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Don't interrupt me! Task interruption depletes the self's limited resources

Nicholas Freeman · Mark Muraven

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Abstract It is a common occurrence in daily life to be interrupted prior to completing a task. Such interruptions may have deleterious effects for limited self-resources, especially if they occur just prior to task completion. This hypothesis was tested in three experiments. In the first two, participants initially engaged in a card sorting task, and then subsequently performed a self-control task. In Experiment 3, participants first engaged in a word search task and then worked on an executive function task. In all instances, participants who were interrupted just prior to attaining their goal of completing the initial task, but not those who were stopped earlier in the task or who were allowed to finish, showed evidence of impairment on the subsequent measures. The findings suggest that the desire to pursue a goal increases as goal attainment draws nearer, and that the amount of self-control needed to stop working on a task is modified by situational variables such as goal distance.

Keywords Self-control · Goals · Depletion · Momentum · Motivation

Imagine you are at home, washing the dishes. As you work, you see the stack of dirty dishes slowly dwindling down; you are almost finished. Then, just as you are about to finish, the telephone rings and pulls you away from completing your task. Knowing that there is not much time to answer the phone, with effort, you pull yourself away from the dishes, leaving the job incomplete.

N. Freeman (✉) · M. Muraven
University at Albany, SUNY, Albany, NY, USA
e-mail: nfreem@gmail.com

Situations such as the one above may require the use of self-control. Specifically, we might feel compelled to finish tasks that we have begun, making stopping just short of task completion especially effortful (Heath et al. 1999; Kivetz et al. 2006). Furthermore, such an event may not be just a trivial irritation. Indeed, accumulating evidence strongly supports the view that self-control is a limited resource that is prone to depletion (Muraven et al. 1998). After exerting self-control, subsequent acts of self-control and other volitional self-processes are more likely to fail. Therefore, being pulled from a task just prior to completion may not simply be an annoyance; it may also have detrimental effects on subsequent self-regulatory and executive functioning. When the interruption occurs may be critical: tasks that are interrupted close to completion might require more self-control to stop than tasks interrupted earlier in the behavioral sequence (Baumeister et al. 1994). Hence, not all instances of stopping oneself are alike; the distance from the goal of completing the task may modify how much self-control is required to stop an ongoing activity.

Better understanding the consequences of task interruption may have important practical and theoretical implications. The ability to successfully exert self-control over one's impulses and urges is a critical determinant of success in a plethora of interpersonal and social domains (Baumeister et al. 1994), which makes identifying factors that lead to self-control depletion an important endeavor. In addition, the current investigation may shed light on the motivational changes that occur as one approaches a goal, an area of research that has been understudied (Kivetz et al. 2006). To date, there is limited data available on the consequences of stopping an activity that has already begun, and whether or not these consequences depend on how close one is to reaching their goal of completing the activity.

Task interruption

Interruption that occurs just prior to goal completion may be particularly depleting because as a task nears completion, an individual likely becomes more engaged in the task, resulting in an increase in task engagement and effort. To then pull away from such an engrossing endeavor would require overriding a strong impulse to complete the task. Hence, as a person nears a goal, the prepotent response to continue working may become stronger and more difficult to override. This, in turn, would mean that stopping should require more self-control as a person nears task completion. The notion that as a task draws closer to completion it becomes more engaging is supported by research on goals and on the goal-gradient hypothesis.

A recent synthesis of the goal literature by Heath et al. (1999) suggests that as a goal is approached, people become more engaged in the task and have a stronger desire to finish the task. In particular, Heath et al. (1999) concluded that goals can act as reference points in a value function, thereby subjecting them to the principles of Kahneman and Tversky's (1979) Prospect Theory. In a value function, outcomes have larger marginal utility (benefits) the nearer those outcomes are to a reference point. Hence, from this idea, one could predict that as a goal is approached, the desire to reach that goal should also increase. Put another way, as a goal is approached, pursuing the goal becomes more worthwhile, which in turn leads to more engagement and a stronger desire to complete the task. Indeed, this prediction was supported in an experiment (Heath et al. 1999). Participants were given a hypothetical situation in which two actors had performed equally on a physical task, though one was closer to their goal than the other. The participants reported that the actor closest to his or her goal would exert more effort on the task, presumably because those closest to a goal are most engaged in goal pursuit and benefit most from continued performance. Thus, it appears that people increase their engagement and desire to continue an ongoing task as a goal is approached.

Additional empirical evidence on the goal-gradient effect suggests that as people approach a goal they become more engaged in the task. Whereas much of the earliest work on the goal-gradient hypothesis was conducted using animal samples (Brown 1948), it has more recently been applied to human pursuits (Kivetz et al. 2006). In essence, the goal-gradient effect occurs because in goal-directed behavior, each goal-directed action "reduces a higher proportion of the remaining discrepancy" between the current status and the goal (Förster et al. 1998, p. 1117). For example, if an individual has a goal of solving 10 math problems, the first problem solved reduces 10% of the goal discrepancy while solving the 10th problem reduces 100% of the remaining discrepancy. Presumably, as the value of each goal-directed action increases, so should engagement in the task, as marked by increases in task motivation and effort (Förster et al. 1998). Support for this proposition has been established in several recent experiments that examined participants' behavior as they approached a goal (Förster et al. 1998, 2001; Kivetz et al. 2006). These experiments suggest that as the goal draws nearer, motivation, persistence, and engagement with the goal also increase.

The aforementioned findings suggest that as people near a goal, they become more engaged in the task and have a stronger desire to finish the task. This increase in engagement is evidenced by increases in effort and persistence as the task nears completion. Given that overcoming strong desires requires self-control (Baumeister et al. 1994), it may take self-control to stop working on a task that is near completion. Perhaps unexpectedly, it should take more self-control to stop working on a task that is nearly completed, rather than a task that has recently been started. Because engagement increases as the goal gets closer, it may be more difficult, and require more self-control, to give up working on a task that is nearly finished.

Self-control

Extensive empirical evidence compiled in the last decade strongly supports the limited resource view of self-control. In particular, the amount of self-control resources available to an individual is a critical determinant of their self-control success. Individuals who have had their resources depleted tend to perform poorly on ensuing tests of self-control. Moreover, the amount of self-regulatory resources available fluctuates over time. Specifically, any act of self-control uses up, or depletes self-regulatory resources, making subsequent acts of self-regulation less likely to be successful (Muraven et al. 1998).

All acts of self-control, no matter how disparate they may seem, should deplete the same self-regulatory resources. Indeed, individuals who engage in self-control in one domain show deficits in subsequent self-regulatory ability, even if measured in a different context. For instance, in one experiment, participants were asked to either suppress or exaggerate their emotional response to a disturbing movie (Muraven et al. 1998, Experiment 1). Compared to a control group who simply watched the video with no further instructions, those who either suppressed or exaggerated their emotional response (effortful acts that require self-control) performed worse on a physical persistence task that followed. The most parsimonious explanation for this and related findings is that self-control requires limited resources.

Experiments have repeatedly found that depletion effects occur because of the prior expenditure of self-control. Differences in the level of difficulty, unpleasantness, or frustration in the initial task do not cause the depletion effect (i.e., Muraven and Slessareva 2003). Rather, for a task to impair future self-regulatory performance, it must require the overriding of a prepotent, automatic response (Muraven and Baumeister 2000).

Researchers have suggested that the limited resource view should be extended beyond acts of self-control to include all aspects of the active self (Baumeister et al. 1998). Specifically, these researchers propose that all acts of volition may be affected by resource depletion. In support of this perspective, Baumeister et al. (1998, Experiment 2) found that making an effortful, personal choice impaired future self-regulation. Additionally, in another experiment, after performing a task that required self-control, participants were far more likely to choose a passive response option, seeming to shy away from acts of volition (Baumeister et al. 1998, Experiment 4). Both of these experiments suggest that the effects of depletion reach beyond self-control. In short, research on task interruption and the self's limited resources suggests that stopping oneself just prior to completing a task should deplete self-control strength and hence lead to poorer subsequent self-regulatory performance.

Current research

Three experiments were conducted to test the hypothesis that stopping one's behavior is effortful and depletes the self's limited resources. Based on the research pertaining to goals as reference points and goal gradients, we predicted that task interruption is the most depleting when the interruption occurs close to task completion. To test this hypothesis, participants first engaged in a simple, basic task. In all three experiments, participants were either interrupted shortly after beginning the task, near completion of the task, or were allowed to complete the task. Following the initial task, participants' performance on a subsequent task that required the use of the self's resources was assessed. Although the experiments were similar, they differed in how participants were interrupted, what they were working on, and how final self-regulatory performance was measured. This was done to improve the generalizability of the effect and to help rule out alternative explanations. In all three experiments, we predicted that participants who were interrupted close to completion of the initial task, but not those stopped early or allowed to finish, would show evidence of depletion on the dependent measure.

Including two interruption conditions not only allowed us to illustrate that *when* the interruption occurs is an important determinant of subsequent self-control, but also helped us rule out the possibility that our effects were caused simply by being interrupted (i.e., increased intrusions of the interrupted task due to the Zeigarnik (1935) effect). Further, including a control condition in which participants actually completed the initial task allowed us to rule out fatigue as an explanation of our findings. That is, a difference in subsequent depletion between participants stopped at the beginning of the task and those stopped near completion could be simply explained by increased fatigue experienced by the group that worked on the initial task longer. Including a condition in which participants actually completed the initial task helped to rule out this alternative explanation.

Experiment 1

In Experiment 1, participants first engaged in a card sorting task. Participants were given a stack of multi-colored index cards and were instructed to sort the cards one-by-one into piles by color as quickly and accurately as possible. The task was designed to be simple and to allow participants to get into a rhythm while working.

After either being stopped by the experimenter or allowed to finish, all participants engaged in a continuous performance test, a commonly used measure of self-control (Hall et al. 1999). We predicted that participants who were stopped just prior to sorting all the cards would show evidence of depletion on this task, but not those who were stopped early in the task or who were allowed to finish.

Method

Participants

One-hundred and six undergraduates (60 female, 46 male) participated in return for partial course credit. Participants were tested individually in sessions that lasted for 30 min.

Procedure

After signing an informed consent sheet, participants were told that they would be taking part in an experiment examining the effects of different tasks on cognitive performance. They were told that they would engage in several different activities, beginning with a card sorting task. Specifically, participants were given a stack of roughly 350 index cards. The cards were shuffled so that five different

colors of index cards were intermixed throughout the stack. Participants were asked to sort the cards one-by-one into piles by color as quickly as possible, and to ring a bell upon completion. They were given no external incentive to complete the task quickly, rather they were simply told to "do their best" on the task. Pilot testing revealed that this task takes approximately 5 min to complete. Before beginning the task, participants were randomly assigned to one of three different sorting conditions. Some participants were stopped by an experimenter after 2 min of sorting, some after 4 min of sorting, and some were allowed to sort until they rang the bell, thereby indicating completion of the task. An experimenter surreptitiously timed participants from a separate room and stopped them once the allotted time was up. To stop participants, the experimenter entered the room and told the participant that it was time to move onto the next task. The experimenter did not provide a rationale for the interruption other than to say that the participant would be moving onto something else. The participants themselves handed the unsorted cards to the experimenter, and they were given no indication that they would complete the task at a later time.

Following completion of the sorting task, all participants were seated at a computer to engage in a continuous performance test (CPT). This task consisted of numerical digits presented one-by-one on the computer screen at an average interval of 750 ms (±350 ms) between digits with each digit on screen for an average of 250 ms (±100 ms). Further, participants were instructed to respond (by hitting the space bar) only when they saw the number 4 immediately after the number 6. This task is well suited as a test of attentional self-control because the fast pace, short presentation, and irregular timing of the stimuli mean that even a brief lapse in attention could result in missing a target. Additionally, the task lasted for nearly 12 min, so self-control was required to maintain vigilant attention for such a long time. Participant's performance on this task should vary in accordance with their level of self-control, such that participants higher in self-control should miss fewer targets and make fewer false alarms (pressing the space bar when a target is not present) than those lower in self-control.

After completion of the two experimental tasks, participants completed a manipulation check questionnaire that asked about their perceptions of the two tasks. The questionnaire contained Likert items with a seven-point scale (1 = Very Little, 7 = Very Much) that asked about the card sorting task (e.g., "How much did you care about the card sorting task?") and the computer task (e.g., "How distracted were you during the task?"). Questions probed participants about different aspects of the experiment such as their level of effort, motivation, frustration, task enjoyment, and distraction.

Table 1 Experiment 1: responses on key variables

Variable	2 min		4 min		Completion	
	M	SD	*M*	SD	*M*	SD
Sensitivity index (CPT)	0.39	1.02	−0.55	2.26	0.16	1.33
Focus (CPT)	4.44	1.56	4.18	1.89	4.33	1.89
Distraction (CPT)	3.22	1.74	3.56	1.73	3.43	1.82
Frustration (Cards)	1.91	1.28	2.12	1.49	1.55	0.846
Level of caring (Cards)	4.47	1.92	4.56	1.73	4.85	1.79
Enjoyment (Cards)	3.03	1.98	3.06	1.76	2.90	1.52
Effort to stop (Cards)	3.97	1.99	4.74	1.76	4.33	1.89

$N =$ 06. CPT = continuous performance test

Results and discussion

CPT performance

Data from the CPT was analyzed using a one-way ANOVA with two planned contrasts. Prior to the ANOVA analysis, a sensitivity index of participants' responses was calculated. The sensitivity index utilized in the current experiment was *d'*, which is a frequently used sensitivity index derived from signal detection theory (Amir et al. 2001; Johnson 2005). In the present experiment, it was calculated by converting each participant's hit rate and false alarm rate on the CPT task into a *z* score and then subtracting the false alarm rate from the hit rate (MacMillan and Creelman 1991). Participants with a high *d'* were better able to discriminate between targets and false alarms than participants with a low *d'*. The one-way ANOVA on participants' sensitivity index was significant, $F(2, 103) = 3.109$, $p < 0.05$. An examination of the means (Table 1) revealed that participants who were stopped after 4 min of sorting performed worse on the concentration task than did participants in the other two conditions. Indeed, a planned contrast comparing the 2 min and completion group against the 4 min group was significant, $t(103) = 2.45$, $p < 0.05$. Additionally, a planned comparison between the 2 min group and the completion group was not significant, $t(70) = 0.612$, *ns*. In sum, participants stopped after 4 min, and thus who were closest to finishing, performed worse than the other two groups on a test of self-control.[1] Stopping

[1] Due to the fact that the cards became worn down over time, some participants assigned to the 4 min condition actually completed the task. For the purpose of the analyses, they were included in the completion group. Whereas this is reasonable based on our theory, the data also supports that there were no differences in CPT performance between people who were assigned to be stopped after 4 min but finished early ($M = 0.03$, SD = 1.40) and those who were initially assigned to the completion group ($M = 0.26$, SD = 1.29), $t(38) = 0.519$, $p = 0.607$. In Experiment 2, steps were taken to ensure that the cards did not wear down, and no participants in the 4 min condition completed the task prior to interruption.

oneself when close to finishing a task requires more self-control than stopping when further from task completion.

Alternative explanations

It could be argued that the participants stopped just before finishing the card sorting task were more frustrated, causing them to perform more poorly on the CPT task. However, the groups did not differ in the level of frustration that they experienced while working on the card task, $F(2, 103) = 2.07$, *ns*. Additionally, there were no differences amongst the groups in how much they cared about the task, $F(2, 103) = 0.447$, *ns.*, or how much they enjoyed it, $F(2, 103) = 0.089$, *ns*. Furthermore, there is no evidence that differences on the CPT were due to differences in level of focus or level of distraction. All three groups reported similar levels of focus and distraction when probed at the end of the task (all $p > 0.73$). Further, contrast analyses conducted on these variables found no evidence of any differences between participants stopped after 4 min sorting and the other two groups (all $p > 0.12$). In short, differences in frustration, task enjoyment, or other variables do not seem to explain the differences in performance between groups.

Interestingly, the group stopped after 4 min reported a near significant increase in the amount of effort that the card sorting task required, $t(103) = 1.85$, $p < 0.07$. This difference is rather difficult to interpret, as the question was asked at the end of the experiment, after the CPT task was completed. Because all participants sorted the same cards, there is no reason to assume that the sorting would require more effort for one group than another. If anything, it seems reasonable that the group allowed to finish would report more effort simply because they spent a longer time sorting. It is possible that while thinking back on the card sorting task, participants stopped after 4 min were able to recognize that the task as a whole (including the interruption) was an effortful experience.

Experiment 2

In Experiment 2, we sought to replicate and extend the findings from Experiment 1 by using a different dependent variable as a measure of self-control depletion. Participants in Experiment 2 again first worked on a card sorting task. Once more we had three conditions: participants were either stopped after 2 min of sorting, after 4 min of sorting, or were allowed to complete the task.

To measure self-control depletion, we assessed participants' level of persistence on unsolvable and difficult anagrams. Degree of persistence on an impossible task has commonly been used by self-control researchers as a measure of self-control performance (Ciarocco et al. 2001; Muraven et al. 1998). In these tasks, participants do not realize that the task is impossible, so the time spent working on them represents an instance of persistence in the face of failure. Persistence on such tasks serves as a measure of self-control because, presumably, to continue exerting effort in the face of failure requires participants to override the easier, more appealing response option of quitting.

In Experiment 2, we also took additional steps to rule out potential alternative explanations by measuring participants' mood and arousal following the card sorting task as well as their perceptions of performance on the card sorting task. To more strongly bolster our findings, we kept track of how many cards remained if a participant was interrupted and we also asked participants about their desire to continue sorting the cards when the task was over.

We predicted that participants who were stopped after 4 min of sorting, and who were therefore closer to completing the initial task, would show evidence of self-control depletion on the anagram task as marked by less persistence on the anagrams that they were unable to solve. Moreover, amongst participants who experienced interruption, we predicted that the amount of cards they had remaining would be positively correlated with persistence on the anagram task and that participants stopped closest to completing the task would report a stronger desire to continue sorting the cards.

Method

Participants

Fifty-nine undergraduate students (29 male, 29 female, 1 failed to respond) participated in this experiment in return for partial course credit. Each participant was run individually in a testing session that lasted approximately 30 min.

Procedure

Once in the lab, participants were told that they would be working on an experiment in which they would complete several new psychological tasks. After signing an informed consent sheet, the card sorting task was introduced. The task was administered following the procedures outlined in Experiment 1 using the same three experimental conditions. Specifically, participants were either stopped after 2 min of sorting, after 4 min of sorting, or were allowed to finish. If they were stopped early, at the appropriate time

the experimenter entered the room and told the participant that they would now be moving onto the next task. If they were allowed to finish, the experimenter returned when the participant had rung the bell. Immediately following the card sorting task, participants completed the Brief Mood Introspection Scale (BMIS; Mayer and Gaschke 1988) to measure mood and arousal. The BMIS assesses participants' current mood based on their responses to 16 adjectives. In particular, participants rate how they feel in relation to each of the adjectives on a seven-point Likert (1 = definitely do not feel, 7 = definitely do feel). The scale contains two subscales; mood valance and arousal (α 0.82 and 0.60 in the current experiment).

Following the card sorting task, participants were seated at a computer where they completed the rest of the experiment. The first computer task was an anagram task, which served as the dependent variable in the current experiment. Participants were instructed verbally, as well as in writing on the computer screen, that they would be working on a series of anagrams. Anagrams were presented one at a time on the computer screen, and participants were unaware of how many anagrams were included in the task. For each anagram, the computer screen displayed the scrambled letters in a box on the left. On the right was a box for participants to enter their solution. In addition, participants could click an arrow icon to advance to the next screen. Crucially, participants were instructed that if they could not solve an anagram, they could also press the button to advance to the next one. This task contained five anagrams total. Thus, participants saw a total of five anagrams one by one, and they advanced to the next anagram when either they entered a solution to the current anagram, or, when they decided to give up, leaving the current anagram unanswered. Unbeknownst to participants, only the first and fourth anagrams were actually solvable; the other three had no solutions. The computer recorded participant answers as well as time spent on each of the five anagrams, and the time spent persisting on any unsolved anagrams served as the primary dependent variable in this experiment.

After concluding the anagram task, participants filled out a manipulation check questionnaire and a demographic questionnaire. The manipulation check questionnaire contained Likert items with a seven-point scale (1 = Very Little, 7 = Very Much) that asked about the card sorting task (e.g., "Overall, how well do you think you performed on the card sorting task?") and about the anagram task (e.g., "During the anagram task, how distracted were you?"). Questions probed participants about different aspects of the experiment such as their level of frustration, motivation, task enjoyment, desire to continue sorting the cards, and distraction.

Results and discussion

Manipulation check

Prior to conducting any analyses, we first assessed whether the three groups did indeed differ in how near they were to completing the card sorting task when they were stopped. Not surprisingly, the groups differed significantly in the amount of cards that remained unsorted at the end of the experiment, $F(2, 56) = 246.11$, $p < 0.001$. In addition, a planned contrast revealed that the group stopped after 4 min of sorting had significantly less cards remaining than did the group stopped after 2 min, $t(56) = 13.74$, $p < 0.001$.

Anagram persistence

We examined anagram persistence to assess whether people stopped just prior to finishing the card task exhibited evidence of self-control depletion. As a measure of persistence, we used the average time spent per anagram that the participant was unable to solve, regardless of whether the anagram was objectively solvable or unsolvable. That is, anagrams that were objectively solvable were used in the calculation of a participant's persistence mean if the participant was unable to correctly solve them. From the participant's perspective, whether or not the anagram is objectively solvable or not is immaterial; time spent persisting without generating a solution represents time spent persisting in the face of failure. As an example calculation, if a participant was able to solve only one of the two objectively solvable anagrams, then their persistence time would be the mean time spent persisting on each of four anagrams; the three unsolvable ones, and the one objectively solvable anagram that they did not solve.

We conducted a one-way ANOVA with two planned contrasts to probe for differences amongst the groups on persistence times. An overall ANOVA was significant, $F(2, 56) = 3.54$, $p < 0.05$, indicating that there were indeed differences in persistence times. Furthermore, a planned contrast revealed that the group stopped after 4 min of sorting differed significantly from the other two groups, $t(56) = 2.45$, $p < 0.05$. An examination of the means (Table 2) suggests that participants stopped after 4 min of sorting spent less time persisting on anagrams that they could not solve. The 2 min group and the group allowed to finish the task did not differ from each other, $t(56) = 1.04$, *ns*. The results remained largely the same if we examined responses on only the three unsolvable anagrams. A one-way ANOVA approached conventional levels of significance, $F(2, 56) = 2.74$, $p = 0.07$, and a contrast comparing the mean of the group stopped after 4 min to the other two conditions was significant, $t(56) = 2.10$, $p < 0.05$. Again,

Table 2 Experiment 2: responses on key variables

Variable	2 min		4 min		Completion	
	M	SD	*M*	SD	*M*	SD
All unsolved anagrams	61.80	28.07	43.99	20.87	73.16	47.96
Three unsolvable anagrams	62.27	32.04	46.37	23.04	74.85	52.36
Effort (Anagrams)	5.20	1.54	5.05	1.58	4.37	1.80
Distraction (Anagrams)	5.55	1.67	5.79	1.55	5.16	1.18
Percentage of cards left	0.62	0.10	0.23	0.12	0.00	0.00
Mood	9.15	10.04	5.84	12.76	7.4	15.49
Arousal	25.05	4.85	22.10	8.22	20.8	9.66
Frustration (Cards)	4.50	1.80	4.95	1.93	5.58	1.58
Enjoyment (Cards)	4.50	2.31	4.74	2.10	4.63	1.92
Motivation (Cards)	1.80	1.28	2.00	1.37	2.21	1.51
Perceptions of performance (Cards)	6.00	1.78	6.63	.597	6.42	.838
Desire to continue sorting (Cards)	4.20	2.04	5.58	2.09	5.42	1.81

$N = 59$. All unsolved anagrams refers to the time spent per anagram on any anagram that the participant was unable to solve. Three unsolvable anagrams refers to the spent per anagram on only the three anagrams that were objectively unsolvable

the 2 min group and the group allowed to finish did not differ from each other $t(56) = 1.05$, *ns*. Consistent with our hypothesis, participants who were stopped when they were close to finishing performed more poorly on a subsequent test of self-control as compared to participants who were either stopped earlier in the task or who were allowed to finish. This suggests that it can take self-control to pull oneself away from a task that is near completion, even when the task itself does not require self-control.

To further examine the relationship between task interruption and subsequent depletion, we correlated the percentage of cards remaining and persistence times for participants who were interrupted during the card sorting task. Presumably, participants closest to finishing the task (i.e., with fewer cards remaining), should need to exert the most self-control to stop, thereby leaving them depleted for the anagram task. Indeed, a significant correlation emerged between percentage of cards left and anagram persistence, $r(39) = 0.318$, $p < 0.05$, indicating that participants with fewer cards remaining persisted less on the anagram task.

Consistent with a depletion explanation, a planned contrast comparing the two groups that were stopped early with each other, indicated that the 4 min group reported a stronger desire to continue sorting cards at the end of the experiment than did the 2 min group, $t(55) = 2.17$, $p < 0.05$. Thus, for those participants stopped early, it seems like the longer they sorted, and the closer they were to finishing the task, the more they wanted to continue.

Alternative explanations

As in the previous experiment, we attempted to rule out competing explanations. Participants did not differ in level of frustration with the card sorting task, $F(2, 55) = 1.82$, *ns.*, their enjoyment of the card sorting task, $F(2, 55) = 0.061$, *ns*., or their motivation to perform well on the card sorting task $F(2, 55) = 0.425$, *ns*.[2] Also, groups did not differ in how well they thought they performed on the card sorting task, $F(2, 55) = 1.41$, *ns*. Additionally, they did not differ in their reported effort on the anagram task, $F(2, 55) = 1.40$, *ns*., or level of distraction on the anagram task, $F(2, 55) = 0.767$, *ns.* Finally, we examined participants' mood and arousal level. Participants did not differ in regards to their mood, $F(2, 56) = 0.318$, *ns*., or level of arousal, $F(2, 56) = 1.54$, *ns*. Further, in no instance did a contrast on any of these variables comparing the 2 min and completion group versus the 4 min group reach significance (all $p > 0.21$). Thus, it seems unlikely that any of these variables exerted much influence on persistence times (means depicted in Table 2).

Experiment 3

Experiment 3 sought to replicate and extend the findings of the previous two experiments by using different measures. The initial task was designed to be more standardized so that all participants who were stopped early were stopped at exactly the same distance from completing the task. To accomplish this, participants worked on a word find task in which they were asked to find words hidden in a letter grid. Also, the computer, and not the experimenter stopped

[2] For analysis conducted on the manipulation check questionnaires, the data from one participant was not included because the participant chose not to answer the manipulation check questions.

participants, leaving the experimenter blind to participant's condition.

In addition, Experiment 3 used a task that assessed executive functioning as opposed to self-control. Participants engaged in a computerized version of the Tower of Hanoi puzzle, a commonly used task of executive functioning and planning ability (Mataix-Cols and Bartres-Faz 2002). Because executive functioning performance has been found to be affected by depletion (e.g., Baumeister et al. 1998; Schmeichel et al. 2003; Vohs et al. 2008), we predicted that participants stopped just short of completing the word find would show impairments on the Tower of Hanoi task as compared to all other research participants.

Method

Participants

Fifty-seven undergraduate psychology students (27 male, 27 female, 3 who did not report gender) participated in this experiment for partial course credit.

Procedure

Upon entering the laboratory, participants were told that they would be taking part in an experiment that was assessing performance on several different types of mental puzzles. They were told that over the course of the experiment they would work on several different, unrelated, types of puzzles. After providing informed consent, participants were introduced to a word find task. The task consisted of a 20 × 20 letter grid printed on a sheet of paper that contained 10 hidden neutral words (e.g., city, switch, elephant, etc.). The words to be found in the grid were also listed on a nearby computer screen. Participants were also given an envelope which they were told that they would need later. Participants were instructed to find all of the words in the letter grid, and to both circle the words on the paper and click a box icon next to the word on the computer screen once each word was found. As in the first two experiments, participants were told to "do their best" on the task, but they were not given any other incentive to do well on the task. Participants were instructed that after clicking a word on the computer, the computer could possibly prompt them with further instructions that they were to follow.

The computer randomly assigned participants to one of three conditions at runtime. Participants were either stopped after finding 3 of the 10 words, were stopped after finding 8 words, or were allowed to find all 10 words in the grid. If they were stopped, the computer notified them to sound a bell to contact the experimenter after the finding of either the third or eighth word and to put the word search into the envelope. Participants who were allowed to complete the task were prompted by the computer to put the word search into the envelope after they found the tenth word. As in the first two experiments, participants who were interrupted were given no indication that they would complete the task at a later point in time.

All participants then completed a computerized test of executive functioning. Specifically, the Tower of Hanoi puzzle was used. Previous research has indicated that the computerized version of the puzzle is a suitable substitute for the more cumbersome physical version of the task (Mataix-Cols and Bartres-Faz 2002). The Tower of Hanoi puzzle consists of three pegs and a number of different sized disks that fit on the pegs. At the start of the task, all of the disks are arranged in order by size on the center peg, with the largest disk lowest on the peg. The participant must rearrange the disks, one-by-one, so that the initial pattern is replicated on a different peg. While moving the disks, two rules must be followed. Participants can only move one disk at a time, and, a larger disk is never allowed to be placed on top of a smaller disk (Mataix-Cols and Bartres-Faz 2002). Participants were given detailed instructions of the puzzle's rules and were instructed to complete both the four-disk and five-disk version of the task as quickly and accurately as possible.

All participants first completed the easier four-disk version as a warm-up to familiarize themselves with the rules and operation of the task. Participants then completed the five-disk version of the puzzle, and the amount of time taken on this task served as the primary dependent variable in this experiment. All solving times were recorded by the computer program. Following completion of the Tower of Hanoi task, participants completed a brief procedure questionnaire that asked about the word find task (e.g., "How frustrated were you when the word task ended?") using a seven-point Likert scale (1 = Very Little, 7 = Very Much).

Results and discussion

Tower of hanoi performance

Performance on the five-disk puzzle was analyzed using a one-way ANOVA and two planned contrasts. There were significant differences amongst the three groups on time taken to solve the five-disk puzzle, $F(2, 54) = 3.19$, $p < 0.05$. An examination of the means (Table 3) indicates that those stopped after finding eight words took longer on the puzzle than the other two groups. Indeed, a planned contrast comparing the group stopped after finding eight words with the other two groups was significant, $t(54) = 2.28$, $p < 0.05$. The group stopped after finding eight words took longer to complete the Tower of Hanoi task than did the

Table 3 Experiment 3: responses on key variables

Variable	3 Words		8 Words		10 Words	
	M	SD	*M*	SD	*M*	SD
Time on five-disk (TOH)	152.3	74.98	187.67	82.68	128.05	48.22
Time on four-disk (TOH)	64.10	28.26	71.20	26.56	80.60	44.39
Frustration (Word find)	2.00	1.30	2.38	2.02	1.70	1.22
Motivation (Word find)	4.91	1.66	5.08	1.69	5.15	1.50
Enjoyment (Word find)	4.45	1.82	4.31	1.38	4.25	1.52

$N = 57$. TOH = Tower of Hanoi task

other two groups. A second planned contrast revealed no difference in time taken to solve the puzzle between the group stopped after finding three words and the group who finished the task, $t(54) = 1.14$, *ns*. Overall, the results suggest that stopping oneself when close to finishing takes more self-control (and hence results in poor subsequent executive functioning) than stopping when further from task completion or when allowed to finish.

It should be noted that participants did not differ in their performance on the easier, four-disk baseline version of the task (all $p > 0.339$). This lack of a difference on the four-disk version of the task is not wholly unanticipated; in fact, it is consistent with previous research that has found that depletion effects only occur if the second task is complex enough to require sufficient amounts of self-control and executive functioning (Schmeichel et al. 2003). That is, tasks that are too easy do not require much use of the self's resources to begin with, making them less susceptible to depletion effects. It is possible that the four-disk version of the Tower of Hanoi task did not sufficiently tax participants' self-regulatory resources.

Alternative explanations

The three groups did not differ in the level of frustration they felt when the word find task ended, $F(2, 52) = 0.821$, *ns*.[3] Nor did they differ on their enjoyment or motivation to perform well on the task (both $p > 0.88$). Therefore, differences on the five-disk version of the task do not appear to be due to differences in these variables.

[3] Two participants inadvertently skipped the manipulation check questions.

General discussion

The results of these three experiments suggest that stopping an ongoing task requires self-control even if that task is relatively uninteresting. However, the deleterious effects of interruption were only found when participants were stopped just prior to finishing the task. Using a self-control depletion paradigm (Muraven and Baumeister 2000), we found that people who had to stop when they were close to finishing performed more poorly on a subsequent and unrelated task that required self-control as compared to individuals who were either allowed to finish or who had to stop further from finishing. This was found in three experiments that used a variety of tasks and measured self-control performance in different ways. In Experiment 1, participants engaged in a repetitive card sorting task and were interrupted either after 2 min of sorting, after 4 min of sorting, or were allowed to finish. Those who were stopped after 4 min, and who were therefore closest to completion, demonstrated impaired self-regulatory performance on a measure of attentional self-control. Experiment 2 replicated and extended the results found in Experiment 1. Using the same initial task, but a different dependent measure of self-control, decrements in self-control performance were again found for those stopped just prior to completing an initial task.

The results of Experiment 3 expanded on these findings. In the third experiment, a different initial task was used. Rather than using a repetitive, mundane task, participants in this experiment engaged in a word find task. Once again, some participants were interrupted shortly after beginning the task, some near completion of the task, and some were allowed to finish. As in the previous experiments, impaired performance on a subsequent task was found only for those stopped just short of completing the word find. More specifically, participants stopped after finding eight words took longer to solve the Tower of Hanoi puzzle, a task that requires the use of executive functioning and should be sensitive to depletion (Baumeister et al. 1998).

The findings of these experiments may have important implications for understanding both the nature of the self's limited resources and the motivational pull that individuals experience when progressing towards a goal. All three experiments supported the notion that task interruption, if it occurs near completion of a goal, can have deleterious effects for subsequent acts that require the active self. Thus, it seems that interruption near the completion of a task can be added to the list of events that deplete the self's resources. Given the nature of contemporary human life, one fraught with constant interruptions and distractions, this may be especially important. Because so many critically important activities require the use of the active self, such as self-control, decision making, and complex thinking, the negative effects of task interruption may be

widespread (Baumeister et al. 1998; Schmeichel et al. 2003). Indeed, this may be a previously unrecognized negative consequence of task interruption.

The current findings also increase our knowledge of how people respond to goals. Previous research has suggested that people become more engaged in a task as they get closer to their goal (Kivetz et al. 2006). This engagement seems to reflect a desire to finish, as stopping working takes self-control. As we found, as people approach a goal, stopping the task seems to require more effort and more self-control. Moreover, for this to occur the task itself need not be pleasurable or even terribly interesting. Instead, we found evidence of depletion even after the interruption of rather boring tasks that participants had little reason to care about (e.g., sorting a stack of index cards). These results may have occurred because as participants approach a goal, stopping goal-directed behavior may require more self-resources because the desire to pursue the goal and finish is greatest closest to goal attainment. Put another way, people's engagement in a task and desire to finish increases as the goal nears and hence stopping, especially when the goal is close, requires overcoming the desire to continue. This suggests that not all occurrences of stopping oneself are the same, but that the effects of stopping are modified by situational variables such as goal distance. In other words, the act of stopping may be less depleting if the person is further from task completion.

The notion that stopping a task becomes more effortful as a goal is approached is similar to the concept of psychological inertia but also has important differences. Baumeister et al. (1994) suggested that for many behavioral acts, stopping is easiest early in the behavioral sequence. Once a behavior has begun, a snowballing effect may occur, making stopping more difficult. Essentially, a behavior may in a sense gain momentum, so that over time it becomes more difficult to stop. Although related, the present research suggests that regardless of how long someone has been working on a task, the nearness to finishing is an important factor in how difficult it is to stop.

Alternative explanations

We have suggested that interruption that occurs just prior to task completion may be particularly depleting because as individuals approach a goal, their engagement with the task increases, thereby making stopping the task more effortful. While conducting these experiments, attempts were made to rule out competing explanations of the findings. Indeed, we found no differences amongst experimental condition in mood, frustration, motivation, perceptions of task performance, distraction, or enjoyment of the task. Participants who were stopped when they were close to finishing the initial task did not differ from other participants on these variables. This suggests that these variables did not cause the decline in subsequent self-regulatory performance, but rather that the reported effects were caused by differences in effort exerted to interrupt an ongoing activity.

Additionally, it is unlikely that the observed differences in self-control after interruption were caused by either intrusions or distraction elicited by the interrupted task or by fatigue amongst those who were interrupted near completion. Much of the early work on task interruption studied the well known Zeigarnik Effect which maintains that tasks that are interrupted are better recalled by memory than tasks that are completed, presumably due to unresolved tension about the unfinished task (Zeigarnik 1935). It is conceivable that in the current experiments, participants interrupted prior to goal attainment were distracted by thoughts about the unfinished task, thereby impairing performance on the subsequent dependent measure. However, four arguments can be levied against such an explanation. First, in each experiment, two groups of participants were stopped prior to completing the initial task, yet results indicated that only the group stopped close to completion, and not the group stopped earlier in the behavioral sequence showed impairment. Presumably, any unresolved tension due to not finishing the task should exist in both groups. Second, in Experiments 1 and 2, there were no differences among groups in their level of focus or degree of distraction while working on the dependent measure. Had the effects been due to increased recall of memories related to the first task, it would be expected that participants would report less amounts of focus and more distraction. Third, the results of Experiment 2 are in the opposite direction of a distraction explanation. If participants were indeed distracted after being interrupted close to goal attainment, then they should have spent more time on the subsequent anagram task, not less time as we observed. Finally, Experiment 3 found differences in performance only on the more difficult of the two Tower of Hanoi puzzles, indicating that a deficit in executive processing and not a mere lack of motivation or increase in distraction caused the effects.

Finally, it is unlikely that the observed effects were caused by increased fatigue amongst participants stopped just prior to goal completion. While these participants did work for a longer period of time on the initial task than those interrupted shortly after beginning the task, they did not work as long as participants allowed to complete the task. Therefore, it is unlikely that fatigue elicited by working on the initial task caused the subsequent decrements in self-control ability.

Limitations and future directions

Whereas the current findings do suggest that stopping near the completion of a task may have deleterious effects for

the subsequent use of limited self-resources, certain questions remain. Most importantly, it is difficult to be certain that the observed decline in self-regulatory performance occurred because participants expended self-control to stop the initial task. That is, our suggestion that interruption near task completion depletes the self's resources because stopping oneself near goal attainment requires self-control remains somewhat speculative. For instance, it is possible that depletion occurs as a result of having a desire thwarted. As such, a person nearing goal completion may experience a strong desire to complete the task, and it is the regulation of cognition associated with the thwarting of that goal, and not the self-stopping of activity per se, that leads to subsequent depletion. This could be tested by having the task programmatically stopped (for example, by having the computer automatically switch to a new task) and observing the subsequent effect. Also, whereas the results are clearly consistent with a depletion explanation, we did not directly measure participants' engagement with the task or their level of self-regulatory resources. Measuring self-regulatory resources may be particularly challenging as recent research on the role of glucose and self-control suggests that it may be very difficult, if not impossible, for people to know when and if they are depleted (Gailliot et al. 2007).

Further, we largely relied on self-report measures to rule out alternative explanations. The shortcomings of introspective self-report measures have been widely documented (e.g., Wilson 2002) and it is quite possible that participants were unable to accurately assess their internal states (e.g., their level of distraction, focus, etc.). Additionally, we relied largely on null effects to rule out alternative explanations. This may be problematic since there are numerous reasons why we may have found null results (e.g., there really were no differences between conditions on the variables, our questions were inadequately constructed, participants were unable to accurately report, etc.). In other words, it remains possible that differences in variables such as frustration or distraction contributed to our results, but were not detected by our self-report measures.

To address these limitations, it may be fruitful for future researchers to more precisely explore the underlying cause of why task interruption near a goal leads to subsequent depletion. To more explicitly test the idea that it requires more self-control resources to stop a task as the task nears completion, it may be beneficial for future researchers to directly assess engagement and motivation during the task, as well as assessing more objective measures of self-control expenditure (e.g., glucose levels). Further, researchers may want to move beyond self-report measures to assess the role of other variables such as frustration and distraction in the process.

Conclusion

Across three experiments, support was found for the notion that the interruption of a task near completion leads to impairment on a subsequent task that requires the active self. This potentially has widespread consequences for day-to-day behavior, as unwanted interruption is certainly a common occurrence. One possible cause of these effects is that there is a motivational pull of goals, such that engagement with a task increases as goal attainment draws nearer. This suggests that stopping oneself near the attainment of a goal requires a great deal of self-control.

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References

Amir, T., Alshibani, F., Alghara, T., Aldhari, M., Alhassani, A., & Bahry, G. (2001). Effects of caffeine on vigilance performance in introvert and extrovert noncoffee drinkers. *Social Behavior and Personality, 29*, 617–624.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*, 1252–1265.

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation*. San Diego: Academic Press.

Brown, J. S. (1948). Gradients of approach and avoidance responses and their relation to level of motivation. *Journal of Comparative and Physiological Psychology, 41*, 450–465.

Ciarocco, N. J., Sommer, K. L., & Baumeister, R. F. (2001). Ostracism and ego depletion: The strains of silence. *Personality and Social Psychology Bulletin, 27*, 1156–1163.

Förster, J., Grant, H., Idson, L. C., & Higgins, E. T. (2001). Success/failure feedback, expectancies, and approach/avoidance motivation: How regulatory focus moderates classic relations. *Journal of Experimental Social Psychology, 37*, 253–260.

Förster, J., Higgins, E. T., & Idson, L. C. (1998). Approach and avoidance strength during goal attainment: Regulatory focus and the "goal looms larger" effect. *Journal of Personality and Social Psychology, 75*, 1115–1131.

Gailliot, M. T., Baumeister, R. F., DeWall, N. C., Maner, J. K., Plant, A. E., Tice, D. M., et al. (2007). Self-control relies on glucose as a limited energy source: Willpower is more than a metaphor. *Journal of Personality and Social Psychology, 92*, 325–336.

Hall, S. J., Halperin, J. M., Schwartz, S. T., & Newcorn, J. H. (1999). Behavioral and executive functions in children with attention-deficit hyperactivity disorder and reading disability. *Journal of Attention Disorders, 1*, 235–247.

Heath, C., Larrick, R. P., & Wu, G. (1999). Goals as reference points. *Cognitive Psychology, 38*, 79–109.

Johnson, V. E. (2005). Comprehension of third person singular/s/in AAE-speaking children. *Language, Speech, and Hearing Services in Schools, 36*, 116–124.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*, 263–291.

Kivetz, R., Urminsky, O., & Zheng, Y. (2006). The goal-gradient hypothesis resurrected: Purchase acceleration, illusionary goal progress, and customer retention. *Journal of Marketing Research, 43*, 39–58.

MacMillan, N. A., & Creelman, C. D. (1991). *Detection theory: A user's guide*. New York: Cambridge University Press.

Mataix-Cols, D., & Bartres-Faz, D. (2002). Is the use of the wooden and computerized versions of the Tower of Hanoi puzzle equivalent? *Applied Neuropsychology, 2*, 117–120.

Mayer, J. D., & Gaschke, Y. N. (1988). The experience and meta-experience of mood. *Journal of Personality and Social Psychology, 55*, 102–111.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247–259.

Muraven, M., & Slessareva, E. (2003). Mechanisms of self-control failure: Motivation and limited resources. *Personality and Social Psychology Bulletin, 29*, 894–906.

Muraven, M., Tice, D. M., & Baumeister, R. F. (1998). Self-control as a limited resource: Regulatory depletion patterns. *Journal of Personality and Social Psychology, 74*, 774–789.

Schmeichel, B. J., Vohs, K. D., & Baumeister, R. F. (2003). Intellectual performance and ego depletion: Role of the self in logical reasoning and other information processing. *Journal of Personality and Social Psychology, 85*, 33–46.

Vohs, K. D., Baumeister, R. F., Schmeichel, B. J., Twenge, J. M., Nelson, N. M., & Tice, D. M. (2008). Making choices impairs subsequent self-control: A limited-resource account of decision making, self-regulation, and active initiative. *Journal of Personality and Social Psychology, 94*, 883–898.

Wilson, T. D. (2002). *Strangers to ourselves: Discovering the adaptive unconscious*. Cambridge, MA: Harvard University Press.

Zeigarnik, B. (1935). On finished and unfinished tasks. In K. Lewin (Ed.), *A dynamic theory of personality* (pp. 300–314). New York: McGraw-Hill.