AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Experimental Psychology:
Human Perception and Performance

© 2025 American Psychological Association
ISSN: 0096-1523

2025, Vol. 51, No. 7, 895–910
https://doi.org/10.1037/xhp0001331

Setting Specific Goals Improves Cognitive Effort, Self-Efficacy, and Sustained Attention

Lauren D. Garner[1], Rija Mohammed[2], and Matthew K. Robison[1]
[1] Department of Psychology, University of Notre Dame
[2] Department of Psychology, University of Texas at Arlington

Investigating the efficacy of goal-setting strategies is critical in understanding how individuals regulate their behavior, particularly within cognitive tasks. The present study examines the impact of self-set versus experimenter-set goals and point incentives on performance across three experiments using two sustained attention tasks. In Experiment 1, we compared self-set and experimenter-set goals in the psychomotor vigilance task, hypothesizing that self-set goals would lead to better performance due to increased agency. No significant differences emerged in task performance between the two conditions. Participants who self-set their goals also set increasingly easier goal standards over time. Experiment 2 introduced a novel task paradigm "Green Means Go," modeled after the psychomotor vigilance task, and revealed faster reaction times in goal-setting conditions compared to a no-goal condition. Having a specific goal, either self-set or experimenter-set, was better for performance than having no goals. Experiment 3 allowed all participants to set their own goals and explored the influence of a points-based incentivization system on goal-setting tendencies. Those who received points set more difficult goals. Findings suggest that goal-setting mechanisms can enhance task performance and help reduce vigilance decrements, with potential implications for using goal-setting to elevate cognitive performance.

Public Significance Statement
Sustaining attention and maintaining performance can be very challenging, and there is ongoing debate as to why this is the case. In the present study, we investigate how setting goals can improve our ability to hold our attention on a simple reaction time task, which becomes difficult as time on the task increases. We were interested in comparing how setting one's own goals influences performance as opposed to having no goals or having a goal assigned by the experimenter. Having a goal, either self-set or experimenter-set, was much better for performance than having no goal. Performance still declined over time, but not as rapidly as when one had no goal. Additionally, receiving points for a completed goal improved performance, but did not wholly prevent a decline in sustained attention over time.

Keywords: sustained attention, goal setting, vigilance, self-efficacy, rewards

Supplemental materials: https://doi.org/10.1037/xhp0001331.supp

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The problem of mental fatigue is a common one, which typically manifests as a worsening of cognitive performance over time, and it can be observed in many different paradigms. For example, time-on-task performance decrements have been observed in perceptual discrimination (i.e., vigilance) tasks (Parasuraman, 1979), simple reaction time (RT) tasks (Unsworth & Robison, 2016), choice RT tasks (Strayer et al., 2023), and working memory tasks (e.g., *n*-back; Hopstaken et al., 2015a, 2015b, 2016). More pragmatically, most people acknowledge a sense of encroaching mental fatigue during events that feel monotonous with time, like while listening to a lecture, driving across states, or checking code for errors. As time progresses, work becomes slower and/or more error-prone. The precise causes of mental fatigue, however, are still under debate. One theory of mental fatigue—resource depletion—is that the psychological sensation of fatigue is driven by a depletion of mental energy or cognitive resources (Brzezicka

This article was published Online First May 15, 2025.
Paul E. Dux served as action editor.
Lauren D. Garner https://orcid.org/0009-0008-1475-2429
The authors were supported by collaborative agreements with the U.S. Naval Research Laboratory (N00173-22-2-C006) and the U.S. Army Research Institute (W911NF-23-1-0300). All data and analysis scripts are publicly available on the Open Science Framework at https://osf.io/k4pzy/.

Lauren D. Garner served as lead for data curation, formal analysis, and writing–original draft and served in a supporting role for project administration. Rija Mohammed served in a supporting role for project administration. Matthew K. Robison served as lead for conceptualization, funding acquisition, methodology, project administration, resources, software, supervision, validation, and visualization. Rija Mohammed and Matthew K. Robison contributed equally to writing–review and editing.

Correspondence concerning this article should be addressed to Lauren D. Garner, Department of Psychology, University of Notre Dame, Corbett Family Hall 355A, 18931 Moose Krause Cir, Notre Dame, IN 46556, United States. Email: lgarner@nd.edu

et al., 2013; Warm et al., 2008). In this sense, fatigue signals the body to rest so those resources can be recuperated. Another model—the motivational control model—suggests that fatigue occurs in high-demand tasks over which people do not have control (G. R. J. Hockey, 1997, 2011). The cognitive-energetic model blends the two, prioritizing both task goals and bodily arousal to explain performance costs (Unsworth & Robison, 2020). Here, we examine the extent to which these theories explain sustained attention performance using a goal-setting manipulation to further uncover the causes of mental fatigue and ways to combat these effects.

The resource depletion theory posits that sustained attention tasks are stressful work and lead to the depletion of cognitive resources over time (Parasuraman, 1979). Neuroimaging studies employing positron emission tomography, functional magnetic resonance imaging, and transcranial Doppler have corroborated this theory by revealing alterations in cerebral blood flow corresponding to task demands (Parasuraman & Caggiano, 2005; Parasuraman et al., 1998; Warm et al., 2008). Furthermore, recent studies using transcranial photobiomodulation, which uses a light-emitting diode to stimulate tissue in the cortex, have shown interesting preliminary effects in improving cognitive abilities. This noninvasive neuromodulator increases oxygen production during cellular respiration and thereby increases available adenosine triphosphate, the body's energy molecule. Chaudhari et al. (2023) found that repeated stimulation over 4 weeks during the psychomotor vigilance task (PVT) improved RT compared to those in a sham group. This would suggest adenosine triphosphate functions as a cognitive resource that can enhance performance when an abundance of this resource is present. However, more research should be done in this realm to test the reproducibility of these results. Additionally, self-report measures and physiological indicators have demonstrated heightened stress levels during vigilance tasks, highlighting the cognitive and emotional strain involved (Lundberg, 2005; Warm et al., 2008). This research challenges the notions that vigilance tasks are simple or undemanding and underscores the importance of considering workload and stress in work environments where vigilance is required.

Resource theorists suggest that performance decrements occur because people are unable to continue performing at an optimum level unless a rest or resource replenishment is accomplished. According to resource theory, the presence of a goal would not have an influence over sustained attention performance because cognitive resources continue to be consumed; performance may even decrease at an even greater rate due to the consumption of extra resources required to achieve and maintain a goal standard. Resource theory is an incomplete explanation of the vigilance decrement because it does not explain how certain resource-consuming activities (e.g., exercise) can boost performance, or how simple manipulations like incentives, feedback, and competition can mitigate the decrement (Garner et al., 2023; Massar et al., 2016; Robison & Nguyen, 2023; Robison et al., 2021; Tomporowski, 2003).

Another theory that explains sustained attention behavior patterns is the cognitive-energetic model (Unsworth & Robison, 2020). Rather than suggesting performance declines solely due to consumption of cognitive resources, this model incorporates how the level of intensity of attention and motivation to maintain a goal will regulate performance during sustained attention. According to this theory, a goal is selected based on task instructions ("be fast and accurate"), incentives, and self-efficacy to achieve the goal (i.e., a goal may not be selected for performance if the individual does not believe they can achieve the goal set before them). Once a goal is selected, it is activated and maintained through a "control center." The "control center" maintains the goal by preventing interference from task-irrelevant goals (i.e., "I need to shop for groceries when I get out of this experiment—what's missing from my fridge?"), to produce a fast and accurate task-relevant response. The "system monitor" receives feedback on performance and adjusts intensity or implements strategies to maintain control to achieve task goals (Unsworth & Robison, 2020). In the case of sustaining attention, the monitor may pick up on a slow response time or lapse in attention and adjust the intensity of attention or deploy another strategy (i.e., avoid daydreaming) to improve performance on a subsequent trial. The intensity of attention can be influenced by motivation or arousal levels. In the present study, we used goal-setting and point incentives to persuade the system monitor to increase the intensity of attention so that RTs stay below a set point, and thus reduce the vigilance decrement. We introduce eye-tracking measures in Experiments 2 and 3 to corroborate evidence of intensity of attention: larger pupillary responses to a task are related to greater cognitive arousal and intensity of attention. According to the cognitive-energetic model, we expect that adding goals to a sustained attention paradigm will reduce the vigilance decrement because the system monitor will increase the intensity of attention so that the control center can successfully maintain the goal.

Thorndike observed in his seminal work *Mental Fatigue* concerning the investigation of mental abilities, "First and most important there is danger lest you measure not the ability but the willingness to do work." (Thorndike, 1900). Perhaps the differences we see in performance on sustained attention tasks are not restricted to cognitive resources or ability but also involve a person's willingness to give effort toward the task. Similar to the cognitive-energetic model, the motivational control theory of cognitive fatigue recognizes the inadequacy of a purely resource-driven theory of cognitive fatigue, as the vigilance decrement can be mitigated through incentives (Garner et al., 2023; Massar et al., 2016), feedback (Robison et al., 2021), or goal setting (Strayer et al., 2023). Motivational control theorists suggest that performance declines occur because people are unwilling to continue performing at an optimum level unless sufficiently motivated. G. R. J. Hockey (2011) stressed the importance of task demands (high or low) and the subjects' control over the situation: when subjects are placed under high demand, but have low control, subjects experience strain, distress, and disengagement, and performance suffers. For example, if someone needs to sustain attention while under pressure with deadlines at work but has no autonomy (control) over the workload or deadline, it may be difficult for that person to maintain an adequate level of attention to maintain and achieve that goal. However, when subjects are placed under high demand but are given a high level of control, participants remain engaged with the task, giving effort without distress, and performance is less likely to suffer over time. Having a sense of control over the task distinguishes the motivational control theory from the cognitive energetic model: in the motivational control theory, autonomy motivates someone to pursue task goals more than if they had no control, which is not addressed by the cognitive energetic model. In the present study, we leverage the subject's control over the task (via goal setting) to potentially mitigate the vigilance decrement. The motivational control theory predicts that

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people who are allowed to set their own goal, and thus achieve control over the task, may show better performance during sustained attention than those who are assigned a goal or have no goal at all. According to the theory, for those without control over the goal, the task is more likely to be disengaging or stressful, and the vigilance decrement will be steep (G. R. J. Hockey, 2011).

We used a goal-setting approach to mitigate the vigilance decrement during sustained attention because it been demonstrated to be a powerful moderator of human performance by directing attention toward the task, increasing the intensity of attention toward the task, prolonging persistence toward the task, and improving performance strategies on the task (Locke & Latham, 2013). In the present work, goals are characterized by defining a specific RT (either in milliseconds or on a visual scale) on a simple RT task. Goal setting has been co-opted by cognitive psychologists as a tool for understanding the consequences of mental fatigue on cognitive performance. For example, prior work has shown that setting specific goals within laboratory-sustained attention paradigms produces better performance than vague, do-your-best goals (Robison et al., 2021; Strayer et al., 2023). The motivational control theory also states that people will elect to perform activities that are rewarded, even if those activities are not intrinsically rewarding, such as work (i.e., a reward of salary vs. a reward of finding meaning and purpose). That is, they will adopt a performance protection strategy, maintaining a high level of effort and thus performance when they feel as though the current activity carries benefits that outweigh the costs (R. Hockey, 2013; see Boksem & Tops, 2008, for a similar theory). Therefore, the setting and achievement of specific goals in the present study may lead to more rewards, even if those rewards are nonmonetary (e.g., sense of accomplishment, social desirability, competition). The motivational control theory predicts that setting specific, difficult goals will produce better and more stable performance across time because the task goal will be protected against other, task-irrelevant goals (e.g., personal concerns).

Prior work has been consistent with this goal-setting premise within the realm of sustained attention. For example, Robison et al. (2021) had participants complete a simple RT task—the PVT—for 30 min. In one condition, they gave participants a vague do-your-best goal; in a second, they told participants to try to keep their average RT below 300 ms (specific and difficult goal); in a third, they told participants to keep their average RT below 800 ms (a specific, yet easily achievable goal). Both specific-goal conditions produced better and more stable performance across time than the vague instructions. This pattern was replicated with a broader range of goals in a follow-up experiment (Robison et al., 2021). In a subsequent study, Strayer et al. (2023) gave participants a difficult goal while they completed an extended choice RT task. In one condition, participants were given the goal of keeping their RTs below 400 ms, while maintaining a high level of accuracy. In the other, they were told to respond as quickly as possible, also while maintaining a high level of accuracy. Doing so produced fewer attentional lapses among participants in the specific goal condition. In follow-up experiments, Strayer et al. (2023) used harder-over-time goals rather than static goals. In these conditions, participants exhibited faster RTs and stable performance across time, compared to participants given the vague do-your-best goals. Collectively, these results indicate that the pursuit of specific goals can direct and sustain attention on such tasks, consistent with the motivational control theory.

As a final consideration, we were interested in the role of self-efficacy in cognitive performance, and the extent to which self-efficacy can be moderated by goal setting. Attention self-efficacy is a task-specific confidence in one's ability to accomplish an attention-demanding task, which can help to motivate and regulate behavior to achieve a task goal (Unsworth & Miller, 2024). According to the cognitive-energetic model, self-efficacy plays a role in goal selection, activation, and maintenance. Conative factors like motivation, self-efficacy, goal setting, and temperament are important when considering variation in attention control (Unsworth & Miller, 2024; Unsworth & Robison, 2020). Prior research has indicated that memory self-efficacy predicts memory performance, and these self-efficacy reports can be extended to provide insight into other cognitive processes (e.g., sustained attention; Beaudoin & Desrichard, 2011). Individuals with higher task-specific self-efficacy may be more likely to set higher goals and maintain motivation to meet those goals throughout the task, expend more cognitive effort, persist throughout the task, and therefore display a shallower vigilance decrement. However, there is a unique variance in attention control tasks attributed to self-efficacy after accounting for motivation and self-set goals, so the constructs are distinct, yet related. Unsworth and Miller (2024) examined self-efficacy as it related to performance on attention tasks (i.e., antisaccade, arrow flanker, and PVT) by asking participants to report how confident they were (10%–100%) they would be able to accurately complete 10 trials out of a 100, then 20 trials out of 100, and so on. The overall attention self-efficacy score was the sum of 10 confidence ratings divided by 10 for each task. They found that attention self-efficacy accounted for variation in attention control even after accounting for working memory capacity and processing speed, and proposed motivation and attention self-efficacy influenced performance via participants internally setting higher goals for themselves. We used a similar self-efficacy rating system to investigate how a participant's belief in their ability to achieve goals might relate to goal setting and sustained attention performance: we wanted to see whether the process of striving toward specific goals would have an immediate impact on self-efficacy for the task.

Critically, a majority of the abovementioned studies using goal-setting approaches have employed experimenter-set goals. That is, participants were told what standard to strive toward, rather than being allowed to set their own goals. Importantly, the motivational control theory predicts that less fatigue, and therefore better performance, should be observed under conditions in which people feel a sense of agency or control over their activities. Thus, while the specific goals in those previously described experiments may have produced a greater sense of reward, they might not have affected one's sense of control. So, the present set of studies was designed to evaluate whether a sense of control additively or interactively affected performance when combined with goal setting. In so doing, we hope to test predictions made by the motivational control theory of mental fatigue while using pupillometry to give insight into how arousal changes across the tasks.

Experiment 1

Experiment 1 compared the effects of self-set and experimenter-set goals on performance in a typical version of the PVT. According to Hockey's motivational-control model, we first hypothesized that self-set goals should produce better performance than experimenter-set

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goals because people will feel a sense of agency over their self-set goals (Hypothesis 1.1). However, given there was no incentive to set stringent goals, we also hypothesized that goal standards would decrease across time within the task as people set more easily attainable RT goals (Hypothesis 1.2).

Method

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. All data, materials, and analysis code can be found on the Open Science Framework at https://osf.io/k4pzy/. The study's design and its analysis were not preregistered.

Participants

A sample of 208 participants (64% identified as female, 35% as male, <1% as nonbinary, and 1% did not report; $M_{age} = 20.61$, $SD = 4.58$, range = 17–49) from the human subject pool at the University of Texas at Arlington completed the study in exchange for partial course credit. Participants were assigned to either a self-set ($n = 115$, $M_{age} = 20.65$, $SD = 4.35$) or experimenter-set ($n = 93$, $M_{age} = 20.52$, $SD = 4.78$) goal condition. After exclusions, the self-set condition did not change ($n = 115$) and the experimenter-set condition was $n = 90$. Our target sample size was 100 participants per condition, and we stopped collecting data on the week we achieved that sample size for the self-set condition. We did not achieve the target of 100 participants in the second condition because the academic semester ended and we ceased running the experiment, given we were just shy of the target sample size. After running the self-set condition, we used the average goal levels reported by those participants to administer the experimenter-set condition. In all three experiments, we felt comfortable collecting each condition in temporal order because it has been previously demonstrated that neither cognitive abilities nor task motivation change as a function of time in the semester that data collection takes place (Robison & Unsworth, 2016).

The study was conducted online in Spring 2021, because of the COVID-19-related shutdowns to in-person laboratory research. Participants were directed to a link hosted on Pavlovia.org. The first several screens showed an informed consent document. Participants indicated their consent by proceeding with the task. They then completed the task and were granted credit for their participation.

Task

Participants completed a version of the PVT. Each trial started with a row of zeros (0.000) centered on the screen. Then, after a random period of time, sampled from a uniform distribution ranging from 2 to 10 s in 500-ms increments, the "timer" began counting forward like a stopwatch. The participants' task was to press the spacebar as quickly as possible to stop the timer. When they did so, their RT was shown in milliseconds (e.g., 0.456) for 1 s. If the RT was below the goal threshold, the feedback was shown in green text. If not, it was shown in red text (see goal-setting instructions below). The next trial started after a 500-ms blank intertrial interval (Figure 1).

The trials were divided into five blocks of 25 trials each. After five practice trials, participants in the self-set goal condition were told:

> For the real trials, you will set a goal for yourself before each block. You will type in a number (e.g., 400), and your goal will be to keep your RTs below that number, in milliseconds (e.g., 0.400). You will type in this number at the beginning of each block. There will be 5 blocks, and you will be able to set a new goal for each block. Your new goal can be higher, lower, or the same as the previous block. It is up to you.

At the end of each block, participants were told what percentage of trials they kept their RT below their goal, and then were allowed to set a new goal for the upcoming block. We used the mean goal level for participants in the self-set condition as the goals for participants in the experimenter-set condition. After exclusions (see below), we ended with a sample size of 115 participants in the self-set condition and 90 participants in the experimenter-set condition.

Postexperimental Questionnaire

At the end of the task, participants were asked four questions: (a) How frustrating did you find the task? (b) How bored did you feel during the task? (c) How difficult did you find the task? and (d) How personally meaningful did you find the task? (Westgate & Wilson, 2018). They answered these questions on a 5-point Likert-type scale.

Data Analysis

Data were analyzed in R Version 4.3.1 (R Core Team, 2023) using the tidyverse (Wickham et al., 2019), data.table (Barrett et al., 2024), lmerTest (Kuznetsova et al., 2017), SIMR (Green & MacLeod, 2016), and rstatix (Kassambara, 2023) packages. Plots were generated using ggplot2 (Wickham, 2016) and cowplot (Wilke, 2020).

We used linear mixed-effects models to analyze the dependent variables. In the model, block was entered as a fixed effect centered at zero (−2, −1, 0, 1, 2), and condition was entered as a fixed effect, sum-to-zero effects coded depending on the contrast. Participant was entered as a random effect, and both intercepts and slopes (i.e., effect of block) were allowed to vary across participants. To calculate the effect size (Cohen's d) for the linear mixed models, we used the formula $2 \times t/\sqrt{df}$ for each model component.

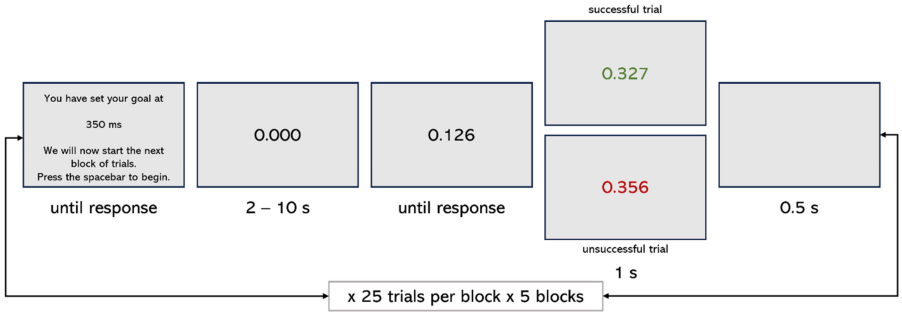
For this experiment, conditions were not randomly assigned because the experimenter-set goal condition was only defined after the initial self-set goal condition was completed, and an a priori power analysis was not conducted before data were collected. To preview results across all three experiments, significant effect sizes were generally greater than ± 0.40, and nonsignificant effect sizes were generally less than ± 0.20. Using a cutoff of ± 0.30 as a moderate effect size, we feel justified that our sample sizes across experiments were large enough to generate power to detect these effects. The goal was to have 100 participants per condition to have a stable estimate of behavioral performance and a standard for goals.

Data Exclusions

We excluded any trials in which participants either (a) pressed the spacebar prior to the timer onsetting, or (b) emitted a RT outside the range of 200 ms (Donders, 1868/1969) to 3,000 ms, which accounted for both the limitations of physiological response and the lack of a response deadline on the task. Then, we excluded any participants who had fewer than 100 analyzable trials.

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Figure 1
Diagram of Task Used in Experiment 1



Note. The figure is for illustrative purposes and is not drawn precisely to scale. See the online article for the color version of this figure.

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For goals, we excluded any self-reported goals that were outside the range of 100 and 1,000 ms, which eliminated 25.74% of goals.[1] This was to accommodate extreme responses due to the free-response nature of the goal-setting question.

Results

RT for each condition are displayed in Table 1. For those in the self-set condition, people were successful with their goals in 73.90% of trials. Our first analysis examined goal standards by time in the self-set condition. The model revealed that self-set RT goals significantly increased across blocks, $b = 16.77$, $SE = 4.54$, $p < .001$, $d = 0.88$, such that people gradually decreased their goal standard across blocks by setting easier goals (Figure 2A). A similar model on RTs by block and condition indicated a significant main effect of block, $b = 23.63$, $SE = 3.36$, $p < .001$, $d = 1.00$, no main effect of condition, $b = 14.05$, $SE = 9.15$, $p = .126$, $d = 0.22$, and no Block × Condition interaction, $b = 4.69$, $SE = 3.36$, $p = .165$, $d = 0.20$ (Figure 2B). Overall, RTs slowed, but this did not differ between the self-set and experimenter-set conditions.

Responses to the postexperimental questionnaires were submitted to independent sample t tests with condition as the between-subjects variable. This analysis yielded no differences across conditions in how frustrating, $t(206) = 0.48$, $p = .63$, Cohen's $d = 0.07$; boring, $t(206) = 1.33$, $p = .19$, $d = 0.19$; difficult, $t(206) = -0.25$, $p = .80$, $d = -0.03$; or meaningful, $t(206) = -1.25$, $p = .21$, $d = -0.18$, they found the task (see Table 2).

Discussion

In Experiment 1, we were primarily interested in how giving participants agency over goal setting would influence performance on the PVT by allowing some participants to set their own goals, while other participants were assigned a goal from the experimenter (which was an average of the self-set goals). We hypothesized, based on the motivational-control model, that those who were in the self-set condition would perform better (have faster RTs) than those who were assigned a goal. We also hypothesized that participants would set easier goals for themselves with time on task. Both conditions showed a slowing of responding with time, replicating the classic vigilance decrement in the PVT. But contrary to Hypothesis 1.1, the self-set condition did not produce either shorter RTs overall, or a shallower decrement across time, compared to the experimenter-set condition. So, goal autonomy did not improve upon performance beyond having a specific goal. However, we found evidence to support Hypothesis 1.2, that those in the self-set condition would give themselves progressively easier goals on each trial block. Finally, we found that those in the self-set condition did not find the task more meaningful, or less frustrating, difficult, or boring than those in the experimenter-set condition. Even though they were given agency in choosing their own goals throughout the task, this was not enough of a motivational boost to increase performance compared to the experimenter-set condition.

Experiment 1 also lacked a control condition: perhaps having a goal, either self-set or experimenter-set, still enhances performance when compared to having no goal at all. We investigated this question in Experiment 2.

Table 1
RTs by Goal Condition in Experiment 1

Condition	*M*	*SD*
Experimenter set	433.07	30.86
Self-set	462.36	146.89
Overall	449.50	132.69

Note. RTs = reaction times.

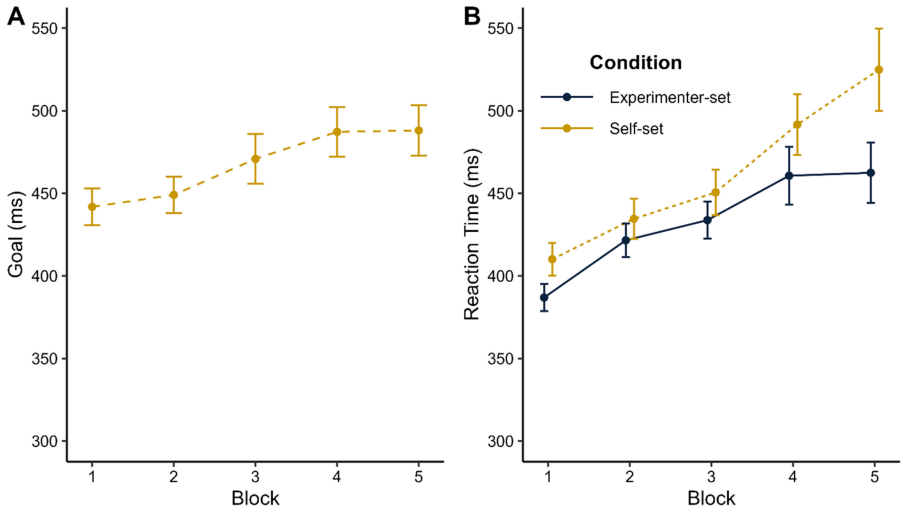
Experiment 2

In Experiment 2, we changed the task paradigm to give it a more intuitive visual structure and perhaps make it more amenable to our manipulations. This new task, which we describe in detail below, kept the same basic structure as the PVT: it was a simple RT task with a variable foreperiod. However, rather than having a timer, it showed a green bar moving horizontally across the screen. Again, the participant's task was to stop this bar from moving as quickly as

[1] While this seems to be a large elimination of goals, 9% of this figure is due to nonnumber responses, as participants either left the entry box blank or typed letters. Another 11% of these goals were excluded because they were less than 100 ms, which is a generous cutoff compared to the physiological limitation of 200 ms. This exclusion did not eliminate these participants from other RT analyses, only analyses concerning goals.

Figure 2

Experiment 1, Dependent Variables



Note. (A) Goals and (B) RTs by block in Experiment 1. Error bars represent standard error. RTs = reaction times. See the online article for the color version of this figure.

possible by pressing the spacebar. The conditions were similar to Experiment 1, but we also included a no-goal condition to provide a baseline comparison. In addition, we included a measure of attentional self-efficacy after the task (Unsworth & Miller, 2024). We asked participants to rate how often they believed they could succeed in performing at various levels of task difficulty. Finally, we had participants complete the task while we measured their pupillary dynamics with an eye tracker. Pupillometry can be used as an indirect measure of attentional effort and arousal. As cognitive effort increases, pupil diameter increases (Beatty & Lucero-Wagoner, 2000; Hess & Polt, 1964; Kahneman, 1973). We hypothesized that pupillary dynamics would lend support to the cognitive-energetic model, providing a corroborating physiological signal for the increased attentional intensity: those who show greater task-evoked pupillary response (TEPR) will have faster RTs and a shallower vigilance decrement.

Hypothesis 2.1 was that the two conditions with goals (self-set and experimenter-set) would perform better than participants in the no-goal condition. Hypothesis 2.2 was that participants in the two goal conditions would self-report greater effort than participants in the no-goal condition. This would provide evidence for the motivational theory of control, but not for resource theory. Hypothesis 2.3 was that, after having and achieving goals, participants in the two goal conditions would self-report greater attentional self-efficacy than participants in the no-goal condition. Finally, Hypothesis 2.4 was that participants in the two goal conditions would exhibit greater pupillary responses, as indicators of effort, than participants in the no-goal condition, which would support the cognitive-energetic model.

Table 2

Responses to Postexperimental Questionnaire in Experiment 1

Question	Condition	
	Experimenter set ($n = 90$), *M* (*SD*)	Self-set ($n = 115$), *M* (*SD*)
Boredom	6.71 (2.16)	6.30 (2.29)
Difficulty	4.08 (2.01)	4.15 (2.10)
Frustration	5.33 (2.37)	5.18 (2.09)
Meaningfulness	2.98 (2.22)	3.37 (2.19)

Method

Participants

A sample of 190 participants (60% identified as female, 38% as male, 1% as nonbinary, and <1% did not report; $M_{age} = 19.97$, $SD = 2.91$, range = 18–47) from the human subjects pool at the University of Texas at Arlington completed the study in exchange for partial course credit. The study was conducted during Spring 2023, in person. Participants in the first phase of the study were randomly assigned to either a self-set ($n = 66$, $M_{age} = 20.16$, $SD = 3.99$) or no-goal ($n = 69$, $M_{age} = 19.79$, $SD = 1.63$) condition. We collected data during the second half of an academic semester, using the end of the semester as our stopping rule for data collection. In the second phase, a new sample of participants completed the task using the average (mean) goals made by participants in the self-set condition, and this served as the experimenter-set condition ($n = 47$, $M_{age} = 20.13$, $SD = 2.66$).

Task

Green Means Go. On each trial, a blank horizontally oriented box appeared on the screen. After a random interval, ranging uniformly from 2 to 8 s in 1-s intervals, a green bar started moving across the box. The participants' task was to press the spacebar as soon as they noticed the change. The bar moved at a rate such that it would fill the box after 1 s. The bar would stop progressing across the screen after 1 s, but the trial did not terminate until a participant pressed the spacebar. There were five practice trials, then five blocks of 25 trials each. In the self-set condition, participants moved a triangular marker to a position on the block rectangle to set their

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goals. Goals could range continuously from 0 to 50 (50 = *furthest point on left*, 0 = *furthest point on right of rectangle*), although these goal values were hidden to participants. In the no-goal condition, there was no such marker. In the experimenter-set condition, this marker was set to be at the average level made by participants in the self-set condition (see Figure 3). Participants in the self-set condition set a new goal prior to each block.

Effort Ratings

At the end of each block, participants were asked to rate their effort level. Specifically, they saw a screen that said, "Please rate your effort level on the previous block of trials." with a 9-point scale (1 = *my lowest possible effort*, 9 = *my maximum possible effort*).

Self-Efficacy Questionnaire

In all three conditions, participants were asked to complete an attentional self-efficacy scale at the end of the task (Unsworth & Miller, 2024). For these questions, the goal marker was placed at a point on the rectangle, and participants were asked to rate the proportion of trials they believe they would be able to stop the green bar from hitting that point on a 10-point scale (0 = *0% of the time*, 1 = *10%*, etc.).

Eye Tracking

Eye data were collected with a Gazepoint GP3 HD eye tracker sampling at 150 Hz. Data were preprocessed using custom-written R scripts. We screened data by first excluding physiologically implausible values for pupil diameter (<1 and >9 mm; Mathôt et al., 2018). Then, we down-sampled the data to 20 Hz by averaging samples within nonoverlapping 50-ms-wide bins. We normalized values within a trial to account for variation across people and trials in pupil diameter. To compute a task-evoked response, we baseline-corrected the values on a trial-by-trial basis by subtracting the mean over a 200-ms window from all subsequent bins. Data from the right eye were used.[2]

Transparency and Openness

See Experiment 1.

Data Analysis

See Experiment 1.

Data Exclusions

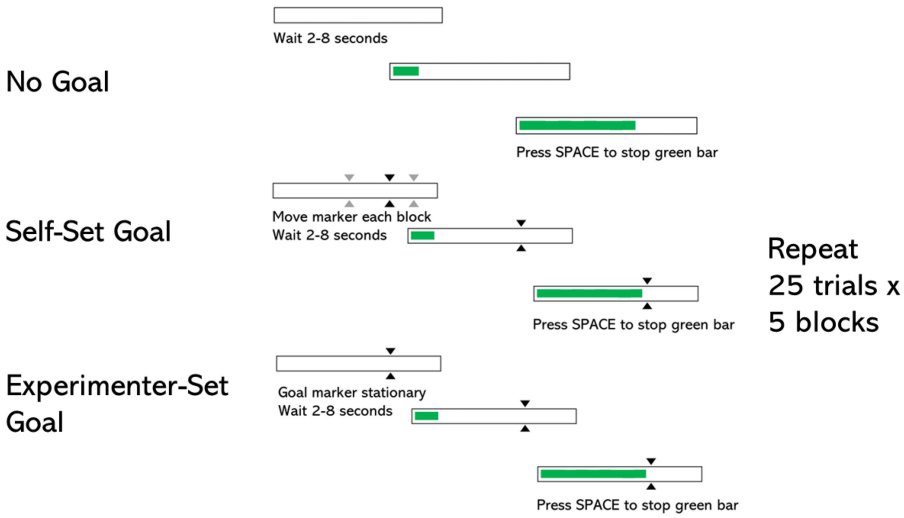
For behavioral data, we excluded extremely short RTs (less than 200 ms) and extremely long RTs (greater than 3,000 ms). For eye analyses, we excluded trials with more than 50% missing or invalid data, and participants who subsequently had more than 50% missing trials. Next, for each variable, we excluded *z*-score values that fell ±3 *SD*s outside the mean at each aggregation step.

Results

RTs for each condition are displayed in Table 3. For those in the self-set condition, people were successful with their goals on 70.04% of trials. In the self-set condition, there was not a main effect of block, $b = -0.42$, $SE = 0.27$, $p = .117$, $d = -0.39$, such that participants were not changing their goals (by making them either

[2] We also computed two pretrial pupil measures: average pretrial pupil diameter (millimeter) and pretrial pupil variability, coefficient of variation = (*SD*/*M*) × 100 (for readability). For brevity, we only report a comparison of grand-averaged task-evoked responses between conditions. For analyses of these dependent measures, see the online supplemental materials.

Figure 3
Green Means Go Task in Experiment 2



Note. The figure is for illustrative purposes and is not drawn precisely to scale. See the online article for the color version of this figure.

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Table 3
RTs by Goal Condition in Experiment 2

Condition	*M*	*SD*
Experimenter set	371.65	30.86
Self-set	370.71	43.49
No goal	394.94	55.02
Overall	380.14	46.83

Note. RTs = reaction times.

harder or easier) across task blocks (Figure 4A). This differed from Experiment 1, where participants gradually made their goals easier.

We collapsed across goal conditions (self-set and experimenter-set) to compare having a goal versus not. We did so by creating a sum-to-zero contrast code (1 = *self-set or experimenter-set*, −1 = *no-goal*) for the effect of condition. This analysis yielded a significant main effect of block on RT, $b = 12.72$, $SE = 1.30$, $p < .001$, $d = 1.46$, a significant main effect of condition, $b = -12.08$, $SE = 3.51$, $p < .001$, $d = -0.51$, and a significant Block × Condition interaction, $b = -3.95$, $SE = 1.30$, $p = .003$, $d = -0.45$. People in either goal condition had faster RTs and had shallower vigilance decrements than people who had no goals. Next, we reparsed the goal conditions to separately evaluate self-set and experimenter-set goal RTs by block. There was a main effect of block, $b = 8.78$, $SE = 1.62$, $p < .001$, $d = 1.03$, but no main effect of condition, $b = -0.45$, $SE = 3.71$, $p = .903$, $d = -0.02$, nor a Block × Condition interaction, $b = -0.03$, $SE = 1.62$, $p = .987$, $d = -0.003$, indicating a time-on-task effect for both goal conditions but no difference in RTs between the two types of goals (self-set or experimenter-set; see Figure 4B).

We performed the same set of models with self-reported effort as the dependent variable. We again collapsed goal conditions (self-set and experimenter-set) and compared them to the no-goal condition, and this revealed a significant main effect of block, $b = -0.11$, $SE = 0.04$, $p = .002$, $d = -0.47$, but no significant main effect of condition, $b = -0.07$, $SE = 0.12$, $p = .55$, $d = -0.09$, and no Block × Condition interaction, $b = -0.02$, $SE = 0.04$, $p = .623$, $d = -0.07$. Therefore, effort decreased over blocks, but goals did not change average effort or effort over time. Among the two goal conditions, there was a significant main effect of block, $b = -0.14$, $SE = 0.05$, $p = .002$, $d = -0.59$, a significant main effect of condition, $b = 0.35$, $SE = 0.15$, $p = .018$, $d = 0.46$, but no Block × Condition interaction, $b = 0.06$, $SE = 0.05$, $p = .191$, $d = 0.25$. So, effort decreased over time for self-set and experimenter-set goals, and effort was generally higher in the self-set condition than the experimenter-set condition (Figure 4C).

Next, we examined self-efficacy (confidence) ratings. First, we compared the two goal conditions to the no-goal condition. Results indicated a main effect of difficulty, $b = -5.46$, $SE = 0.37$, $p < .001$, $d = -2.23$, a main effect of condition, $b = 3.30$, $SE = 1.04$, $p = .002$, $d = 0.47$, and a significant Difficulty × Condition interaction, $b = -2.03$, $SE = 0.37$, $p < .001$, $d = -0.83$, such that self-efficacy ratings were lower on more difficult goals, having a goal led to higher self-efficacy than having no goal, and that this effect was more pronounced on easier goals (Figure 4D). For the self-set and experimenter-set goal conditions, there was a main effect of goal difficulty, $b = -7.50$, $SE = 0.44$, $p < .001$, $d = -3.27$, a main effect of condition, $b = 2.27$, $SE = 1.08$, $p = .038$, $d = 0.40$, and no Difficulty × Condition interaction, $b = 0.08$, $SE = 0.44$, $p = .863$, $d = 0.03$. Thus, people in the self-set goal condition had slightly higher self-efficacy ratings than the experimenter-set condition.

Eye Analyses

Next, we investigated differences in TEPRs, an indicator of attentional intensity, across conditions. Waveforms are presented in Figure 5. We again collapsed across goal conditions in a linear mixed effects model to investigate whether the TEPR magnitude changed with goal condition. There was not a significant difference in TEPR across blocks, $b = -0.01$, $SE = 0.01$, $p = .233$, $d = -0.19$. There was no difference in TEPR magnitude when comparing goal conditions to having no goal, $b = 0.03$, $SE = 0.02$, $p = .069$, $d = 0.29$. There was a significant Block × Condition interaction, $b = -0.01$, $SE = 0.01$, $p = .015$, $d = -0.39$.

We reparsed the conditions to specifically compare the two goal conditions. We found a significant main effect of block on TEPR, $b = -0.02$, $SE = 0.01$, $p = .005$, $d = -0.57$, a significant main effect of condition on TEPR, $b = 0.04$, $SE = 0.02$, $p = .037$, $d = 0.42$, but no significant Block × Condition interaction, $b = -0.01$, $SE = 0.01$, $p = .142$, $d = -0.30$. As can be seen in Figure 5, those who were able to set their own goals had greater TEPRs than those who did not experience agency in their goal selection.

Discussion

Hypothesis 2.1 was supported, in that both goal conditions had faster RTs and showed a shallower vigilance decrement than those with no goal, although this did not differ for the self-set and experimenter-set groups. This corroborates the evidence from Experiment 1 that there was no difference in RTs between self-set and experimenter-set conditions, but the baseline condition, absent from Experiment 1, confirmed that having any type of goal was better for performance than having no goal at all. While effort level decreased with time on task, contrary to Hypothesis 2.2, having any goal (either self-set or experimenter-set) did not persuade participants to self-report greater effort throughout the task than those without goals. However, effort was slightly higher in the self-set goal condition when compared only to the experimenter-set condition, showing that giving one control over goals may still be beneficial to enhancing effort. As expected, attentional self-efficacy ratings were lower on more difficult goals.[3] Additionally, those who had either type of goal displayed greater self-efficacy than those without a goal, particularly for the easier goals, which supported our Hypothesis 2.3. Those who set their own goals also showed elevated self-efficacy when compared to the experimenter-set condition.

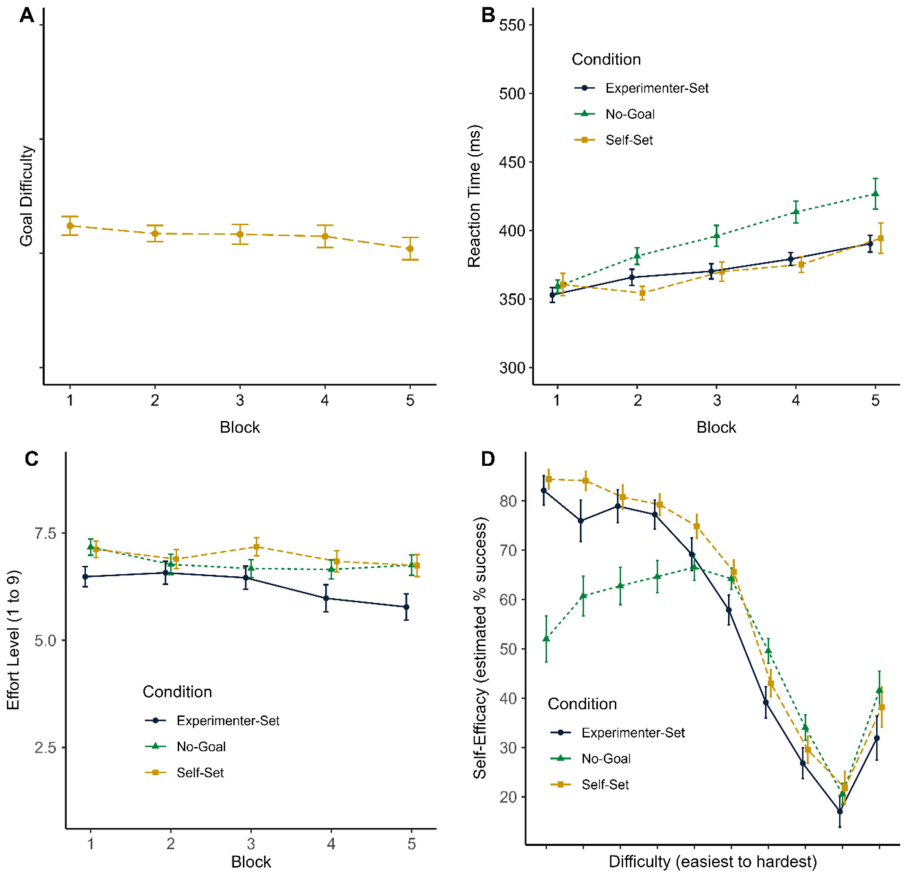
Finally, we hypothesized that having goals, particularly self-set goals, would produce larger TEPRs (Hypothesis 2.4). Our hypothesis was partially supported in that the self-set condition demonstrated greater TEPRs than both the experimenter-set and no-goal conditions, although the experimenter-set condition TEPRs were not

[3] It was unclear to us why there was a "blip" in confidence ratings at the most difficult level. But this was consistent across all three conditions and was observed in both Experiments 2 and 3. The participants were asked to rate confidence sequentially with the difficulty level moving from most difficult to easiest. Therefore, the most difficult question was answered first, and perhaps there was some confusion among participants regarding the question and response scale at first.

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Figure 4

Experiment 2, Dependent Variables



Note. (A) Goal difficulty, (B) RT, (C) effort, and (D) self-efficacy level. Error bars represent standard error. RT = reaction time. See the online article for the color version of this figure.

greater than the no-goal condition. It appeared that letting one set their own goal increased their cognitive effort level, which was reflected by both their TEPRs and effort ratings.

To summarize, behavioral results indicate having either self- or other-set goals is better than having no specific goals, exemplified by faster RTs and shallower vigilance decrements in the two goal conditions. It appears that having a specific goal is more important in mitigating the vigilance decrement than having autonomy over the goal, as the motivational control theory would suggest. However, it is clear that a purely resource-driven account of sustained attention is incomplete, as the goal conditions demonstrated better performance than the no-goal control condition. The self-report and pupillary data partially corroborated this evidence; interestingly, both self-reported effort and TEPRs were greater in the self-set condition compared to the experimenter-set condition, which did not differ in task performance.

Experiment 3

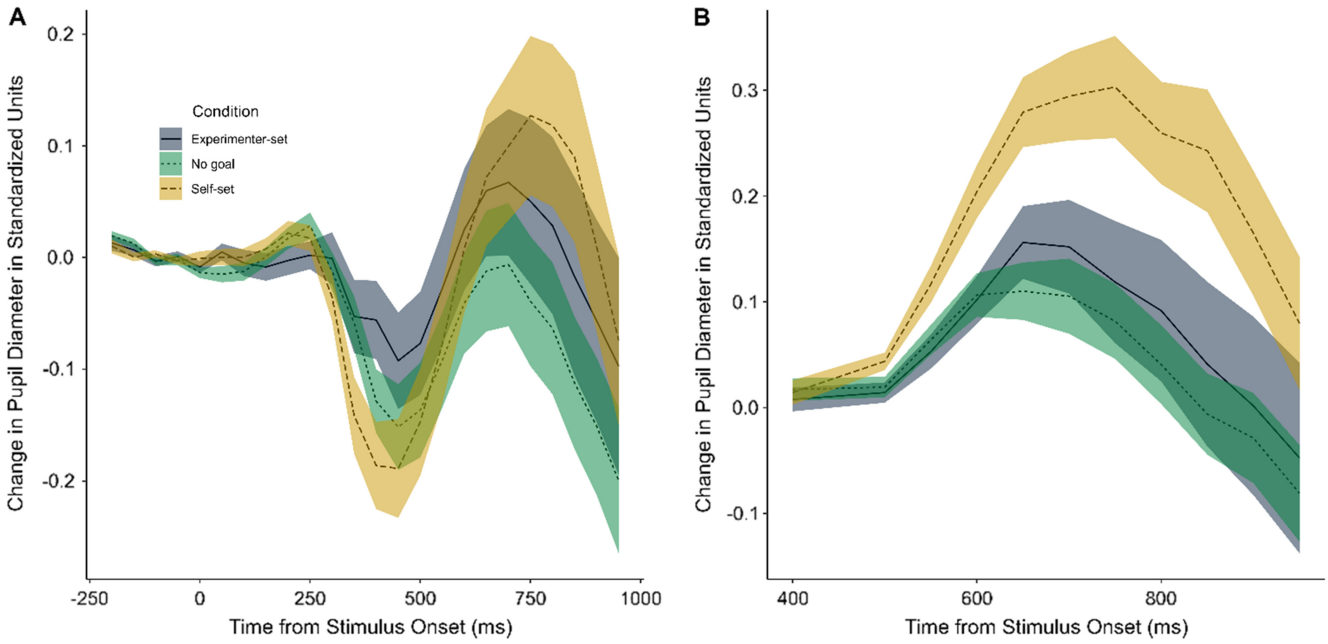
To expound upon how setting goals may influence performance, for the final experiment we nuanced the self-set condition from the previous experiment and introduced a reward component for achieving more difficult goals. Robison and Nguyen (2023) found that giving participants points based on performance drastically reduced the vigilance decrement, as evidenced both by faster RTs and greater pupillary responses compared to those without any reward. Although the points system was immaterial (i.e., the points could not be exchanged for any tangible reward), its affordance indicated that a point system can be a powerful motivator. In Experiment 3, we tested this notion again to determine whether a point system would augment the way people allocate effort and also set more difficult goal standards for themselves. In Experiment 2, there was no incentive to set difficult goals—participants could set the goal marker anywhere they wished (and we found no difference in goal-setting difficulty across blocks). But here, we structured the task such that in one condition success would be rewarded with points. And more importantly, achieving more difficult goals would be rewarded with more points. While all participants set their own goals, some participants also received points according to their success in accomplishing their goals.

We hypothesized that those who received points for successful trials would be motivated to set more difficult goals, which would allow a greater point accumulation for successful trials (Hypothesis 3.1). Hypothesis 3.2 was that those who received points would exhibit faster RTs and a shallower vigilance decrement than those not receiving points for achieving the goals they set.

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Figure 5

Experiment 2, TEPR by Goal Condition



Note. (A) Pupil diameter after stimulus onset and (B) rebaselined pupil diameter after constriction due to stimulus onset to avoid conflating changes in TEPR. TEPR = task-evoked pupillary response. See the online article for the color version of this figure.

We also hypothesized that points would motivate participants to put forth greater effort and report greater self-efficacy (Hypothesis 3.3). For pupillary measures, we hypothesized that participants who received points would utilize greater cognitive effort and thus exhibit greater TEPRs (Hypothesis 3.4).

Method

Participants

We collected data during the first half of an academic term and stopped collecting data when we had reached a sample of 150 participants (75 per condition). After exclusions, a sample of 144 participants (74% identified as female, 22% as male, 1% as nonbinary, and 3% did not report; $M_{age} = 19.08$, $SD = 2.20$, range = 17–32) from the human subjects pool at the University of Texas at Arlington completed the study in exchange for partial course credit. The data were collected in person in Fall 2023. Participants were randomly assigned to either a no-points ($n = 71$, $M_{age} = 19.22$, $SD = 2.50$) or points ($n = 73$, $M_{age} = 18.95$, $SD = 1.79$) condition. Participants first completed an informed consent document and a brief demographics questionnaire before beginning the task.

Task

Green Means Go. The task appeared the same as Experiment 2, with a green bar that filled a horizontal rectangle after an interval from 2 to 8 s in 1-s intervals. All participants moved the goal marker, similar to the self-set condition of Experiment 2. Participants selected goals that ranged continuously from 0 to 50 (50 = *furthest point on left*, 0 = *furthest point on right of rectangle*). Only those in the points condition were rewarded with points corresponding to the goal value, such that harder goals were rewarded with more points. When setting their goal, participants in the points condition were told the point value associated with their goal marker position as they moved it around. The goal values were hidden to those in the no-points condition. Points were displayed at the end of each trial, so participants were aware of the rewarded points. Participants in the no-points condition were just instructed to meet their goal. For each trial, the participants' task was to press the space bar as quickly as possible after noticing the onset of the green bar. There were five practice trials, then five blocks of 25 trials each. Goals were set prior to each block (see Figure 6).

Effort Ratings

See the Experiment 2 section.

Self-Efficacy Questionnaire

See the Experiment 2 section.

Eye Tracking

See the Experiment 2 section.

Transparency and Openness

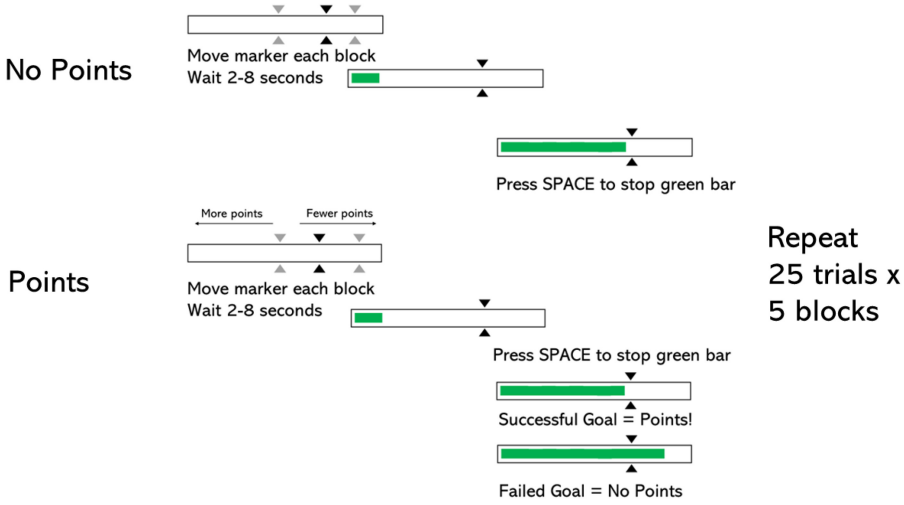
See the Experiment 1 section.

Data Analysis

See the Experiment 1 section.

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Figure 6
Green Means Go Task for Experiment 3



Note. The figure is for illustrative purposes and is not drawn precisely to scale. See the online article for the color version of this figure.

Data Exclusions

See the Experiment 2 section.

Results

RTs for all conditions are presented in Table 4. People were successful with their goals on 67.03% of trials. There was a significant main effect of condition on self-set goal difficulty, $b = 2.02$, $SE = 0.42$, $p < .001$, $d = 0.81$, such that participants in the points condition set more difficult goals than the no-points condition. But there was not a significant main effect of block on self-set goal difficulty, $b = -0.28$, $SE = 0.17$, $p = .095$, $d = -0.28$, and no significant Block × Condition interaction, $b = 0.19$, $SE = 0.17$, $p = .257$, $d = 0.19$. People in the points condition set more difficult goals than those who did not receive points, and this did not change as a function of time, which was consistent with our hypothesis (see Figure 7A).

There was a significant main effect of block on RTs, $b = 7.23$, $SE = 1.53$, $p < .001$, $d = 0.79$, a significant main effect of condition, $b = -8.39$, $SE = 4.08$, $p = .043$, $d = -0.34$, but no significant Block × Condition interaction, $b = 2.99$, $SE = 1.53$, $p = .053$, $d = 0.33$. RTs increased with time on task, but those in the points condition had faster RTs overall (Figure 7B). In general, the points condition performed better than the no-points condition, but vigilance decrements were small in both conditions, especially compared to the no-goal condition in Experiment 2.

Table 4
RTs by Point Condition in Experiment 3

Condition	*M*	*SD*
Points	361.02	45.53
No points	377.75	51.80
Overall	369.50	49.36

Note. RTs = reaction times.

There was no main effect of block on self-reported effort level, $b = -0.02$, $SE = 0.05$, $p = .56$, $d = -0.10$, no main effect of condition, $b = -0.08$, $SE = 0.10$, $p = .452$, $d = -0.13$, and no Block × Condition interaction, $b = -0.01$, $SE = 0.05$, $p = .854$, $d = -0.03$. Effort level did not differ over time or in the points and no-points conditions (Figure 7C).

There was a significant main effect of difficulty on self-efficacy, $b = -6.55$, $SE = 0.39$, $p < .001$, $d = -2.92$, but no main effect of condition, $b = 0.31$, $SE = 1.00$, $p = .760$, $d = 0.05$, and no Difficulty × Condition interaction, $b = -0.28$, $SE = 0.39$, $p = .470$, $d = -0.13$. People had less self-efficacy on more difficult goals (Figure 7D), but this did not differ across conditions.

Eye Analyses

A *t* test compared the magnitude of TEPRs between conditions. There was not a significant difference, $t(100) = 0.80$, 95% confidence interval (CI) [−0.06, 0.14], $p = .428$, $d = 0.16$. Contrary to our hypothesis, having points did not influence the magnitude of the TEPR (Figure 8).

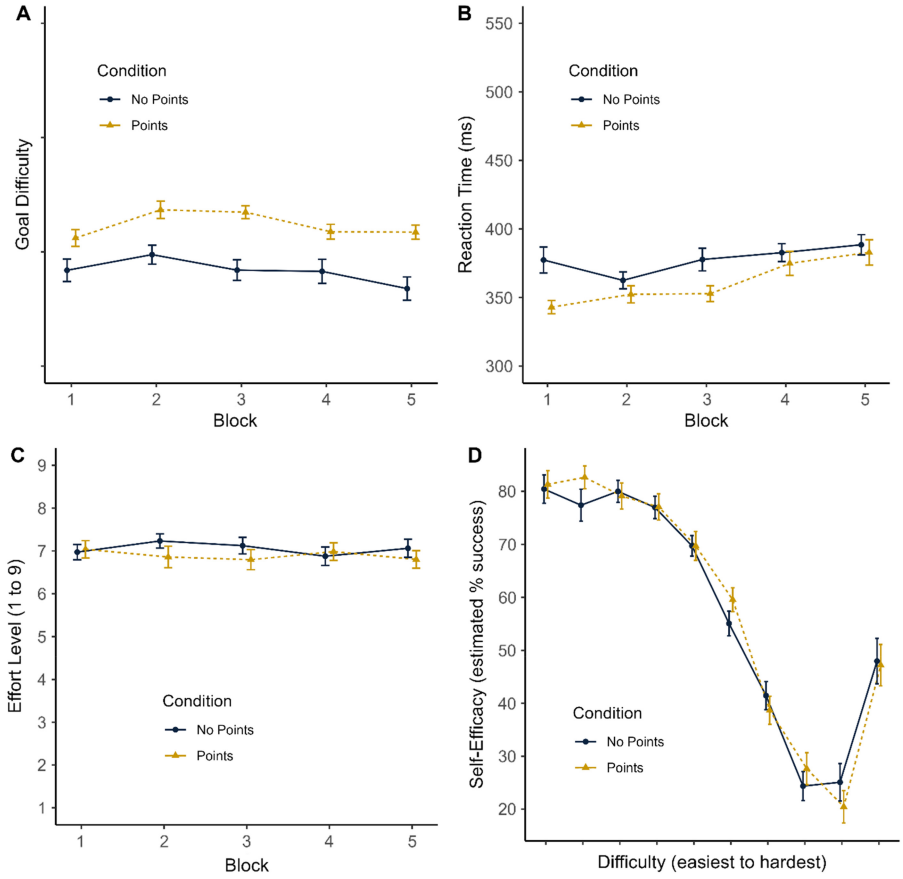
Discussion

In Experiment 3, all participants were allowed to set their own goals, and half received points for completing successful trials according to those goals. Additionally, point rewards were tied to goal difficulty, such that more difficult goals were rewarded with higher points. Our Hypothesis 3.1 was supported that points encouraged people to set more difficult goals for themselves. We found that while both conditions displayed a similar vigilance decrement, those who received points were faster to respond throughout the task (Hypothesis 3.2). Points were a strong motivator for people to sustain attention and maximize performance, but receiving points did not further mitigate the vigilance decrement, which was already small due to setting goals (see Experiment 2). Contrary to our Hypothesis 3.3, people in the points condition did not self-report

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Figure 7

Experiment 3, Dependent Variables



Note. (A) Goal difficulty, (B) RT, (C) effort, and (D) self-efficacy. Error bars represent standard error. RT = reaction time. See the online article for the color version of this figure.

more effort on the task, nor report higher self-efficacy than those in the no-points condition. Finally, contrary to Hypothesis 3.4, the magnitude of TEPRs did not differ across conditions.

General Discussion

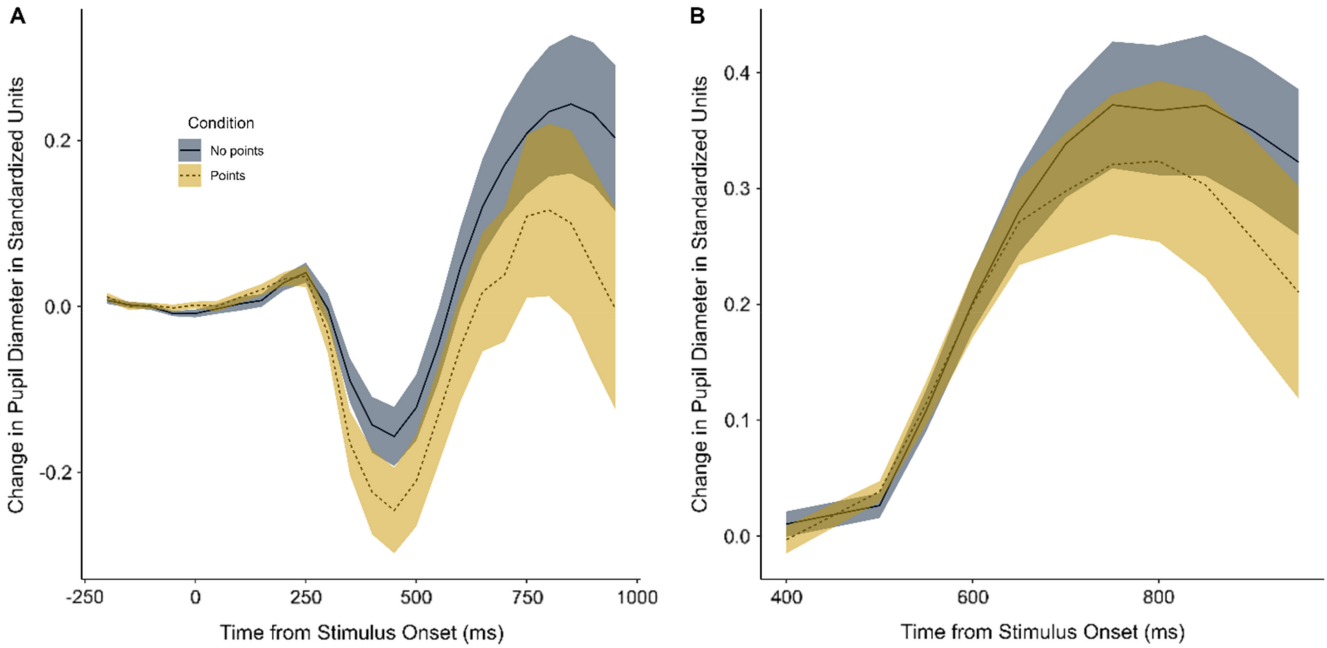
In the present set of experiments, we investigated how setting goals and receiving points influenced performance and effort in a simple RT sustained attention task. Currently, there are several explanations as to why performance declines with time on task: (a) cognitive resources may be depleted in a localized brain area that is responsible for accomplishing the task and is only recuperated after a rest (resource depletion; Brzezicka et al., 2013; Warm et al., 2008), (b) people experience mental fatigue when they are not motivated to perform well on a task or lack control (motivational-control; G. R. J. Hockey, 2011), and (c) both bodily arousal levels and goal monitoring through a feedback loop determine the ability to sustain attention (cognitive-energetics; Unsworth & Robison, 2020), among other theories that nuance these concepts. We expected to find that beyond goal setting, having autonomy over the task through setting one's own goals would mitigate the vigilance decrement even further than having a specific goal.

Our data did not support a purely cognitive-resource account of the vigilance decrement: while resource theory suggests that expenditure of cognitive resources fully explains the decline in performance over time and does not incorporate task motivation or other factors in improving performance (only rest or replenishment), we found that goal setting improved sustained attention performance compared to those who had no goal. This finding has already been demonstrated widely in the literature (Robison et al., 2021; Strayer et al., 2023). According to resource theorists, without rest, it should not be possible to mitigate time-on-task effects, and resources should be depleted at an equal rate regardless of whether one has a specific goal in mind or not. That is, resource-depletion theorists argue that effortful exertion over time is the process by which resources are depleted. Therefore, assuming participants with specific goals give equal (or greater) effort compared to those without a goal, resources should be depleted at least as rapidly as those without specific goals, which would result in the same or larger vigilance decrement than those without a specific goal. This is different from both motivational control and cognitive energetic theories, because according to these theories, giving greater effort toward the task (through motivation and goal monitoring) will result in a shallower vigilance decrement, which is what our data suggested.

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Figure 8

Experiment 3, TEPR by Point Condition



Note. (A) TEPR after stimulus onset; (B) rebaselined pupil diameter after constriction due to stimulus onset to avoid conflating changes in TEPR. TEPR = task-evoked pupillary response. See the online article for the color version of this figure.

We hoped to test the motivational theory of control by incorporating autonomy and control over these goals to enhance performance, which previous research has not demonstrated. We hypothesized that adding autonomy to achieving goals would improve performance beyond the simple presence of a specific goal, as the motivational control theory suggests (G. R. J. Hockey, 2011). However, in Experiments 1 and 2, we did not find any difference in the vigilance decrement between those who set their own goals and those who had specific goals assigned by the experimenter. So, there was partial support for the motivational control theory, in that having a goal elevated performance over not having a goal, perhaps by increasing motivation to complete the task through the intrinsic reward of achieving a goal; but, letting the participants have control over their goals did not further improve performance. In Experiment 3 we leveraged points as an extrinsic reward for achieving a self-set goal, but again, the presence of points did not reduce the vigilance decrement compared to those who did not receive points. Instead, those with points set more difficult goals for themselves and had faster RTs overall than those who did not receive points for achieving their self-set goal. Taken together, it appears that having a specific goal is an important motivator for achieving steadier performance in sustained attention, and when adding autonomy or a point reward on top of that, additional effects on mitigating the vigilance decrement are not significant.

While we did not find much difference in RT performance when participants were allowed to choose their own goal compared to an assigned goal, they showed greater pupillary responses in those conditions in Experiment 2. So, according to the cognitive-energetic model (Unsworth & Robison, 2020), the autonomy gained from setting one's own goal influenced the system monitor's adjustment of the intensity of attention, and this increase in arousal resulted in faster RTs on average due to the control center acting on the activated goal. There was no difference between the vigilance decrements between those who set their own goal and those who were assigned a goal. Again, it's possible that the presence of a specific goal presented a ceiling for any changes in the slope of the vigilance decrement even though the intensity of attention (and thereby mean RT) still had flexibility to fluctuate.

Overall, our findings suggest that having a self-set or assigned specific goal is about equally beneficial to enhancing sustained attention performance when compared to having no goal. This has implications for accomplishing a variety of sustained attention tasks outside the laboratory. Suppose a music student is practicing an instrument for an extended amount of time. If there's no specific goal for how long the student should continue practicing, the ability to pay attention will suffer. But, if the parent set a timer for 20 min (e.g., an assigned specific goal), performance declines will be less steep than having no goal, and about the same as if the student decided for themselves to practice for 20 min (e.g., a self-set goal). Similarly, if one has a specific goal of writing an abstract by 3 p.m., either designated by oneself or the online submission portal, directing focused work toward the abstract within the deadline goal ("I need to submit this abstract by 3 P.M.") will be better for productivity and attention than a generic goal ("I need to submit this abstract"). Consider also how some employers use a performance-based system to incentivize productivity, where accumulated points are redeemable for rewards (e.g., extra vacation days, company merchandise, monetary bonuses). These points, when used in combination with specific goals, may encourage people to set more difficult goals for themselves when compared to receiving no incentive for setting difficult goals.

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It is important to note that neither setting goals nor receiving points for performance completely mitigated the vigilance decrement. Clearly, time-on-task performance declines in a sustained attention task are not avoidable simply by asking participants to abide by an experimenter-set goal, nor by asking participants to set their own goal, even when goal success is rewarded with points. Thus, vigilance is stressful, hard work that results in cognitive fatigue (Warm et al., 2008). However, the vigilance decrement in goal-present conditions was much shallower than the decrement in conditions where no goal or incentive was present, which indicates that the level of fatigue-related slowness can be manipulated through someone's motivation to complete the task. Our research lends some support the motivational control theory, in that having a goal motivated people to have faster RTs than having no goal (although the subjective effort ratings show that people did not necessarily feel they were exhibiting greater effort). However, our finding that it did not matter whether the goals were self-set or experimenter-set to enhance sustained attention performance was at odds with the central role of agency/control within Hockey's theory (2011). So, within this framework, having a specific goal was more influential on performance and motivation than the power of choice within the task.

Another goal of this research was to investigate self-efficacy, performance, and tendency to set difficult goals. We hypothesized that those in the self-set goal condition would report greater self-efficacy after completing the task, because the autonomy experienced in that group would provide a boost in confidence that those in the experimenter-self goal or no-goal condition lacked (Unsworth & Miller, 2024). We found that those who had no goals reported less self-efficacy after the task than those who had specific goals, and this was particularly true at lower task difficulty. So, it was not the autonomy that provided a boost in confidence, but rather the presence of a specific goal. There are two possibilities for why this effect emerged. First, it is possible that the process of seeing oneself achieve any specific goal (either self-set or experimenter-set) lead to a greater sense of belief in one's own capabilities. Second, it is possible that the visual feedback associated with the goal marker on the Green Means Go task allowed for a better metacognitive calibration of one's ability to meet the goal standard. Regardless, these findings indicate that self-efficacy is manipulable with goal setting.

Limitations and Future Directions

In these experiments, we were interested in how autonomy, goals, and incentives would influence performance on sustained attention. We tested the motivational control theory and cognitive energetic theories, both of which cite motivation as a key tenant in regulating and maintaining goals. However, we did not include a motivation questionnaire of any type in our research, and so conclusions about whether goals increase motivation to perform well were derived indirectly through performance measures, without supporting data from specifically asking whether the participants felt motivated in each condition.

In all three experiments, participants received feedback and had knowledge of their goal success. In Experiment 1, the milliseconds displayed when the spacebar was pressed turned green in the goal was met, and in Experiments 2 and 3, participants could tell visually if the green bar stopped before or after the arrow goal marker. This feedback could have impacted motivation, besides the simple presence of a goal. Specifically, the knowledge of achieving the goal may have motivated participants to perform well, not just the knowledge that a specific goal existed.

Another limitation of this series of experiments is that in Experiment 3, there was not a no-goal condition that received points to tease apart the influence of having a goal versus gaining points on performance. Instead, all participants set their own goals and the only difference between condition was the point reward for achieving their set goal. This is because we were more interested in investigating how people adjust their goal-setting tendencies when given the opportunity to receive points for accomplishing goals, rather than determining the influence of a point system on performance. A points/no goal condition could be achieved through utilizing a condition that tied RT in milliseconds to a point scale, rather than relying on achievement of a goal to give points. Therefore, there is some uncertainty on how the point incentives incorporated in Experiment 3 may separately sway sustained attention and reduce the vigilance decrement without the presence of goals. Others have already contributed to the question of how points effect sustained attention behavior outside goal setting and compared to goal setting (e.g., Massar et al., 2016; Robison & Nguyen, 2023). While our research indicated that points encouraged people to set more difficult goals, we could not determine the isolated influence of points on the vigilance decrement.

Constraints on Generality

As the results are restricted to an undergraduate, majority female sample, the findings of this article may be limited in generalizability to broader populations (i.e., aging and less educated/lower socioeconomic status). While people outside this sample may vary in their sustained attention abilities, we presume that the mechanisms behind motivation through goal-setting remain largely the same as we found in the present experiments. Furthermore, our hypotheses were tested within a narrow range of laboratory-based tasks (i.e., simple RT paradigm), and may not generalize to other more complex ecological settings where there are multiple simultaneous influences on sustained attention.

Conclusion

Across three simple RT experiments, we investigated how control over goal setting could possibly improve performance in sustained attention. We sought to test hypotheses regarding why it is so difficult to maintain attention for extended time periods: is it because people are physically unable, or because they are unwilling? We found support for the motivational theory of control, in that those who had goals generally performed better and displayed shallower vigilance decrements than those who had no goal. However, contrary to our hypotheses, having control over those goals did not improve further on performance. We also found some support for the cognitive-energetic model, in that those who set their own goals displayed higher TEPRs than those who were assigned goals or had no goal. Adding points on top of self-set goals did not significantly alter performance, but it did motivate participants to set more difficult goals for themselves. Overall, setting specific goals can be a helpful tool for performance when striving to sustain attention, but it does not matter if one is striving toward a goal set before them by someone else, compared to having autonomy over those goals.

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Received June 28, 2024
Revision received January 24, 2025
Accepted March 6, 2025 ■

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