Mean number of trials
Uncertain			
Plus progress marker	166.05	19.32	6.40
No progress marker	185.37		4.50
Low certainty			
Plus progress marker	165.30	11.89	4.96
No progress marker	177.19		4.97
Certain			
Plus progress marker	180.14	−17.85	4.50
No progress marker	162.29		5.61

Discussion

The results of Experiment 3 replicate those of Experiment 1. In particular, Experiment 3 demonstrates that DPMs can either increase (if progress information is unavailable) or decrease (if progress information is available) overall performance and preferences. The results further generalize the findings of Experiment 1 to a more complex task that involves accuracy and not just sheer effort. Moreover, whereas the progress cues in Experiment 1 were implicit (i.e., background colors and the ability to see the exact position), in Experiment 3, progress information was more explicit, in that it displayed stage numbers and the exact percentages of task completion. Furthermore, we manipulated progress certainty in two different ways: by omitting the direct measure of progress and by making the actual length of the task less predictable. Both types of progress certainty influence performance and preferences in a similar direction. That these results largely replicate Experiment 1 suggests that the effects of progress information on performance may be more general.

Experiment 4: Spelling Bee

To generalize our findings to more common tasks, as well as replicate our explicit information manipulation, we turn to judgments of spelling correctness. We constructed an Internet task that required participants to identify whether words are misspelled and then to complete the task under progress information conditions that varied in the same vein as those in Experiment 3. We incentivized the participants to complete the task as quickly as they could. Because a person either knows a word or does not (and the words we chose were relatively easy), we expected greater motivation in this task to lead to faster reactions but to make little difference for the overall level of accuracy. If our results hold, we should find an interactive effect of adding DPMs to the task, depending on whether progress information is available.

Method

Participants. Three hundred fifteen participants from an online participant pool participated in the experiment. Participants' ages ranged from 18 to 73 years, and most were from the United States. Participants were paid on the basis of their performance in the task.

Task. Participants logging onto the Web site viewed an initial screen that explained the task as well as the graphical interface appropriate for the condition to which they had been assigned. The task entailed reviewing one word per screen and judging whether it was spelled correctly. In addition to the focal word, each screen contained two buttons, one labeled *Correct* and the other *Incorrect.* Clicking on either button advanced participants to the next screen and a new word; they could not return to a previous screen. Participants were told they would be paid on the basis of the speed and accuracy of their judgments. Unbeknownst to the participants, the task included 100 such judgments. For each word judged correctly, participants earned \$0.15, minus the number of seconds required for the judgment. Pretests showed that participants take between 3 s and 5 s to identify a word correctly. Next, we calculated the participants' earnings by summing the individual word earnings, which could range between \$0 and \$15 for the entire task. This reward structure ensured that participants had little incentive to click randomly. At the end of the experiment, participants were shown their earnings and were paid.

Design. The experiment consisted of four conditions in a 2 (DPM: available vs. not available) × 2 (level of progress certainty: certainty vs. uncertainty) between-participants design. Similar to Experiment 3, we manipulated the progress markers by instructing participants that the game consisted of five stages and displaying an indication of the current stage of the game (i.e., Stages 1–5). We ensured progress certainty by displaying the percentage completed (from 0% to 100%). Because the game consisted of 100 words, the percentages signified exact progress in the game. In the uncertainty condition, we provided no such display.

Dependent measures. The main dependent measure, overall performance (i.e., amount of money participants earn), was equivalent to the total time spent on correct spelling judgments. We measured the task time for each word to serve as a proxy for local effort or motivation. We also observed the level of accuracy across conditions.

Results

Each participant completed one game, so we had a total of 315 games across the four conditions. As predicted, the average level of accuracy of spelling judgments was high (89%) and did not differ across conditions. The main dependent measure, however, was task performance, as measured by the total time participants took to complete all correct judgments during the task (Figure 5). Replicating our previous results, we found a nonsignificant positive effect of progress certainty, or the display of the exact percentage completed ($B = 27.22$), $t(311) = 1.39$, $p = .16$; and of DPMs ($B = 29.73$), $t(311) = 1.51$, $p = .13$. More important, we found a significant interaction between DPMs and progress certainty, whereby adding DPMs to a situation with ample progress information hinders performance in the task ($B = -41.51$), $t(311) = 2.11$, $p = .035$. In Figure 6, we display the differential effect of DPMs on the individual task completion time under low and high progress uncertainty. Replicating our previous results and consistent with the proposed mechanism, responders seemed to slow down much more after reaching the DPMs in the low uncertainty condition than in the high uncertainty condition.

Discussion

In addition to replicating the effects in Experiment 3 by using explicit displays of progress information, Experiment 4 extends the previous findings in another important way. That is, we confirm the predicted interactive effects of DPMs in a more realistic task with a heterogeneous participant population. As previously, we find that reducing progress uncertainty by displaying the percentage of the task completed increases motivation and decreases participants' task completion times, which improves performance. We further find that adding DPMs to a task with no progress indication achieves the same effect. More important, adding DPMs to an environment rich in progress information and certainty hinders performance. Finally, it seems as though participants reduce their effort much more after reaching a DPM under low uncertainty than under high uncertainty, corroborating our account of the dual role of DPMs.

General Discussion

The goal of this article is to investigate the influence of DPMs on performance in the pursuit of a goal and the propensity to repeat a task (i.e., preference for a task). In particular, we suggest that in contrast to the allure of progress feedback (Early, Northcraft, Lee, & Lituchy, 1990; Erez, 1977; Locke & Latham 1990), DPMs may actually decrease overall performance. We further suggest that the effect of this type of progress information depends on the level of progress uncertainty in a task, that is, on the ability to know the distance to goal completion. This theory views DPMs as having a dual role: They may provide progress information and reduce uncertainty, but they also may serve as subgoals. The informative role contributes to performance when there is high progress uncertainty, but it adds little when there is progress certainty. The

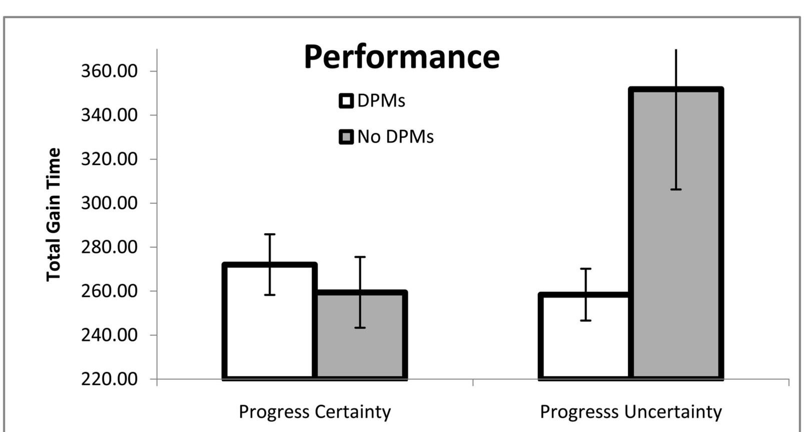

Figure 5. Total time (in seconds) for correct judgments of word spelling. DPM = discrete progress marker.

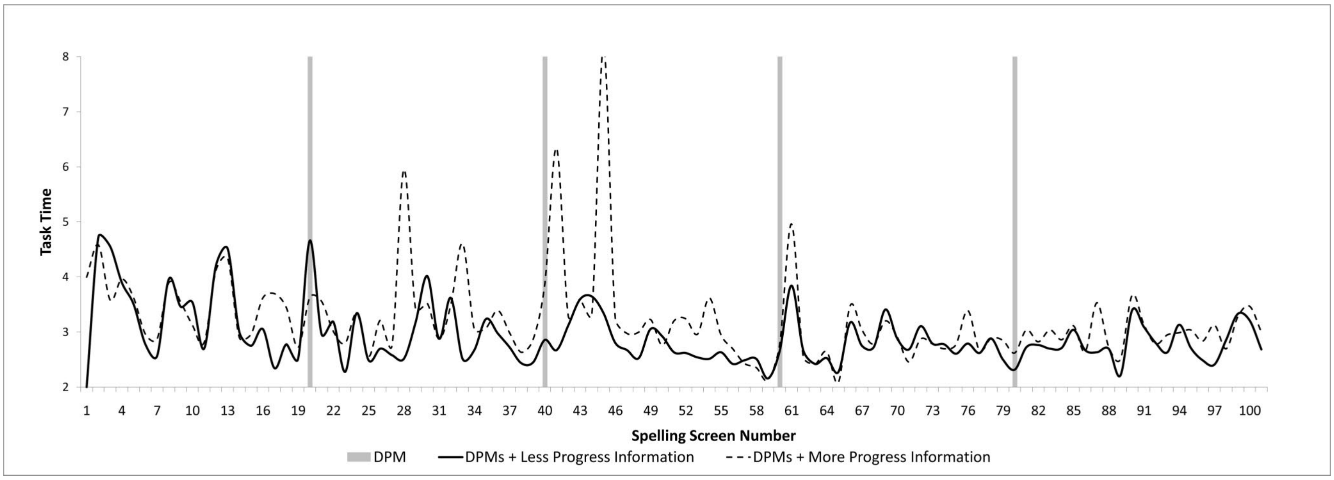

Figure 6. Task times (in seconds) in the discrete progress marker (DPM) conditions with high and low progress uncertainty, Experiment 4.

subgoal may enhance performance, consistent with the goal-gradient effect, and simplify the task by breaking it into smaller, more manageable bits, but it may also shift motivational focus away from the main goal and thus hinder overall performance. Our findings support these claims.

Experiment 1 demonstrated that DPMs improve performance and preference for the task when progress is uncertain but that the reverse may be true for tasks with ample progress information. In the high progress feedback condition, providing DPMs decreased both performance in the task and the likelihood that it would be repeated. The momentary effort results combined with the preference results suggest that DPMs influence behavior and decrease overall motivation in the condition in which they provide little intrinsic reward (i.e., progress certainty). These effects contradict common beliefs that the addition of more positive feedback, positive reinforcement, or information can only improve performance in and enjoyment of a task. Experiment 2 replicated the negative influence of DPMs on performance under progress certainty, but it also demonstrated that the effect of the DPMs is not due to an attentional distraction caused by DPMs. Although participants attended to the unrelated distraction, they did not decrease effort, nor was their performance dampened, as it was when we introduced DPMs instead.

Experiment 3 replicated and extended the results in three ways. First, the results persisted even when the task was more complex and involved both effort and accuracy. Second, the same pattern of results emerged even when we explicitly manipulated DPMs, feedback, and progress certainty in the environment. Third, when we examined the impact of DPMs on performance and preferences at different certainty levels and with two different sources of progress certainty (i.e., continuous measure of progress and predictability of task length), the results showed that the value of DPMs lies in their ability to reduce the ambiguity and uncertainty about task progress. The two types of progress certainty in Experiments 1, 2, and 3 thus display the same effect and a similar interaction with DPMs, providing convergent evidence that the construct we manipulated was progress certainty. Finally, Experiment 4 revealed this interactive effect for a mostly cognitive task in a completely different domain that may be much closer to real-life tasks. Moreover, it again demonstrated the local effect of DPMs on the effort level, in further support of our proposed underlying mechanism.

Our results reinforce basic behavioral findings that suggest that the relationship among rewards, certainty, performance, and preferences is complex and may differ from conventional wisdom. First, participants in our experiments sometimes performed better when some uncertainty existed about progress toward rewards than when they experienced certainty, which suggests there may be an optimal level of certainty. Second, participants' choices to repeat the tasks followed a similar pattern, suggesting greater enjoyment when some level of uncertainty existed. Neither of these statements holds for very high levels of uncertainty, but rather they apply to moderate levels. On the basis of these results, we can hypothesize that uncertain rewards (e.g., uncertain size or timing) might generate motivation that is stronger, longer lasting, and slower to decay than certain rewards of the same magnitude. This conclusion is analogous to the findings in operant conditioning literature that variable schedules of reinforcements generate more behavioral responses that are more difficult to extinguish (Ferster & Skinner, 1957; Skinner, 1957/1972). Moreover, several documented reasons explain why organisms' willingness to exert effort in a task may be nonmonotonically related to rewards or reinforcements (Duncan & Fantino, 1972; Killeen, 1982; Korman, Glickman, & Frey, 1981; Miller, Barnet, & Grahame, 1995; see also Festinger & Carlsmith, 1959). Our research extends some of these principles to human behavior. In particular, we show that people treat DPMs in a way similar to the ways that pigeons react to secondary reinforcements; if progress information is available, DPMs (i.e., greater overall reinforcements) may dilute the overall appeal of the primary reward or goal. Finally, if we reverse the direction of the analogy, the results from the pigeon experiments seem to suggest that they act in an environment with high certainty, perhaps because animals in such experiments usually receive a lot of training before starting the task, which leads to expertise and a greater ability to predict and realize progress.

Our findings further suggest that a large volume of prior research on the effects of subgoals and progress feedback (cf. Early et al., 1990; Erez, 1977; Locke & Latham, 1990) might not have been nuanced enough. Many results point to a variety of personal and task characteristics that may moderate this relationship (Kluger & DeNisi 1996). Our account moreover suggests that one such important moderator may be the overall level of progress certainty in the task.

Between Motivation and Cognition

Our theoretical account juxtaposes insights from two largely distinct perspectives. From a motivational perspective, goals generate the drive that elicits the required resources to mobilize behavior toward a specified end (implicitly assuming that the necessary information to attain the goal exists). From a purely cognitive perspective, goals refer to mental structures that organize information to direct behavior to the means that are most appropriate for further goal attainment (implicitly assuming that the resources can be mobilized according to this information). In the terminology of Locke (2000), the two perspectives represent desire and knowledge, respectively, and necessarily are interrelated with most activities in life (Gollwitzer & Bargh, 1996). Both perspectives hold merit, and their relative weight may depend on the properties of the task situation itself. Locke (2000) discussed a continuum of tasks that range from relying mostly on cognitive metastrategies (e.g., thinking) to relying mostly on motivational metastrategies (e.g., effort). The tasks required in the current work mostly tend toward the metamotivational side of the scale (e.g., the harder you work, the more money you earn), in that they require persistence and effort but little task-specific knowledge. It is thus reasonable to assume that the effects we observe stem primarily from the motivational level.

A somewhat different perspective suggests that DPMs may influence performance through a cognitive as opposed to a motivational route. For example, DPMs might influence the overall cognitive load in the task, and cognitive load hinders learning tasks (Sweller, 1988). From this perspective, DPMs might somehow free cognitive resources in the high uncertainty conditions,[6] leading to improved performance. Although plausible, this explanation is not likely because of the exact opposite effect that DPMs have in the low uncertainty conditions. Moreover, in Experiment 2, we measure the perceived difficulty of the task, and DPMs do not seem to change task difficulty. Note that the opposite prediction also is plausible with respect to cognitive load; that is, DPMs might increase the cognitive load, leading to more intuitive yet efficient strategies under high uncertainty (Payne, Bettman, & Johnson, 1993). Again, this prediction cannot explain the opposite effect under low uncertainty or the inability of the distraction manipulation in Experiment 2 to generate the same effect.

Generalizing this approach, we might ask to what extent our results carry over to more cognitive tasks, such as in the realm of problem solving. Consider, for example, the Tower of Hanoi problem. Progress can be continuously observed by the number of discs in the original configuration that have not been moved yet. As such, progress uncertainty is low. Our results suggest that adding DPMs to such a task would hinder performance, because speed and persistence depend on motivation, even though the decision about which disc to move next is a cognitive operation. Conversely, if we consider another type of subgoal in problem solving that represents progress only in an abstract sense (i.e., that cannot easily serve as DPM), such as spending a day thinking about a research paper, we would not expect to replicate our results. According to our current thesis, the critical aspects that prompt a DPM to produce the results we observe herein pertain to its ability to signal progress clearly, coupled with its ability to serve as the focal point of directed behavior. If a subgoal cannot unambiguously signal that the actor is closer to attaining his or her goal, it falls outside our definition of a DPM.

In summary, we focus on the type of goal pursuit, such that greater effort and persistence imply greater reward. On the basis of past research into goals and their nature, together with our current findings, we posit that the interactive effects of the two types of progress information we study fall toward the motivational end of the spectrum. Effort and persistence may still involve applying many cognitive operations, as Experiments 3 and 4 demonstrate; what is crucial is that the manner in which the goal gets construed creates a motivational incentive for progress.

Dimensions of Progress and Implications to Real-Life Tasks

All of our experimental manipulations were described as characterized by unidimensional progress toward the goal. Progress in real life may not always be construed as simply.[7] Realistic tasks may involve nonlinear progress (e.g., once all the forces in a mechanics problem in physics are identified, the remaining solution may be trivial or obvious), nonmonotonic progress (e.g., climbing a mountain may require a few descents in order to ascend later), or progress on multiple dimensions (e.g., writing a research paper might require a fair bit of planning before the actual writing can begin). To consider whether our results may be applied to such tasks requires careful analysis of each type of progress concept.

Progress linearity. The shape of the progress function is determined by the "distance" covered by each "step." There is little theoretical reason to think that progress linearity is related to our theory. Indeed, in Experiment 3, progress was in fact nonlinear in steps, as some positioning of the cursor yielded several hits in a row, while others yielded none. Despite this nonlinearity, we replicated the predicted interaction between DPMs and progress uncertainty.

Progress monotonicity. All of our experiments involved progress that was monotonic, that is, where the distance to the goal was never increasing. Monotonicity of progress introduces two important insights. First, nonmonotonicity may create natural DPMs. For example, when climbing a mountain one may naturally see each ascent or descent as a subgoal in the same way that the "bridges" or "tunnels" did in Experiments 1 and 2. We find an interactive effect of subgoals and progress uncertainty for those subgoals chosen on the basis of exogenous implicit and explicit DPMs. Would the same effect hold for self-generated endogenous subgoals? Our best guess asserts that it depends on whether the extent to which people are likely to adopt subgoals correlates with the level of uncertainty in the task. If uncertainty in a task is

[6] We thank the reviewers for this insight.

[7] We thank an anonymous reviewer for this important insight.

manifest as task difficulty, for example, and subgoals are self-generated, we predict that negative effects are less likely. If, however, the subgoals are chosen, as in our tasks, because of the natural structure of the problem or environment (e.g., default announcements on a treadmill), we likely would observe these negative effects. Notice that in our experiments such structural aspects of the tasks were known in advance and may have allowed planning (more on this below), but this logic should be true even if someone reaches such an intermediate peak or valley without knowing of it. This last distinction is akin to our progress uncertainty construct.

Second, as in our experiments, as long as the task length is well defined, there is always a dimension on which progress is monotonic; in the case of climbing a mountain this may be distance in miles of the overall track or distance in time. If actual task length is uncertain, then we should expect to find effects similar to our experimental results, as long as DPMs actually signal progress. This is supported by the uncertainty condition in Experiment 3, in which actual task length was probabilistic. An example might be an article submitted for review in a peer-reviewed academic journal: Though one may not know how many rounds, or whether it might even require a try at a different journal, each round may be construed as a DPM and may have the predicted effects on motivation. This last point also applies to the issue of multi-dimensionality in the task. There is always a dimension on which one may assess progress toward a goal; otherwise, the notion of the goal may not be well defined. We further discuss important specific cases of dimensions below.

Multi-dimensionality. Many tasks call for progress on multiple fronts. Running a marathon, for example, might require prior planning, training, acquisition of equipment, and so on, and finally running the course—a situation that is different from our experimental manipulations that allowed ad hoc planning at best, and little preparation, if any. It is therefore important to consider the implications of planning for the proposed theory. The departure point for this consideration has to be the necessary role of motivation in our proposed account. At the extreme case of planning, if one perfectly executes a plan without motivation (e.g., a computer algorithm, or a runner not reaching a motivational or ability constraint), our proposed theory would not apply. If, however, the execution of the plan requires motivation, we should expect effects at least as large as we find in our experiments. This last conclusion is supported by the Pilot Study, suggesting that people have an erroneous metacognition of the effect of DPMs. While a marathon runner might plan to reach a DPM at a certain time, if they require some bit of motivation to achieve their plan they might over-reduce effort once that DPM is reached. Note there is potentially a natural equivalence between the degree of planning and overall progress uncertainty, such that in the more planned tasks DPMs may have a more negative influence. Future work may be directed at the specific effects of DPMs in the domain of planning and of a priori planned tasks. Our current evidence allows but a conjecture. To this end, it may be important to notice that planning may come in many dimensions, some of which would have to do with how to perform the task, and less of which in the planning of progression. In such cases of a purely cognitive task, as discussed in *Between Motivation and Cognition*, our theory says little as to the effects of subgoals, as they are hardly likely to serve as DPMs in the planning phase. Finally, as Fishbach and Dhar (2005) showed, if multiple dimensions involve subgoal competition, the effects of progress markers toward such subgoals may be detrimental.

The implications of our current findings are straightforward: When planning a task or incentive scheme with a motivational component, it is necessary to ensure that the progress information provided does not decrease the overall appeal of the task. This effect may be a function of the relative information and feedback in the task environment, as well as the incentive structure. In some cases, ambiguity or uncertainty about progress may actually enhance performance and the overall appeal of the task by delineating complacency and focusing attention on the main goal. For example, parents might try to protect their children from decreased performance when they receive a good grade on a midterm by devaluing the achievement and refocusing the child on the final exam.[8] However, as our pilot study demonstrates, in the absence of experience, people may ex ante undervalue a more ambiguous scheme and may be reluctant to choose it because of their erroneous metacognition about these effects.

[8] We thank Robert Cialdini for this example.

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