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ORIGINAL PAPER

The influence of performance incentives on the subjective experience of mental effort

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Abstract

How do performance incentives impact subjective experiences of mental effort? Incentives may offset the costs of effort expenditure, resulting in reduced feelings of effort. Or they could lead to an increase in effort expenditure and a corresponding increase in feelings of effort. We tested the influence of incentives on experiences of effort, fatigue, and affect in a series of four experiments ($N = 894$). Participants completed a mentally challenging task (an n-back task) under conditions of a monetary incentive for good performance or no incentive, manipulated in both within-subjects and between-subjects experimental designs. Results revealed that incentives increased feelings of mental effort, especially in within-subjects designs. Incentives also increased pleasant affect and reduced fatigue, especially in between-subjects designs. One implication of these findings is that incentives for good performance increase mental effort and task engagement without increasing aversive affective states.

Keywords Mental effort · Incentives · Subjective experiences · Motivation

The subjective experience of mental effort is a familiar sensation. Imagine poring over a textbook in preparation for a difficult exam, straining to keep your attention focused on the text to learn the material. This type of mental activity, like other acts of executive control, requires mental effort because it involves the allocation of limited cognitive resources (Botvinick et al., 2001; Posner & DiGirolamo, 1998; Shiffrin & Schneider, 1977).

Mental effort is often construed as a resource to be spent, allocated, or invested, which implies a cost associated with exerting effort. Characteristics of mental effort include strain or tension, a feeling of mental workload, and generally unpleasant subjective experience (Dewey, 1897; Inzlicht et al., 2015; Kurzban, 2016). Indeed, people avoid mentally effortful tasks when given the choice and require greater rewards to perform more effortful tasks (Apps et al., 2015; Irons & Leber, 2016; Kool et al., 2010; McGuire & Botvinick, 2010; Westbrook et al., 2013). Thus, mental effort can be characterized as a costly endeavor that, all else being equal, a person would rather avoid (Fiske & Taylor, 1984).

The present research tested the effects of motivational incentives on subjective experiences of mental effort. At a conceptual level, we distinguish between objective effort expenditure, as revealed by physiological indicators such as cardiovascular reactivity and pupil dilation (Brem & Self, 1989; Gendolla et al., 2012; Richter et al., 2016; van der Wel & Van Steenbergen, 2018), and subjective feelings of effort, which pertain to a person's conscious awareness or perceptions of effort. We considered two possibilities for the effects of incentives on subjective feelings of mental effort. On the one hand, performance incentives may reduce the costs associated with effort expenditure and thus reduce subjective experiences of effort. On the other hand, incentives may lead to an increase in effort expenditure and a corresponding increase in subjective experiences of effort. Below we review research and theory lending credence to

Three of the four experiments were preregistered online: Experiment 1: https://osf.io/apn2f; Experiment 2: https://osf.io/hvtfr; Experiment 4: https://osf.io/k9xv7. The data and analysis code for all experiments are available to view here: https://osf.io/ctrjp/.

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those opposing predictions and report four experiments testing them.

When do feelings of mental effort arise?

Cognitively demanding tasks feel more effortful than easier tasks (e.g., Apps et al., 2015; Fairclough & Ewing, 2017). For instance, participants in one study responded to geometric shapes under different instructions and reported how much effort they experienced (Robinson & Morsella, 2014). Sustaining attention toward the shapes felt more effortful than assessing the shapes on specific features (e.g., "Which shape has more corners?"), and assessing the shapes felt more effortful than randomly choosing a shape. The more thoughtful and attention-demanding tasks thus felt more effortful than the simpler, more mindless tasks. Performing mentally demanding tasks for extended periods of time also evokes feelings of mental effort, particularly as participants become fatigued and greater effort is required to maintain performance (e.g., Boksem et al., 2005; Healy et al., 2004; Hopstaken et al., 2016; Kato et al., 2009; Lorist et al., 2000).

Feelings of effort thus appear to increase with increasing task demand. This notion is consistent with motivational intensity theory, which states that individuals mobilize effort to achieve a certain level of task performance (as defined by task difficulty), provided that they believe performance is attainable and are motivated to exert effort (Gendolla et al., 2012; Richter et al., 2016). However, research on motivational intensity theory quantifies effort expenditure using objective physiological measurements such as cardiovascular activity, so the relevance of motivational intensity theory for understanding subjective experiences of effort is unknown.

Subjective feelings of effort may diverge from objective indicators of effort expenditure. For example, recent research in the domains of both physical and mental activity has found that subjective feelings of effort do not stem directly from physiological effort output (Bijleveld, 2018; Marcora, 2009). Although intuition may suggest that feelings of effort stem from afferent signals to the brain from the body (e.g., heart rate, muscle tension), the link between physiological measures and subjective effort is not directly causal. Both outcomes are influenced by similar factors, such as task demands and time on task, and physiological and subjective measures of effort may be positively correlated in some circumstances, but objective effort expenditure does not appear to be the sole cause of subjective feelings of effort.

The current research tested the effects of motivational incentives on subjective experiences of mental effort. Motivational incentives are designed to (and usually succeed at) increasing objective effort expenditure (e.g., Eubanks et al., 2002; Massar et al., 2016; Richter & Gendolla, 2009). Commonplace incentives for motivating effort include rewards such as money or praise and threats such as disapproval or punishment. Motivational incentives tend to increase task engagement and improve performance, even after mental fatigue has already taken root (e.g., Boksem et al., 2006; Garner et al., 2023; Hopstaken et al., 2016; Locke & Braver, 2008; Massar et al., 2016; Muraven & Slessareva, 2003). For instance, participants in one study performed a working memory task for two hours, by which point fatigue had set in and performance had declined. Then participants attempted one more block of the task under the expectation that their performance would determine the duration of the task: If they performed well, then the last block would end within 5 min, but if they performed poorly the task would continue for up to 40 more minutes. With this strong motivational incentive at stake, participants showed signs of reengaging with the task: Self-reported fatigue decreased, task engagement and performance improved, and physiological measures of effort and attention increased relative to before the incentive manipulation (Hopstaken et al., 2015). Although extant research has observed that motivational incentives can increase objective effort expenditure, it is unclear how incentives influence subjective experiences of effort. We elaborate on two possibilities below.

Possible effects of incentives on subject feelings of effort

Whereas the performance-boosting effects of incentives are well established, the influence of incentives on subjective feelings of effort remains relatively untested. This is a consequential oversight because subjective feelings of effort may influence whether a person decides to continue working on difficult tasks, withhold effort, or give up entirely.

One straightforward possibility is that incentives increase both the objective effort allocated to a task, consistent with motivational intensity theory (Brehm & Self, 1989; Gendolla & Wright, 2005; Gendolla et al., 2012; Locke & Braver, 2008; Massar et al., 2016; Richter et al., 2016), as well as subjective feelings of effort. Some evidence supports this view. For example, in one study participants completed easy, difficult, or almost impossible versions of an *n*-back task under both incentive and no incentive conditions (Fairclough & Ewing, 2017). Physiological markers of effort investment were highest during the hard (but possible) task compared to both the easy task and the extremely hard (almost impossible) task. Those same markers were also higher in the incentive condition relative to the no incentive condition. Self-reports of subjective workload also increased linearly from the easy task to the hard task to the extremely hard task and were higher in the incentive condition. These results suggested that feelings of mental effort mirror more objective signs of effort investment, increasing under both task demand and incentives.

Alternatively, incentives may reduce feelings of effort. Some theorists have proposed that sensations of effort and fatigue arise from mental computations of the relative costs and benefits of expending mental effort (Boksem & Tops, 2008; Hockey, 2011; van der Linden, 2011). According to the opportunity cost model, feelings of effort arise from an assessment of the relative opportunity cost of investing mental effort in one activity compared to the next-best alternative (Kurzban et al., 2013). Performing a task should feel more effortful to the extent that another, more valuable activity exists that one could devote mental effort to, because a person can only devote mental effort to one activity at a time (provided that the activity is cognitively demanding). Returning to the studying example, concentrating on a textbook should feel more effortful in the presence of a more desirable alternative opportunity (e.g., a smartphone). But a performance incentive would increase the desirability of investing effort into a task and thereby reduce the opportunity costs. It follows that a performance incentive (compared to no incentive) would reduce subjective feelings of effort.

Related experiences of fatigue and affect We have focused so far on the subjective experience of mental effort, but similar theoretical perspectives apply for mental fatigue. Mental fatigue is related to but distinct from mental effort, insofar as fatigue can be construed as a consequence of expending effort for prolonged periods of time. Several theorists have suggested that mental fatigue also reflects a cost-benefit assessment, such that fatigue arises when the costs of investing effort outweigh the potential rewards (Boksem & Tops, 2008; Wang et al., 2022). In other words, as individuals decide whether to invest effort into a task, they weigh the potential benefits of expending the effort against the inherent costs of effort investment. Feelings of fatigue may represent a subjective signal that the costs outweigh the benefits. So, for instance, if the cost of focusing one's mental efforts on studying became too great, then it would be worthwhile to pause and take a break. In this view, fatigue serves an adaptive function by signaling a need to stop what one is doing and to pursue something else, particularly something more rewarding or less demanding (see also Hockey, 2011; Inzlicht et al., 2014; van der Linden, 2011). Presumably, if the relative rewards from effort investment were greater—perhaps a good score on the exam will boost one's final grade, or perhaps performing well will yield monetary gains—then feelings of fatigue would be lower.

The experience of mental effort has also been likened to an affective state—typically an aversive one (e.g., Inzlicht et al., 2015; Inzlicht et al., 2018; Kurzban, 2016; Shenhav et al., 2017). We thus tracked participants' affective states in the current studies to understand affective responses both to the mental effort manipulations and to motivational incentives. We expected affective states to grow more negative with increasing effort expenditure. But, consistent with the two perspectives reviewed above, opposing predictions were possible and plausible for the effect of incentives on affect. If incentives increase effort expenditure, then they may also increase negative affect. But by reducing opportunity costs and increasing the value of the task, incentives may decrease negative affect. We also explored the extent to which feelings of mental effort relate to fatigue and affect, respectively.

In summary, subjective experiences of effort, fatigue, and affect may be influenced by manipulations to increase the motivation to expend mental effort, although the direction of influence remains to be seen. Understanding the factors that impact subjective feelings of mental effort is important because individuals may use their feelings as cues to continue with what they are doing or to stop and do something else (Boksem & Tops, 2008; Clore et al., 2001; Inzlicht et al., 2014; Kurzban et al., 2013; van der Linden, 2011). Manipulations that influence feelings of mental effort and fatigue may thus be helpful for understanding how to promote goal pursuits that require effort, such as studying for a test or learning a new language.

A note on study design How the incentives are manipulated may influence how they affect subjective experience. For instance, in a between-subjects experimental design participants remain unaware of the condition to which they were not assigned. Thus, participants in the incentive condition perform an otherwise tedious mental task for a potential monetary reward, which may make the work seem somewhat worthwhile. But participants in the no incentive condition simply perform the tedious work because the experimenter asked them to do it (as is common in many past experiments).

But in a within-subjects design participants perform the task under both conditions, which enables an intrapersonal comparison between them; contrast effects may ensue. Furthermore, in within-subjects designs the order of the incentive manipulation may matter. Performing the task for a performance incentive and then having the incentive removed could cause feelings of disappointment or frustration (i.e., an unpleasant surprise), whereas performing a task without an incentive at stake and then being offered an incentive for good performance could cause feelings of relief or excitement (i.e., a pleasant surprise). To provide a fuller picture of the effects of incentives on subjective experiences of mental effort, in the present research we manipulated the presence of performance incentives using both between-subjects and within-subjects experimental designs, and in the within-subjects designs we used a fixed order in one study and a counterbalanced order in another. In this way we could assess whether context and order mattered for subjective experiences. (They usually did.)

The current research

The current experiments tested the hypothesis that performance incentives influence the subjective experience of mental effort (and related feelings). Participants completed a mentally challenging task used frequently in research on effort and cognitive control (i.e., an *n*-back task) under conditions of a monetary incentive for good performance or no incentive. Performance incentives should increase the relative value of the mental task and the motivation to perform well. But this change could either increase or decrease subjective feelings of effort, as outlined above. On the one hand, participants may try harder under an incentive and that may correspond to increased feelings of effort. On the other hand, incentives may offset the cost of effort expenditure, resulting in reduced feelings of effort. The same predictions applied to feelings of mental fatigue and to affect. We tested these competing ideas in a series of 4 experiments, using both between-subjects and within-subjects designs, which we then combined for a mini meta-analysis. The data and analysis code for all experiments are available online (https://osf.io/ctrjp/).

Experiment 1

Method

Participants and design

This experiment used a 3 (Task Difficulty: easy, moderate, hard) × 3 (Incentive: none, reward, punishment) factorial design, with both factors manipulated within-subjects. We preregistered our intent to collect data from 100 participants, which afforded 80% power to detect small-to-medium effects ($d = 0.28$ or $\eta^2 = 0.008$; see Hopstaken et al., 2016; Robinson & Morsella, 2014). One hundred five students participated in an experiment purported to examine personality and cognitive performance. Following preregistered criteria we excluded three participants from analyses for falling below 3 *SD* from the sample mean on one of the dependent measures (i.e., accuracy), leaving a final sample of 102 students (81% women, age $M = 19.14$, $SD = 1.20$). Additionally, one participant did not complete the punishment blocks due to computer failure, but we retained the participant's remaining data in the analyses reported below. Our methods, hypotheses, and analysis plan were preregistered online prior to data analysis (https://osf.io/apn2f).[1]

Materials

Task difficulty manipulation (*n*-back task) We adapted the *n*-back task from Ragland et al. (2002) and Jaeggi et al. (2010) and administered the task using Inquisit 5 (www.millisecond.com). Participants saw a random sequence of uppercase consonant letter stimuli presented one at a time for 500 ms in the center of the computer screen, with an inter-stimulus interval of 2000 ms. Participants were instructed to press the "A" key if the current letter matched a letter occurring a specified number of trials back (i.e., targets) and otherwise to press the "L" key (i.e., non-targets).

The *n*-back task had three difficulty levels: easy (1-back), moderate (2-back), and hard (3-back). For the easy task, target letters matched the letter one trial back (e.g., the second "W" in sequence *B*, *W*, *W*). For the moderate task, target letters matched the letter two trials back (e.g., the second "W" in sequence *W*, *C*, *W*). For the hard task, target letters matched the letter three trials back (e.g., the second "W" in sequence *W*, *C*, *K*, *W*). Participants completed three blocks of each level of *n*-back under each incentive condition for a total of 9 blocks. Each block consisted of 78 trials, including 26 targets (33%) and 52 non-targets (67%).

Incentive manipulation Participants began the task with 300 points and were told that points would be converted to cash at the end of the experiment. A running point total appeared at the top of the screen throughout the task. In the *reward condition* participants gained a point for every correct response (hits, correct rejections) and received nothing for incorrect responses (misses, false alarms). In the *punishment condition* participants lost a point for every incorrect response and received nothing for correct responses. In the *no incentive condition* participants neither gained nor lost points.

Question probes Throughout the *n*-back task questions appeared at random intervals to assess participants' subjective experiences. Specifically, participants were asked, "How much effort were you just expending?" (1 = *none* to 9 = *a great deal*), "How much mental fatigue are you experiencing right now?" (1 = *none* to 9 = *a great deal*), and "How

[1] We also considered the possibility that individual differences in behavioral activation system (BAS) and behavioral inhibition system (BIS) sensitivity may influence subjective experiences under performance incentives but found little evidence to support these predictions. Analyses including individual difference variables can be found in the supplemental online materials (SOM).

do you currently feel?" (1 = *very unpleasant* to 9 = *very pleasant*). To assess attention toward the current task, we probed for mind wandering by asking, "What were you just thinking about?" (0 = *the task*, 1 = *something unrelated to the task*).[2] Question probes appeared randomly in the *n*-back task only during the latter half of trials in each block. The three subjective effort questions were always presented consecutively, in random order, and the mind wandering question was presented on its own. Following the question probes participants were instructed to begin the *n*-back letter sequence "fresh;" that is, they did not have to remember letters presented prior to the questions.

Procedure

Participants completed the experiment individually. After providing informed consent, they completed demographic questionnaires and began the *n*-back task with a set of instructions and 9 practice trials per each *n*-level. Participants could repeat the practice trials if they did not understand the task.

The first three blocks of the *n*-back task were always no incentive blocks, followed by either reward blocks or punishment blocks (counterbalanced). Within each incentive block, participants completed each level of *n*-back (1-, 2-, 3-back) in a random order. Following the first set of no incentive blocks, participants were informed that they would now gain or lose points based on their performance and that their points would be converted to cash at the end of the experiment. Prior to each block participants saw instructions indicating the incentive (e.g., "In these next trials you will WIN points for every correct trial!").

In total, with three no incentive blocks, three reward blocks, and three punishment blocks, participants could earn a minimum of 66 points and a maximum of 534 points. The entire experiment lasted about 1 h, and at the end of the experiment participants received a cash payout ($1–$5) corresponding to the total number of points they earned. Participants earned an average of 465 points (*SD* = 43.59) and $4.32 (*SD* = 0.86).

Participants also completed two personality questionnaires in counterbalanced order during the experiment: the need for cognition scale (Cacioppo et al., 1984) and the behavioral inhibition/behavioral activation system (BIS/BAS) sensitivity scales (Carver & White, 1994). Participants completed one of these questionnaires between the reward and punishment blocks of the *n*-back task and the other after the final *n*-back block.

[2] Mind wandering results are not of central interest to the present study and will not be reported here.

Results

We analyzed the data both with and without the inclusion of outliers, in line with our preregistered plan. Results remained unchanged with outliers included.

Subjective experiences

We conducted 3 (Task Difficulty: easy, moderate, hard) × 3 (Incentive: none, reward, punishment) repeated-measures ANOVAs on in-task self-reports of effort, fatigue, and affect, respectively. When the assumption of sphericity was violated we applied the Greenhouse-Geisser correction. Table S1 in the supplemental online materials (SOM) includes the *M*s and *SD*s for each subjective experience and performance measure as a function of task difficulty and incentive conditions.[3] Figure 1 depicts self-reported effort, fatigue, and affect as a function of *n*-back difficulty and incentive condition.

Subjective effort was influenced by the incentive manipulation, F (1.89, 186.72) = 5.98, $p = .004$, $\eta_p^2 = 0.057$. Participants reported expending more effort in the reward and punishment conditions compared to the no incentive condition, *p*s < 0.009, *d*s = 0.24–0.29, and subjective effort did not differ between reward and punishment conditions, $p = .584$, $d = 0.08$. We also found the expected main effect of task difficulty, F (1.39, 137.67) = 30.01, $p < .001$, $\eta_p^2 = 0.233$, with subjective effort highest during the difficult version of the task, followed by the moderate version, and lowest in the easy version (all comparisons significant, *p*s < 0.039, *d*s = 0.22–0.69).

Further, incentive condition and task difficulty interacted to influence effort, F (3.66, 361.80) = 4.08, $p = .004$, $\eta_p^2 = 0.040$. We had anticipated that incentive condition would have bigger effects as task difficulty increased, but follow-up tests revealed that only for the easy task was subjective effort higher in the incentive conditions (reward and punishment) compared to the no incentive condition, *p*s < 0.001, *d*s = 0.36–0.37. The effect of incentives on the subjective experience of effort was smaller and non-significant for both the moderate task (*p*s > 0.057, *d*s = 0.12–0.19) and the hard task (*p*s > 0.448, *d*s = 0.03–0.04). See Fig. 1.

Subjective fatigue was also influenced by the incentive manipulation, F (1.86, 185.81) = 20.47, $p < .001$, $\eta_p^2 = 0.170$. Participants experienced the most fatigue in the punishment condition compared to both the reward condition, $p = .029$, $d = 0.21$, and no incentive condition, $p < .001$, $d = 0.62$, and greater fatigue in the reward condition compared to no incentive condition, $p < .001$, $d = 0.39$. And, as

[3] We preregistered that we would also analyze the primary results using multilevel modeling. Those results are reported in the SOM and found results consistent with the analyses reported here.

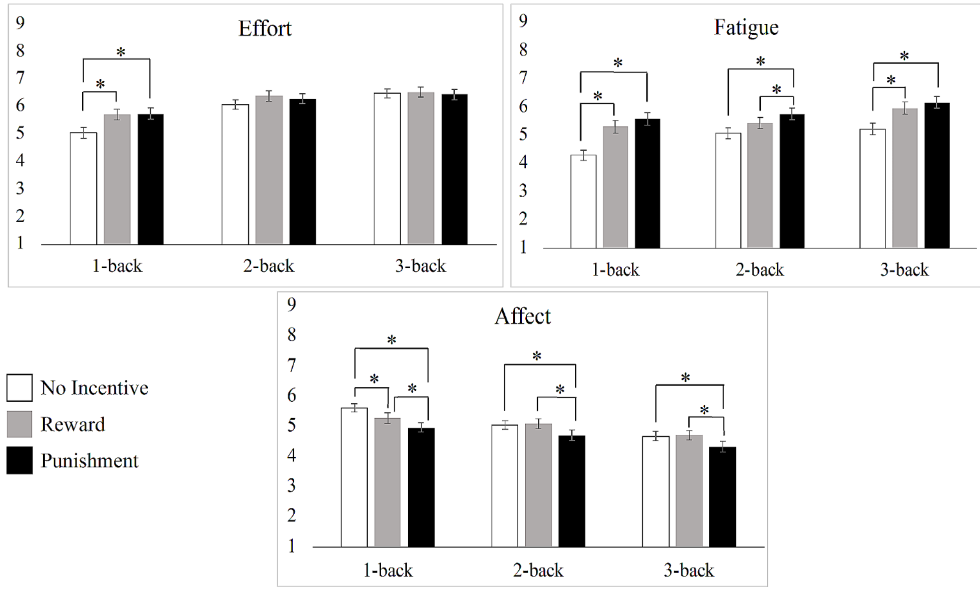

Fig. 1 Feelings of mental effort, fatigue, and affect as a function of n-back difficulty and incentive in Experiment 1. *Note* Error bars represent the standard errors. *denotes significant incentive condition differences

expected, fatigue was highest in the hard task condition, followed by the moderate task, and lowest in the easy task, F (1.68, 168.14) = 26.86, $p < .001$, $\eta_p^2 = 0.212$, and all pairwise comparisons were significant, ps < 0.003, ds = 0.29–0.64. Lastly, the main effects were qualified by an Incentive × Task Difficulty interaction, F (3.65, 364.88) = 4.70, $p = .002$, $\eta_p^2 = 0.045$.

Follow-up tests revealed that fatigue was highest in the punishment condition compared to the no incentive condition across all levels of n-back difficulty, ps < 0.001, ds = 0.35–0.70, and higher in the reward condition compared to no incentive in all levels except for the 2-back, ps < 0.070, ds = 0.18–0.49. Fatigue was generally higher in the punishment versus reward condition, but mostly for the moderately difficult version of the task, $p = .039$, $d = 0.21$, and less so for the easy and hard tasks, ps < 0.173, ds = 0.13–0.14. See Fig. 1.

Regarding affective valence, here again the incentive manipulation had a significant effect, F (2, 200) = 9.50, $p < .001$, $\eta_p^2 = 0.087$. Participants reported the most pleasant affect in the reward and no incentive conditions compared to the punishment condition, ps ≤ 0.001, ds = 0.35–0.43. Pleasant affect did not differ between the reward and no incentive conditions, $p = .477$, $d = 0.078$. Task difficulty also influenced affect, with the most pleasant affect reported during the easy task, followed by the moderate task, and the least pleasant affect during the hard task (all comparisons were significant, ps ≤ 0.001, ds = 0.36–0.55), as indicated by the predicted main effect of task difficulty, F (1.61, 160.93) = 22.54, $p < .001$, $\eta_p^2 = 0.177$. The Task Difficulty × Incentive interaction was non-significant, F (3.50, 350.30) = 1.73, $p = .150$, $\eta_p^2 = 0.017$, ds = 0.02–0.46. See Fig. 1.

Performance

Because performance was not the central focus of the present investigation, full results pertaining to accuracy and RT can be found in the SOM. Briefly, performance was influenced by task difficulty and incentives in predicted ways. RTs increased linearly from the easy to the moderate to the hard versions of the n-back (all comparisons significant, ps < .001, ds = 0.41–1.21), and RTs were faster in the reward and punishment conditions compared to the no incentive condition, ps < .001, ds = 0.55–0.63. Accuracy, quantified as sensitivity (d') using hits and false alarms, was highest on the easy task, followed by the moderate task, and lowest on the hard task (all comparisons were significant, ps < 0.001, ds = 1.1–2.2), and accuracy was highest in the punishment condition followed by the reward condition, and lowest in the no incentive condition (all comparisons significant, ps ≤ 0.001, ds = 0.35–0.70.

Within-person correlations

We explored the within-person correlations among measures using the R package 'rmcorr' (Bakdash & Marusich, 2017). See Table 1. Across the whole sample all correlations were significant with ps < 0.001. Self-reported effort was positively correlated with fatigue, r_{rm} (803) = 0.39, but negatively correlated with pleasant affect, r_{rm} (803) = − 0.17. Self-reported fatigue was negatively correlated with pleasant affect, r_{rm} (804) = − 0.44.

We also explored whether effort and fatigue differentially related to self-reported affect. Both variables have been likened to an affective state but few prior studies have explicitly related them to self-reported affect. We tested the difference

Table 1 Within-person correlations among measures

	Fatigue	Affect
Across Whole Sample		
	Fatigue	Affect
Effort	0.394***	−0.170***
Fatigue		−0.444***
During Incentive (Reward and Punish) Blocks		
	Fatigue	Affect
Effort	0.280***	−0.068
Fatigue		−0.433***
During No Incentive Blocks		
	Fatigue	Affect
Effort	0.579***	−0.376***
Fatigue		−0.532***

Note Significance levels denoted, $*p < .05$, $**p < .01$, $***p < .001$

between the two correlations with a Z test (Hoerger, 2013; Steiger, 1980) and found that affect was more strongly correlated with fatigue than with effort, $Z = 2.67$, $p = .008$.

We next explored whether the correlations among the self-report variables differed as a function of incentive condition (Table 1). Effort was more strongly associated with affect, r_{rm} (200) = −0.38, $p < .001$, and with fatigue, r_{rm} (200) = 0.58, $p < .001$, in the no incentive condition compared to associations between effort and affect, r_{rm} (501) = −0.07, $p = .125$, and effort and fatigue, r_{rm} (501) = 0.28, $p < .001$, in the incentive conditions (combined reward and punishment), $Zs > 3.27$, $ps < 0.021$. The correlation between fatigue and affect did not differ as a function of incentive condition, $p = .363$.

Discussion

Experiment 1 found that performance incentives increase feelings of effort and fatigue and decrease pleasant affect, compared to performing the same tasks for no incentive. We directly manipulated task value by offering monetary incentives for good performance in some blocks, thereby increasing the benefit of effort investment. According to an opportunity cost perspective, this shift in the cost/benefit tradeoff should have reduced feelings of effort and fatigue. Instead, incentives increased feelings of effort and fatigue and reduced pleasant affect. It appeared that participants tried harder under the incentive, as suggested by improved performance, which corresponded to increases in subjective feelings of effort as well.

Both rewards and punishments for performance increased feelings of fatigue, but punishments had stronger effects. Furthermore, punishment reduced pleasant affect but reward did not increase it compared to the no incentive condition. It may be that the punishments were more potent than the rewards, so future experiments should strive to equate the hedonic value of different incentives. Further, incentives increased feelings of effort especially on the easiest version of the cognitive task. This pattern suggested that feelings of effort during more difficult tasks may be less amenable to change by incentives—at least by the incentives available in the current study. Altogether these findings suggest that feelings of effort and fatigue are not due to task difficulty alone; incentives also matter.

We also explored the correlations among the measures in Experiment 1 and those results painted a slightly different picture. Across the entire sample, self-reported affect related both to effort and to fatigue, but the link to fatigue was stronger. But these relationships differed as a function of experimental condition. Specifically, the presence of performance incentives weakened the links from effort to fatigue and negative affect, which suggests that expending effort is less taxing and less unpleasant with an incentive on the line. This pattern is potentially consistent with the opportunity cost perspective. We sought to replicate these exploratory correlational findings in the subsequent studies.

One limitation of Experiment 1 concerns the order in which the incentives were offered. Participants always completed the no incentive condition first because we wanted that condition to serve as a neutral baseline to compare against the incentive conditions. However, completing the incentive blocks only after the no incentive block may have had unintended consequences. For instance, incentives may have increased feelings of effort at least in part because participants recognized that they tried harder to succeed when an incentive was versus was not on the line (i.e., a contrast effect). It remains to be seen whether incentives increase feelings of effort even when participants do not experience performing the task for no incentive. Further, participants may have grown more fatigued later in the study, independent of task difficulty (i.e., a task order confound). We therefore used a between-subjects manipulation of the incentive variable to minimize any possible contrast or order effects in Experiment 2.

Experiment 2

In Experiment 2 we tested the extent to which a monetary incentive influences feelings of effort, fatigue, and negative affect during the n-back task using a between-subjects design, which eliminated the possibility for within-subject contrast effects and task order confounds.

Method

Participants and design

We intended to collect data from 250 participants, which would afford 80% power to detect a between-subjects effect size of $d = 0.36$ or greater. Due to constraints on time and resources, we collected as much data as possible during the semester and ended with 215 participants in the study. Following preregistered criteria we excluded from analyses five participants who scored more than 3 *SD*s from the sample mean on one of the dependent measures, leaving a final sample of 210 (age $M = 19.13$, $SD = 0.96$; 71.4% women), which afforded 80% power to detect an effect size of $d = 0.39$. Task difficulty was manipulated within-subjects and incentive condition was manipulated between-subjects. The experiment thus featured a 3 (Task Difficulty: easy, moderate, hard) × 2 (Incentive vs. No Incentive) mixed factorial design. The method, hypotheses, and analysis plan were preregistered online prior to data analysis (https://osf.io/hvtfr).

Materials

Task difficulty manipulation (*n*-back task) We used the same *n*-back task as Experiment 1, administered using Inquisit 5 (www.millisecond.com). Participants completed two blocks of each difficulty level (1-back, 2-back, and 3-back), for six blocks total, in a random order.

Incentive manipulation As in Experiment 1, a point counter appeared at the top of the computer screen during the task. This time, participants gained one point for every correct response and lost one point for every incorrect response throughout the entire task (rather than having winning/reward blocks separate from losing/punishment blocks). In the *incentive condition* ($n = 105$), participants were told that their points would be converted to cash at the end of the experiment and that they could win up to $5 if they performed well. Furthermore, they were reminded about the monetary incentive at the start of each experimental block. Participants in the *no incentive condition* ($n = 105$) were told nothing about cash and therefore had no explicit incentive to earn points.

Question probes Throughout the *n*-back task questions appeared at random intervals to assess participants' subjective experiences. Specifically, participants were asked, "How much effort were you just expending?" (1 = *none* to 9 = *a great deal*), "How much mental fatigue are you experiencing right now?" (1 = *none* to 9 = *a great deal*), and "How do you currently feel?" (1 = *very unpleasant* to 9 = *very pleasant*). These question probes appeared at a random point once per block, with the only stipulation that question probes appeared only during the latter half of trials in each block. The three subjective effort questions were always presented consecutively in random order. We also probed mind wandering once per block (separately from the subjective experience questions) with the item, "What were you just thinking about?" (0 = *the task*, 1 = *something unrelated to the task*); mind wandering results are not reported here and available upon request.

Procedure

Participants completed the experiment individually. After providing informed consent, they completed demographic questionnaires and began the *n*-back task with 9 practice trials at each *n*-level. For the experimental task, participants were assigned at random to the incentive condition or the no incentive condition and completed each difficulty level (1-, 2-, 3-back) twice in a random order for a total of 6 blocks. The *n*-back task lasted approximately 24 min. After the *n*-back task participants completed two personality questionnaires in counterbalanced order: the need for cognition scale (Cacioppo et al., 1984) and the BIS/BAS scales (Carver & White, 1994). At the end of the experiment all participants were given $3 and debriefed.

Results

We first conducted a 3 (Task Difficulty: easy, moderate, hard) × 2 (Incentive: no incentive vs. incentive) mixed ANOVA on subjective experience measures and task performance. This analysis collapsed across block order, which was counterbalanced to minimize order effects. Nonetheless, to account for block order we also constructed a multilevel model as outlined in the online preregistration. The results did not change when outliers were included in the analysis, which we tested following our preregistered plan. Whenever the assumption of sphericity was violated, we applied the Greenhouse-Geisser correction.

Subjective experiences

Descriptive statistics for the subjective experiences and performance can be found in Table S3 in the SOM. Figure 2 depicts self-reported effort, fatigue, and affect as a function of *n*-back difficulty and incentive condition.

The main effect of incentive condition on the subjective experience of effort was non-significant, $F\ (1, 208) = 0.78$, $p = .379$, $d = 0.12$, such that feelings of effort were similar in the incentive condition versus the no incentive condition. Task difficulty influenced subjective feelings of effort, $F\ (1.62, 336.74) = 40.26$, $p < .001$, $\eta_p^2 = 0.162$, with the lowest

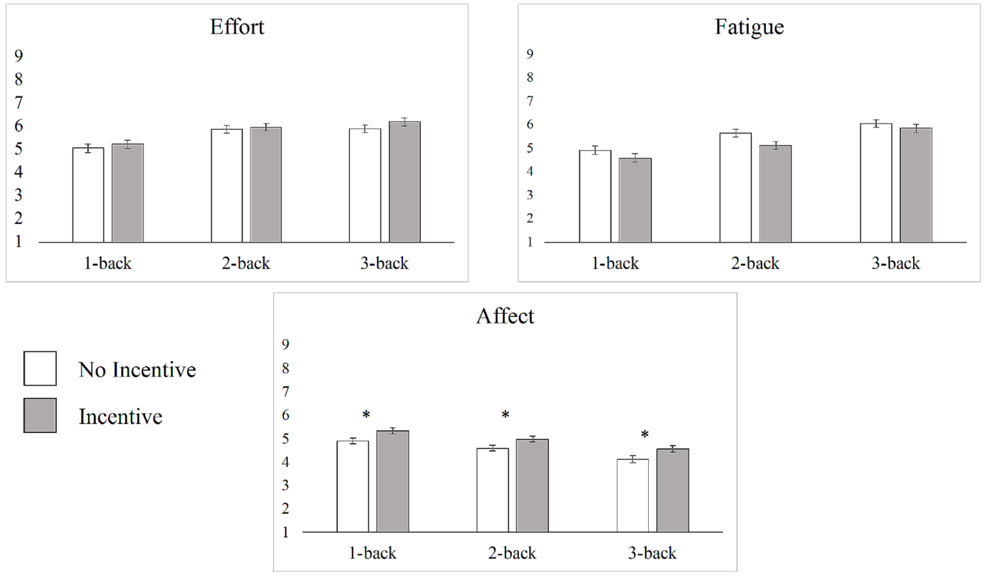

Fig. 2 Feelings of mental effort, fatigue, and affect as a function of n-back difficulty and incentive condition in Experiment 2. *Note* Error bars represent standard errors. *denotes significant incentive condition differences

effort reported during the easy *n*-back task compared to both the moderate and difficult versions, ps < 0.001, ds = 0.47–0.52, but the difference between the moderate and difficult levels was not statistically significant, $p = .135$. The interaction between incentive and difficulty was non-significant, F (2, 416) = 0.47, $p = .625$, $\eta_p^2 = 0.002$.

The main effect of incentive condition on feelings of fatigue was also non-significant, F (1, 208) = 2.85, $p = .093$, $d = 0.23$. Task difficulty did influence feelings of fatigue, F (1.77, 367.95) = 66.27, $p < .001$, $\eta_p^2 = 0.242$, such that fatigue increased linearly from the easy level to the moderate level to the difficult level, and all comparisons were significant, $p < .001$, ds = 0.43–0.68. Incentive condition did not interact with task difficulty to influence feelings of fatigue, F (2, 416) = 1.24, $p = .292$, $\eta_p^2 = 0.006$.

The incentive manipulation exerted a main effect on self-reported affect, F (1, 208) = 6.63, $p = .011$, $d = 0.36$, with participants reporting more pleasant affect in the incentive condition versus the no incentive condition. Self-reported affect was also impacted by task difficulty, F (1.76, 365.85) = 56.54, $p < .001$, $\eta_p^2 = 0.211$, with affect becoming less pleasant as the task increased from easy to moderate to difficult; all comparisons were significant, ps < 0.001, ds = 0.32–0.63. The interaction between incentive and difficulty was non-significant, F (2, 416) = 0.06, $p = .946$, $\eta_p^2 < 0.001$.

Multilevel model with block order

We constructed multilevel models (MLM) with subjective experiences across the six blocks nested within participants. We tested the effects of incentive (1 = incentive, -1 = no incentive), block (participant-centered), and difficulty level (effect-coded; E1 = 1-back (1), 2-back (-1), 3-back (0); E2 = 1-back (0), 2-back (-1), 3-back (1)), and all two-way and three-way interactions, on the subjective experiences. We included a random intercept and a random slope for block, and an unstructured covariance matrix.

Regarding effort, we observed main effects of difficulty in the expected direction (i.e., higher effort with higher *n*-back loads), |Bs| > 0.35, ps < 0.001, but no other effects were significant, ps > 0.133. Regarding fatigue, we also observed main effects for difficulty in the expected direction, |Bs| > 0.56, ps < 0.001. We also observed a main effect of incentive, B = -0.33, SE = 0.10, t (246.92) = -3.38, $p = .001$, with participants reporting less fatigue in the incentive condition compared to the no incentive condition, and a main effect of block, B = 0.24, SE = 0.03, t (210.19) = 8.01, $p < .001$, such that fatigue increased across blocks. No other interactions were significant, ps > 0.099.

Regarding affect, we observed a main effect of difficulty in the expected direction (e.g., less pleasant affect with higher n-back loads), |Bs| > 0.38, ps < 0.001, a main effect of block, B = -0.09, SE = 0.02, t (205.94) = -4.34, $p < .001$, such that affect became more unpleasant across blocks, and a main effect of incentive, B = 0.19, SE = 0.08, t (263.94) = 2.40, $p = .017$, with participants reporting more pleasant under the incentive. In summary, the results from the MLM largely corroborated the ANOVA findings, except that the main effect of incentive on fatigue was statistically significant when accounting for task block structure.

Performance

As expected, RTs increased and accuracy decreased as the task increased in difficulty from the 1-back to the 2-back to the 3-back (all comparisons were statistically significant, ps < 0.001). Incentive condition interacted with task difficulty on RTs such that RTs were slower under the incentive compared to no incentive, but only during the most difficult version of the task (3-back). The incentive manipulation did not impact accuracy.

Within-person correlations

We again tested the within-person correlations among measures (see Table 2). Across the whole sample, all correlations were significant with ps < 0.001. Similar to Study 1, the correlation between fatigue and affect, r_{rm} (1049) = − 0.44, was stronger than the correlation between effort and affect, r_{rm} (1049) = − 0.15, $Z = 3.98$, $p < .001$. However, unlike Study 1, none of the correlations differed between the incentive and no incentive conditions, ps > 0.148.

Discussion

In Experiment 2 we manipulated the incentive for performance as a between-subjects variable to eliminate the possibility of within-subjects contrast effects and task-order confounds. When collapsing across block order in the ANOVA, the effect of incentive on effort and fatigue was non-significant, but affective state was more pleasant in the incentive condition. When accounting for block order with MLM, incentives reduced fatigue, and the effects on effort and affect remained the same. Thus, the presence (versus absence) of a performance incentive reduced feelings of fatigue and increased pleasant affect relative to no incentive.

The within-person correlations observed in Experiment 2 were somewhat consistent with Experiment 1. We again observed that affective state correlated more strongly with fatigue than with effort. Unlike Experiment 1, however, the correlations among measures did not differ between the incentive and no incentive conditions.

The results from Experiment 2 are consistent with an opportunity cost perspective, insofar as the presence of an incentive seemed to reduce subjective costs of expending mental effort by increasing positive affect and reducing fatigue. These results stand in contrast to Experiment 1, wherein an incentive for good performance increased fatigue and reduced pleasant affect.

Table 2 Within-person correlations among measures

	Fatigue	Affect
Across Whole Sample		
	Fatigue	Affect
Effort	0.344***	− 0.149***
Fatigue		− 0.444***
Within the Incentive Condition ($n = 105$)		
	Fatigue	Affect
Effort	0.315***	− 0.053
Fatigue		− 0.378***
Within the No Incentive Condition ($n = 105$)		
	Fatigue	Affect
Effort	0.346***	− 0.250***
Fatigue		− 0.520***

Note Significance levels denoted, *$p < .05$, **$p < .01$, ***$p < .001$

Experiment 3

We had several goals for Experiment 3. First, we wanted to conduct another experiment with a between-subjects manipulation of incentives because the results from Experiment 2 were not conclusive and differed from the results from Experiment 1. Second, we wanted to simplify the study design, so we included only a single level of difficulty on the *n*-back task: Participants completed the 2-back (moderate) task for the duration of the experiment. Third, we attempted to amplify the experience of effort and fatigue by extending the duration of the task. Last, we increased the number of subjective experience items for participants to respond to and used the NASA Task Load Index (NASA-TLX), a well-validated measure of subjective workload (Hart & Staveland, 1988).[4]

We hypothesized an effect of time such that performance and positive affect would decrease whereas feelings of effort and fatigue would increase over time. Predictions for the effect of incentive were more tentative. The results from Experiment 1 suggested that an incentive enhances performance and also increase subjective feelings of effort, fatigue, and unpleasant affect. Simply put, with a financial incentive on the line, participants may try harder, perform better, and report more aversive effort-related subjective experiences. Yet, in Experiment 2 the presence of a performance incentive increased pleasant affect and reduced fatigue, suggesting that the incentive reduced effort-related costs. We put the effects of incentives on subjective experiences to the test again in Experiment 3.

Method

Participants and design

Two hundred forty-one undergraduate students participated in the study in exchange for credit toward a course requirement (Age $M = 18.93$, $SD = 1.41$; 55.2% women). We collected as much data as we could prior to the end of the Spring 2020 semester and stopped early because of the COVID-19 pandemic. This final sample size afforded

[4] Experiment 3 was not preregistered online but was part of the lead author's doctoral dissertation. The hypotheses, method, and analysis plan were formally proposed prior to data collection.

approximately 80% power to detect a medium between-subjects effect of $d = 0.36$. This experimental featured a 2 (Incentive vs. No Incentive) × 10 (Time) mixed-factorial design with incentive as a between-subjects variable and time a within-subjects variable.

Materials

Task difficulty manipulation (*n*-back task) Participants completed a moderately difficult version of the *n*-back task, the 2-back, administered using Inquisit 5 (www.millisecond.com). The task proceeded as in Experiments 1 and 2. Participants completed 12 blocks total. Each block consisted of 78 trials, including 26 targets (33%) and 52 non-targets (67%). Each block lasted approximately 4 min.

Incentive manipulation Participants completed the first two blocks without any incentive. After the second block, the incentive manipulation was introduced. Specifically, participants assigned at random to the *incentive condition* ($n = 123$) learned they would receive money for their performance on the rest of the task and they could win up to $5 if they performed well. Participants assigned to the *no incentive condition* ($n = 118$) were told nothing about money. Thus, for the first two blocks of the task the two conditions were identical, but for blocks 3–12 the incentive condition included a monetary reward whereas the no incentive condition did not. In contrast to Experiments 1 and 2, we did not include a visible point counter in either condition.

Question probes Throughout the *n*-back task questions appeared at random intervals to assess participants' subjective experiences. We borrowed questions from the NASA-TLX as a measure of subjective workload (Hart & Staveland, 1988). Specifically, participants responded to the following questions during the task: "How hard do you have to work to accomplish your level of performance?" (1 = *very low* to 9 = *very high*), "How insecure, discouraged, irritated, stressed, and annoyed are you?" (1 = *very low* to 9 = *very high*), "How mentally fatigued do you feel?" (1 = *not at all* to 9 = *extremely*), and "How bored are you right now?" (1 = *not at all* to 9 = *extremely*). At the end of each block participants additionally responded to the questions: "How successful were you in accomplishing what you were asked to do?" (1 = *very low* to 9 = *very high*), "How mentally demanding was the task?" (1 = *very low* to 9 = *very high*), "How motivated are you to continue this task?" (1 = *not at all* to 9 = *extremely*), and "How do you currently feel?" (1 = *very unpleasant* to 9 = *very pleasant*).

Procedure

After providing informed consent, participants completed demographic information and began the *n*-back task with a set of instructions and practice trials. During the instructions phase participants saw some of the question probes and descriptions about what the questions meant. Following the instructions and practice trials, participants completed the first two experimental blocks while the experimenter waited in the hall (about 8 min). After the second block the experimenter briefly interrupted participants to introduce the incentive manipulation. In the *incentive condition*, participants learned that they would receive a monetary reward for their performance at the end of the experiment. Participants in the *no incentive condition* were also interrupted briefly by the experimenter (for consistency between conditions) but were simply told to continue with the task. Next, participants completed the remaining 10 blocks of the task while the experimenter waited in the hall (about 40 min). Prior to each block participants saw a brief instruction screen reminding them of their respective condition (i.e., "*That is the end of the block, the next block will begin shortly. Remember, doing well = $$$*," or simply, "*That is the end of the block, the next block will begin shortly*").

After the last block of the task, participants completed personality questionnaires assessing need for cognition (Cacioppo et al., 1984) and BIS/BAS sensitivity (Carver & White, 1994).

Results

In keeping with Experiments 1 and 2, we focused our analyses on self-reports of effort, fatigue, and affect. Analyses of the other self-report measures (including the personality questionnaires) can be found in the SOM.

The primary analyses consisted of 2 (Condition: incentive vs. no incentive) × 10 (Blocks 3–12) mixed ANOVAs on the dependent measures to assess the effects of the incentive manipulation over time. When the assumption of sphericity was violated, we applied the Greenhouse-Geisser correction.[5]

Subjective experiences

Descriptive statistics for the subjective experiences and performance measures can be found in Table S5 in the SOM. Figure 3 displays self-reported effort, fatigue, and affect across all 12 blocks as a function of incentive condition (including also the pre-incentive Blocks 1 and 2).

The incentive manipulation had no main effect on the subjective experience of effort (i.e., the NTLX item pertaining to working hard), F (1, 239) = 0.18, $p = .674$, d =

[5] Neither task performance ($ps > 0.854$) nor the subjective measures of effort, fatigue, or affect ($ps > 0.060$) differed during the first two blocks of the *n*-back task (prior to the incentive manipulation).

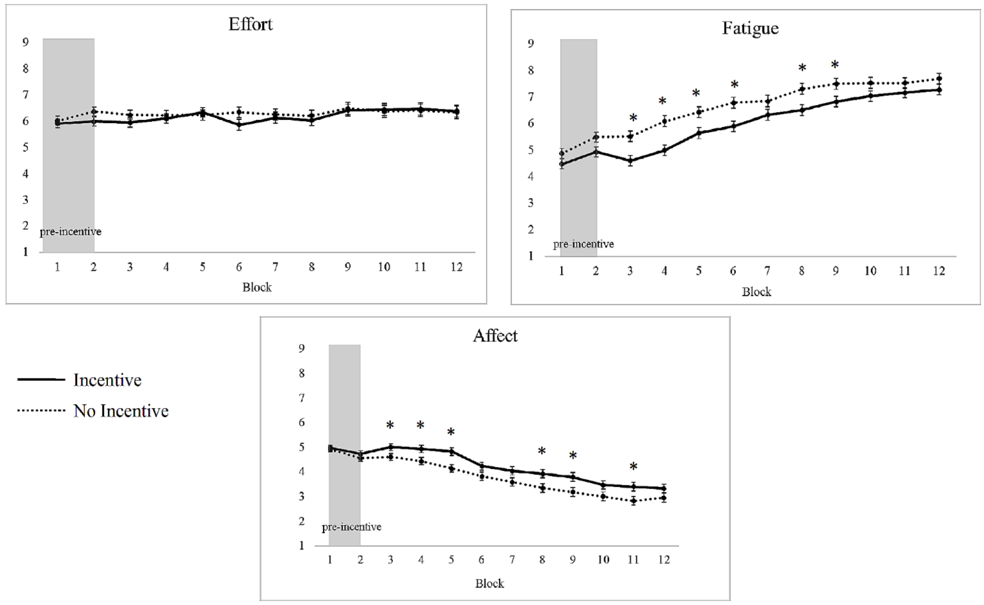

Fig. 3 Feelings of mental effort, fatigue, and affect as a function incentive condition and time/block in Experiment 3. *Note* Error bars represent the standard error. *denotes significant incentive condition differences

-0.05. Effort increased over time, F (5.27, 1260.06) = 2.33, $p = .013$, $\eta_p^2 = 0.01$. Contrary to predictions, incentive condition did not interact with time on task to influence effort, F (5.27, 1260.06) = 0.94, $p = .492$, $\eta_p^2 = 0.004$.

The incentive manipulation exerted a main effect on fatigue, F (1, 239) = 7.99, $p = .005$, d = -0.36, with lower fatigue reported in the incentive condition compared to the no incentive condition. Fatigue increased over time, F (4.83, 1154.08) = 119.56, $p < .001$, $\eta_p^2 = 0.33$, and incentive condition interacted with time, F (4.83, 1154.08) = 2.58, $p = .027$, $\eta_p^2 = 0.01$. Follow-up tests of the effect of condition at each block revealed significant differences in Blocks 3 through 6 and Blocks 8 and 9, ps < 0.018, and non-significant differences in the same direction (i.e., lower fatigue in the incentive condition) in the other blocks, ps > 0.085.

Incentive condition also influenced affect, F (1, 239) = 6.33, $p = .012$, $d = 0.33$, such that affect was more pleasant in the incentive condition compared to the no incentive condition. Affect became more negative over time, F (5.18, 1239.05) = 95.71, $p < .001$, $\eta_p^2 = 0.29$, and incentive condition did not interact with time, F (5.18, 1239.05) = 0.64, $p = .767$, $\eta_p^2 = 0.003$.[6]

Performance

Performance results can be found in the SOM. In general, RTs became faster and accuracy decreased over time from Blocks 3 to 12. The incentive mitigated the drop in accuracy but did not impact RTs.

[6] We also assessed for quadratic effects of time. Affect and fatigue both changed over time in a quadratic trend, but incentive condition did not interact with time to influence the quadratic trend. Full results are in the SOM.

Table 3 Within-person correlations among measures

Across Whole Sample		
	Fatigue	Affect
Effort	0.173***	− 0.051*
Fatigue		− 0.422***
Within the Incentive Condition ($n = 123$)		
	Fatigue	Affect
Effort	0.211***	-0.067*
Fatigue		− 0.407***
Within the No Incentive condition ($n = 118$)		
	Fatigue	Affect
Effort	0.133***	− 0.035
Fatigue		− 0.442***

Note Significance levels denoted, *$p < .05$, **$p < .01$, ***$p < .001$

Within-person correlations

We again assessed the within-person correlations among measures (see Tables 3). Across the whole sample all correlations between subjective experiences were significant. As in Experiments 1 and 2, affect correlated more strongly with fatigue than with effort, $Z = 4.7$, $p < .001$. None of the correlations differed between the incentive and no incentive conditions, ps > 0.312.

Discussion

In Experiment 3, aversive feelings of effort (i.e., fatigue, boredom, frustration, and mental demand) increased whereas motivation, perceived performance, and pleasant affect decreased over time (see SOM). This pattern of results is consistent with past research (Boksem et al., 2005; Healy et al., 2004; Hopstaken et al., 2015, 2016; Lorist et al., 2000;

Muraven & Baumeister, 2000). Accuracy also dropped and RT sped up over time, indicating a speed-accuracy tradeoff with increased time on task.

A performance incentive counteracted some of those effects. Participants reported lower fatigue and higher positive affect under a performance incentive compared to no incentive, but the incentive manipulation did not influence the subjective experience of effort. These results contrast with the idea that incentives increase aversive experiences of mental effort, as Experiment 1 had suggested. These patterns are more consistent with Experiment 2, which also found more pleasant affect and reduced fatigue (when accounting for block order) under an incentive. More generally, the results from Experiment 3 are in line with the opportunity cost model and related perspectives suggesting that performance incentives reduce the costs associated with effort expenditure and therefore reduce aversive sensations (Boksem & Tops, 2008; Hockey, 2011; Inzlicht et al., 2014; Kurzban et al., 2013; van der Linden, 2011). A performance incentive appeared to make the *n*-back task more interesting and engaging: Under the incentive, participants performed better (presumably by working harder) and reported a more pleasant affective state (including less boredom and less frustration; see SOM).

Why did the incentive make the task more pleasant in Experiments 2 and 3, whereas it increased feelings of effort, fatigue, and unpleasant affect in Experiment 1? It may be that differences in study design explain the patterns. Experiment 1 featured a within-subjects manipulation of the incentive variable, so that participants experienced the *n*-back task both with and without an incentive on the line. As mentioned above, the within-subjects manipulation may have created a contrast effect such that participants may have been aware that they tried harder when an incentive was versus was not on the line. When the incentive was manipulated between-subjects, participants did not experience the task under both experimental conditions and working for an incentive improved affective states and reduced feelings of fatigue but not effort. Further, the incentive blocks always followed the no incentive block in Experiment 1, so that time on task may have played a confounding role. We return to these issues below. Also, Experiment 1 had separate blocks for reward (only gaining points) and punishment (only losing points). It remains to be seen whether incentives manipulated within-subjects, wherein participants can gain and lose points in the same block, increases effort, fatigue, and unpleasant affect.

Experiment 4

In Experiment 4, we again manipulated the presence of a performance incentive within-subjects, as in Experiment 1. Subjects performed different difficulty levels of the *n*-back task both with and without an incentive, and the order of the incentive was counterbalanced across participants. This design allowed us to test the within-subjects effect of the incentive manipulation, as in Experiment 1, while also accounting for possible order effects.[7]

Method

Participants and design

We intended to collect data from 350 participants for a mixed experimental design. Three hundred twenty-five participants completed the experiment. We collected data until the end of the semester and finished slightly short of our target. Following preregistered criteria, data from four participants were excluded from analyses because they scored below 3 *SD*s from the sample mean on task performance, as measured by *d'*, three participants were excluded because they reported greater than 3 *SD*s from the sample mean on mind wandering (i.e., 100%), and three participants were excluded for being an outlier on the subjective experience measures. The final sample included 341 participants (age $M = 18.59$, $SD = 0.93$; 63% women), which afforded 80% power to detect a within-subjects effect size of $d = 0.15$. Results did not change with the outliers included in the analyses.

Task difficulty and incentive condition were manipulated within-subjects (i.e., all participants completed different levels of the *n*-back task with and without an incentive on offer), and incentive order was manipulated between-subjects. The experiment thus used a 3 (Task Difficulty: easy, moderate, hard) × 2 (Incentive vs. No Incentive) × 2 (Incentive Order: incentive first vs. incentive second) mixed factorial design. The method, hypotheses, and analysis plan were preregistered online (https://osf.io/k9xv7).

Materials

Task difficulty manipulation (*n*-back task) We used the same *n*-back as Experiments 1 and 2 with a small modification in the number of trials. The *n*-back was administered

[7] We preregistered the intention to test both within-subjects and between-subjects effects of incentive condition in this experiment but settled on testing only the within-subjects effects because this analysis incorporated all the data from this study (the between-subjects effect would include data from only the first half of the task).

using Inquisit 6 (www.millisecond.com) with three difficulty levels: easy (1-back), moderate (2-back), and hard (3-back). Participants completed two blocks of each difficulty level in a random order. Compared to Experiments 1 and 2, the number of total trials per *n*-back block increased from 78 to 96. The target-to-non-target trial ratio remained the same, so each block consisted of 32 target (33%) and 64 non-target (67%) trials.

Incentive manipulation As in Experiments 1 and 2, a point counter appeared at the top of the screen during the task. As in Experiments 2 and 3, participants gained one point for every correct response and lost one point for every incorrect response. During the incentive portion of the task, participants could win up to $8.00 if they performed well (an increase in potential reward value compared to the previous studies). Participants were reminded about the monetary reward at the start of each block in the incentive condition. During the no incentive portion of the task, participants were told nothing about cash. Participants completed *n*-back blocks both under an incentive and under no incentive in counterbalanced order.

Incentive order Participants were randomly assigned to either the incentive first condition or the incentive second condition. In the *incentive first condition* ($n = 171$), participants first received a monetary incentive for completing three levels of the *n*-back task, and then received no incentive for completing the same three levels of the *n*-back task. In the *incentive second condition* ($n = 168$), the no incentive blocks of the *n*-back preceded the incentive blocks. Thus, incentive order was a between-subjects factor.

Question probes Throughout the *n*-back task, questions appeared at random intervals to assess participants' subjective experiences. Specifically, participants were asked, "How much effort were you just expending?" (1 = *none* to 9 = *a great deal*), "How much mental fatigue are you experiencing right now?" (1 = *none* to 9 = *a great deal*), and "How do you currently feel?" (1 = *very unpleasant* to 9 = *very pleasant*). These question probes appeared at a random point once per block, with the stipulation that question probes appeared only during the latter half of trials in each block. The three subjective effort questions were always presented consecutively in a random order. We also probed mind wandering once per block (separately from the subjective experience questions) with the item, "What were you just thinking about?" (0 = *the task*, 1 = *something unrelated to the task*); mind wandering results are not reported here and available upon request. At the end of each block participants reported how much pressure they felt to perform well (1 = *none* to 9 = *a great deal*); results pertaining to pressure are reported in the SOM.

Procedure

Participants completed the experiment individually. After providing informed consent, they completed demographic questionnaires and began the *n*-back task with 9 practice trials at each *n*-level. For the experimental task, participants completed 6 blocks in total (2 blocks of each level of difficulty), which lasted approximately 30 min. After the *n*-back task participants completed two personality questionnaires in counterbalanced order: the need for cognition scale (Cacioppo et al., 1984) and the BIS/BAS scales (Carver & White, 1994). At the end of the experiment all participants were given $5 and debriefed.

Results

To test the effect of the incentive manipulation, we first conducted a 2 (Incentive vs. No Incentive) × 3 (Difficulty: easy, moderate, hard) repeated-measures ANOVA. When the assumption of sphericity was violated we applied the Greenhouse-Geisser correction. Figure 4 depicts self-reported effort, fatigue, and affect as a function of *n*-back difficulty and incentive condition. Table S7 in the SOM reports the descriptive statistics for the subjective experience and performance measures.

Subjective experiences The effect of the incentive manipulation on effort was significant, F (1, 303) = 45.86, $p < .001$, $d = 0.39$, such that feelings of effort were higher in the incentive condition versus the no incentive condition. The main effect of task difficulty was also significant, F (1.73, 525.33) = 9.27, $p < .001$, $\eta_p^2 = 0.03$, with feelings of effort lowest during the 1-back task compared to both the 2- and 3-back, $ps < 0.001$, $ds = 0.18–0.21$; effort did not differ between the 2-back vs. the 3-back tasks, $p = .918$. The Incentive × Difficulty interaction was non-significant, F (1.90, 575.81) = 1.13, $p = .322$, $\eta_p^2 = 0.004$.

The effect of incentive on fatigue was non-significant, F (1, 303) = 0.76, $p = .383$, $d = 0.07$, such that feelings of fatigue were similar in the incentive and no incentive conditions. The main effect of task difficulty was significant, F (1.92, 582.91) = 67.98, $p < .001$, $\eta_p^2 = 0.18$. Fatigue was lowest during the 1-back, followed by the 2-back, and highest in the 3-back; all comparisons were significant, $ps < 0.001$, $ds = 0.26–0.59$. The Incentive × Difficulty interaction was non-significant, F (2, 606) = 0.62, $p = .537$, $\eta_p^2 = 0.002$.

The effect of incentive on valence was significant, F (1, 303) = 4.00, $p = .046$, $d = 0.090$, in the direction of affect being more pleasant under the incentive versus no incentive. The main effect of task difficulty was significant, F (1.84, 557.89) = 63.35, $p < .001$, $\eta_p^2 = 0.17$. Affective state was less pleasant for more difficult versions of the *n*-back task, and

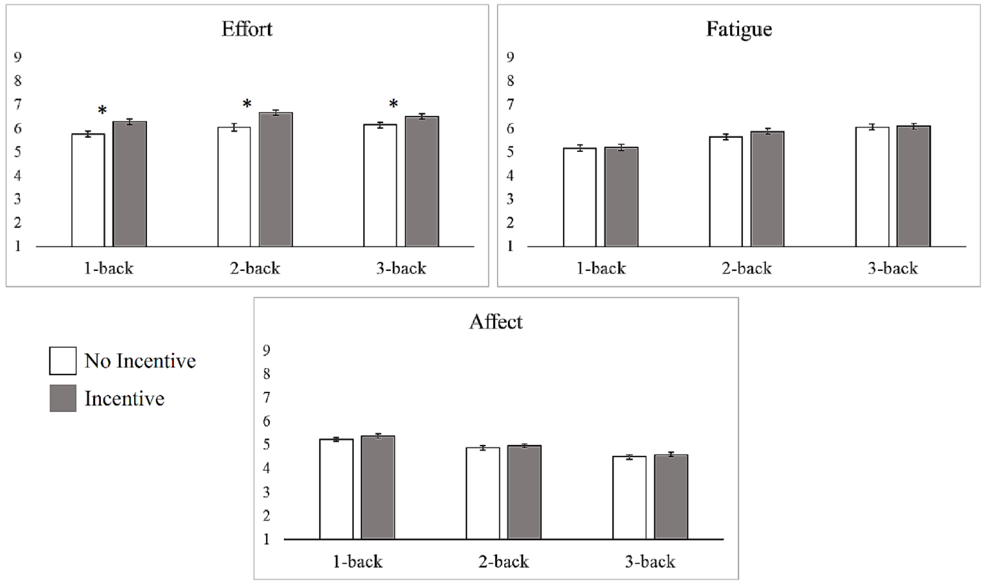

Fig. 4 Feelings of mental effort, fatigue, and affect as a function incentive condition and task difficulty in Experiment 4. *Note* Error bars represent the standard error. *denotes significant incentive condition differences within each *n*-back level

all comparisons were significant, $p < .001$, ds = 0.30–0.38. The Incentive × Difficulty interaction was non-significant, F (1.94, 587.30) = 0.24, $p = .780$, $\eta_p^2 = 0.001$.

In summary, feelings of effort were higher under an incentive versus no incentive, replicating the pattern from Experiment 1. Affect was more pleasant under the incentive, which is consistent with Experiments 2 and 3 but not with Experiment 1. And fatigue was not significantly influenced by the incentive manipulation.

Order effects

To test for potential order effects of the incentive manipulation, we added incentive order into our model and ran a 2 (Incentive vs. No Incentive) × 3 (Difficulty: easy, moderate, hard) × 2 (Incentive Order: first or second) mixed ANOVA with incentive condition and difficulty level (within-subjects) and incentive order (between-subjects) as the factors. This analysis allowed us to test whether the effects of the performance incentive depended on whether the incentive was available for the first part versus the second part of the study.

Regarding subjective effort, the main effect of the incentive manipulation was moderated by incentive order, F (1, 302) = 4.29, $p = .039$. Simple effects tests revealed higher feelings of effort under an incentive versus no incentive, both when the incentive came first, t (170) = -6.64, $p < .001$, and when the incentive came second, t (167) = -3.59, $p < .001$; the interaction indicated that the effect was bigger when the incentive came first. The between-subjects effect of incentive order was non-significant, F (1, 302) = 1.98, $p = .160$.

Regarding fatigue, the effect of incentive was again moderated by incentive order, F (1, 302) = 75.24, $p < .001$. Simple effects tests found higher fatigue during the second half of the task, regardless of whether the incentive came first, t (170) = 4.66, $p < .001$, or second, t (167) = -8.07, $p < .001$. The between-subjects effect of incentive order was non-significant, F (1, 302) = 0.95, $p = .331$.

Regarding affect, the effect of incentive was also moderated by incentive order, F (1, 302) = 4.28, $p = .040$. Simple effects tests found that affect was more pleasant under the incentive only when the incentive came first, t (170) = -2.70, $p = .008$, and not when the incentive came second, t (167) = 0.27, $p = .789$. The between-subjects effect of incentive order was non-significant, F (1, 302) < 0.001, $p = .983$.

Performance

Detailed performance results are reported in the SOM. Briefly, correct-trial RTs were slower under the incentive versus no incentive, but only when the incentive was offered first (RTs were faster under the incentive when the incentive came second). Unexpectedly, accuracy (d') was lower under the incentive versus no incentive, but this was only true when the incentive was offered first.

Within-person correlations

We again explored the within-person correlations among measures. See Table 4. As in Experiments 1–3, affect correlated more strongly with fatigue than with effort, $Z = 5.73$, $p < .001$. None of the correlations differed between the incentive and no incentive conditions, ps > 0.120.

Table 4 Within-person correlations among measures

	Fatigue	Affect
Across Whole Sample		
	Fatigue	Affect
Effort	0.240***	0.035
Fatigue		−0.337***
Within the Incentive Condition		
	Fatigue	Affect
Effort	0.250***	−0.048
Fatigue		−0.405***
Within the No Incentive Condition		
	Fatigue	Affect
Effort	0.247***	0.025
Fatigue		−0.385***

Note Significance levels denoted, $*p<.05$, $**p<.01$, $***p<.001$

Discussion

Experiment 4 tested the within-subjects effect of a performance incentive manipulation on subjective experiences during the *n*-back task. Results revealed higher feelings of effort under the incentive versus no incentive, replicating the results from Experiment 1. Further, the increase in effort occurred regardless of whether the incentive was offered for the first or the second part of the task, suggesting that the effect of time on task—a potential alternative explanation for the findings from Experiment 1—does not explain the result. Pleasant affect was also higher under the incentive, but particularly when the incentive was offered first (rather than second). The incentive manipulation did not impact feelings of fatigue in Experiment 4.

Internal meta-analysis

Given the similarities in the methods used and the hypotheses tested across experiments, we conducted an internal meta-analysis combining all four experiments ($N=894$) for a more robust assessment of the influence of a performance incentive on subjective feelings of effort, fatigue, and affect. Because Experiment 1 included both reward and punishment conditions, we collapsed them into one incentive condition and compared it to the no incentive condition.

We combined the data from all experiments into one dataset and analyzed the aggregate effects with a multilevel model (MLM). Outcome variables (subjective effort, fatigue, affect) were modeled at level 1, nested within participant at level 2, nested within study at level 3. Predictors included incentive condition (-1 = no incentive, 1 = incentive) at level 1, study design (-1 = between-subjects, 1 = within-subjects) at level 3, and the Incentive × Design interaction. The models included a random intercept and random slope for incentive because we were testing a cross-level interaction. We used variance components covariance structure. We focused on the main effect of incentive condition on the outcome variables, and whether they were moderated by study design. Significant interactions were followed up with simple effects tests. Please see Table 5 for the relevant descriptive statistics for each study. Positive (versus negative) effects indicate increased (decreased) subjective experiences in the incentive versus no incentive conditions.

Subjective experiences

For subjective effort, the main effect of incentives was significant, $B=0.102$, $SE=0.042$, $t(1102.29)=2.453$, $p=.014$, such that feelings of effort were higher under an incentive

Table 5 Dependent measures as a function of incentive Condition and Task characteristics across experiments

Experiment	*N*	*N*-back level	Duration	Incentive manipulation	DV	No Incentive Condition M (SD)	Incentive Condition M (SD)	Effect size (d)
1	102	1, 2, 3	9 blocks, ~36 min	Within-subjects (fixed order): Reward, punishment, none	Effort	5.92 (1.45)	6.22 (1.52)	+0.304
					Fatigue	4.98 (1.70)	5.72 (1.81)	+0.552
					Affect	5.13 (1.16)	4.85 (1.35)	−0.279
2	In = 105, No = 105	1, 2, 3	6 blocks, ~24 min	Between-subjects: Incentive vs. none	Effort	5.64 (1.58)	5.82 (1.44)	+0.119
					Fatigue	5.57 (1.36)	5.22 (1.63)	−0.233
					Affect	4.54 (1.23)	4.96 (1.11)	+0.359
3	In = 123, No = 118	2	12 blocks, ~48 min	Between-subjects: Incentive vs. none	Effort	6.32 (1.98)	6.22 (1.73)	−0.054
					Fatigue	6.92 (1.86)	6.23 (1.95)	−0.362
					Affect	3.59 (1.62)	4.10 (1.49)	+0.328
4	341	1, 2, 3	6 blocks, ~ 28 min	Within-subjects (counterbalanced order): Incentive vs. none	Effort	5.99 (1.82)	6.50 (1.76)	+0.394
					Fatigue	5.61 (2.03)	5.72 (1.96)	+0.073
					Affect	4.88 (1.44)	4.98 (1.37)	+0.093

Note The values for incentive condition in Experiment 1 combine the reward and punishment conditions from that study

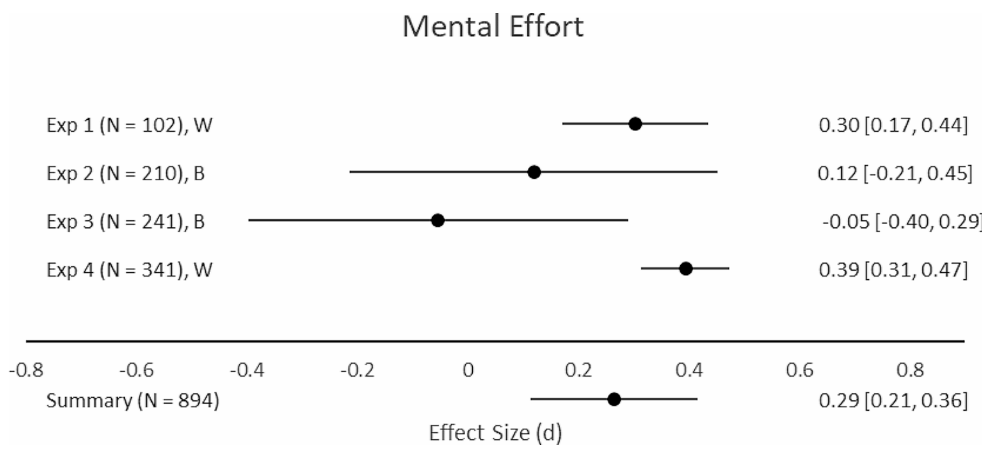

Fig. 5 Forest Plots of Meta-Analytic Effect of Incentives on Subjective Experiences of Mental Effort. *Note* More positive effects indicate greater feelings of effort under the incentive vs. no incentive. W = within-subjects design, B = between-subjects design

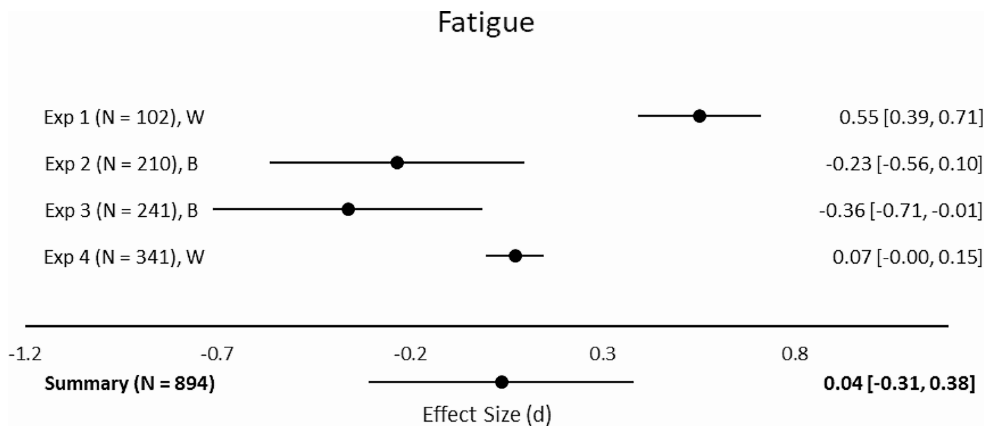

Fig. 6 Forest plot of meta-analytic effect of incentives on subjective experiences of fatigue. *Note* More positive effects indicate greater fatigue under the incentive vs. no incentive. W = within-subjects design, B = between-subjects design

versus no incentive. The Incentive × Design interaction was also significant, $B = 0.121$, $SE = 0.042$, t (1102.29) = 2.902, $p = .004$. Follow-up simple effects tests revealed that the effect of incentives on effort was non-significant in the between-subjects experiments, B = -0.019, $SE = 0.078$, t (925.22) = -0.24, $p = .810$, but significant in the within-subjects experiments, $B = 0.224$, $SE = 0.030$, t (442.65) = 7.54, $p < .001$. See Fig. 5 for a depiction of meta-analytic effect of incentives on subjective experiences of mental effort.

For fatigue, the main effect of incentives was non-significant, B = -0.080, $SE = 0.046$, t (1138.51) = -1.73, $p = .084$, but the Incentive × Design interaction was significant, $B = 0.214$, $SE = 0.046$, t (1138.51) = 4.623, $p < .001$. Follow-up tests revealed that the effect of incentives on fatigue was negative in between-subject designs, B = -0.294, $SE = 0.086$, t (949.47) = -3.55, $p = .001$, but positive in within-subject designs, $B = 0.134$, $SE = 0.034$, t (458.53) = 3.91, $p < .001$.[8] Thus, participants felt less fatigue when working under an incentive manipulated between-subjects, but more fatigue under an incentive manipulated within-subjects (although this latter difference was driven by Experiment 1, which differed in key ways from the other within-subjects study, Experiment 4) (Fig. 6).

For affective valence, the main effect of incentives was significant, $B = 0.113$, $SE = 0.035$, t (1140.35) = 3.25, $p = .001$, as was the Incentive × Design interaction, B = -0.112, $SE = 0.035$, t (1140.35) = -3.208, $p = .001$. Follow up tests revealed that the effect of incentives was positive in the between-subjects designs, $B = 0.225$, $SE = 0.065$, t (941.77) = 3.481, $p = .001$, but non-significant (and in the same direction) in the within-subjects designs, $B = 0.001$, $SE = 0.026$, t (431.87) = 0.056, $p = .955$. Thus, participants felt more pleasant working for an incentive, especially when it was manipulated between subjects (Fig. 7).

In summary, across all four experiments monetary incentives increased feelings of mental effort and pleasant affect but did not consistently influence fatigue. Study design moderated the impact of incentives on all subjective experience measures. When manipulated between-subjects, an incentive increased pleasant affect and reduced fatigue, creating a relatively positive subjective experience of the *n*-back task compared to the no incentive conditions. When the incentive was manipulated within-subjects, however, it

[8] The positive effect of incentives on fatigue in within-subjects designs was driven mainly by the results from Experiment 1. In that study, the incentive blocks always followed the no incentive blocks, and the punishment block had a particularly large effect on fatigue. The other within-subjects study (i.e., Experiment 4) counterbalanced the order of incentives and did not include a punishment block, so results combining the two studies should be interpreted in full awareness of the differences between them.

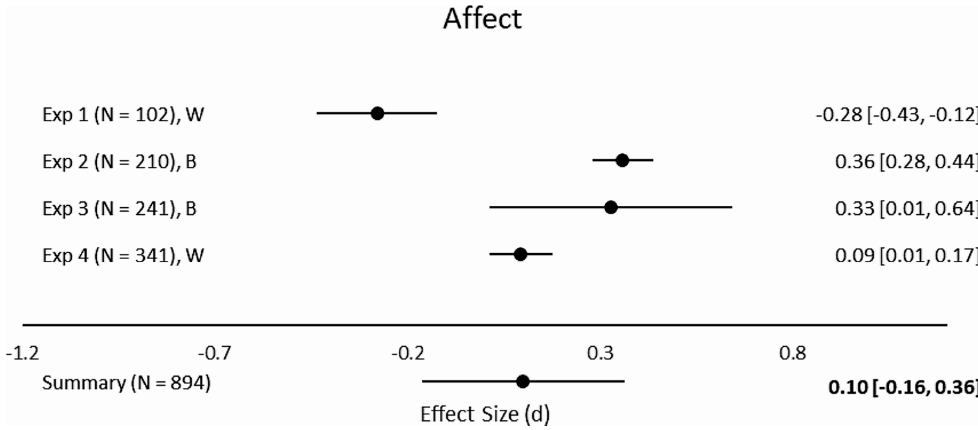

Fig. 7 Forest plot of meta-analytic effect of incentives on subjective experiences of pleasant affect. *Note* More positive effects indicate greater pleasant affect under the incentive vs. no incentive. W = within-subjects design, B = between-subjects design

Table 6 Within-person correlations among measures for experiments 1–4

Across Whole Sample (N = 894)		
	Fatigue	Affect
Effort	0.276***	– 0.069
Fatigue		– 0.397***
Within the Incentive Condition (n = 671)		
	Fatigue	Affect
Effort	0.280***	– 0.055
Fatigue		– 0.406***
Within the No Incentive Condition (n = 666)		
	Fatigue	Affect
Effort	0.332***	– 0.154
Fatigue		– 0.451***

Note Significance levels denoted, *$p < .05$, **$p < .01$, ***$p < .001$

increased feelings of mental effort and had more mixed or non-significant effects of fatigue and affect.

Performance

Regarding performance, we assessed accuracy (d') and RT in the n-back tasks; full results are reported in the SOM. The main effect of incentives on accuracy was significant, such that accuracy was higher under incentives versus no incentive. The effect of incentives on accuracy also depended on study design, such that incentives increased accuracy only when manipulated in between-subjects designs but did not significantly influence accuracy when manipulated in within-subjects designs. The meta-analytic effect of incentive on RT was non-significant and did not interact with study design.

We also tested the effects of incentives on subjective experiences when controlling for accuracy (d'). With accuracy as a covariate, the main effect of incentive on effort remained significant, $p = .011$, as did the Incentive × Design interaction, $p = .006$. The main effect of incentive on fatigue remained non-significant, $p = .145$, and the Incentive × Design interaction remained significant, $p < .001$, with accuracy as a covariate. And both the main effect of incentives on affect, $p = .003$, and the Incentive × Design interaction, $p = .008$, remained significant when accuracy was included as a covariate. Thus, the effect of incentives on subjective experiences did not hinge on accuracy on the n-back task.

Within-person correlations

We also assessed the within-person correlations among subjective experiences across all four experiments. See Table 6. Effort correlated with fatigue, r (892) = 0.27, $p < .001$, but not with affect, r (871) = – 0.07, $p = .183$, whereas fatigue correlated with affect, r (892) = – 0.39, $p < .001$. We again tested the difference between the effort-affect and fatigue-affect correlations and found that affect associated more closely with fatigue than with effort, $Z = 8.49$, $p < .001$.

We also tested whether the correlations differed between the incentive and no incentive conditions. None of the associations differed between the incentive and no incentive conditions, ps > 0.068.

Last, given that the effect of incentives on subjective experiences was moderated by study design, we wanted to test the correlations as a function of incentive and study design; these results are reported in the SOM. The only correlation that differed between the two study designs was the correlation between effort and fatigue: In the within-subjects designs, effort correlated with fatigue more strongly in the no incentive condition, r (441) = 0.42, compared to the incentive condition, r (441) = 0.26, Z = -2.75, $p = .006$; this difference in correlations was not observed in the between-subjects designs, $p = .872$. The effect of incentive condition on correlations did not differ between the study designs for any of the other subjective experiences.

General discussion

Four experiments and an internal meta-analysis tested the effects of performance incentives on subjective feelings of mental effort, fatigue, and affect during a challenging cognitive activity—the *n*-back task. There were four major findings. First, incentives increased feelings of mental effort. This pattern was especially evident when the presence (versus absence) of incentives was manipulated in within-subjects designs; in between-subjects designs, feelings of effort were non-significantly higher in the incentive conditions. Second, performance incentives increased pleasant affect. This was especially evident in between-subjects designs, whereas in the within-subjects designs pleasant affect was non-significantly higher under incentive. Third, the effect of incentives on fatigue appeared to depend on context. When manipulated between-subjects, the presence (versus absence) of incentives reduced fatigue, but the fatigue results were more mixed in within-subjects designs. The strongest within-subjects effects on fatigue emerged in Experiment 1, which may have inadvertently capitalized on a time-on-task confound (because the incentive blocks always occurred after the no-incentive block). When we counterbalanced block order in Experiment 4, the fatigue effect went away. Last, exploratory analyses linked affect more tightly to fatigue than to effort. Thus, although effort has been likened to an aversive affective experience (e.g., Inzlicht et al., 2015; Inzlicht et al., 2018; Kurzban, 2016; Shenhav et al., 2017), it was fatigue that more closely correlated with self-reports of negative affect. Below we elaborate on these results and trace their theoretical implications.

Influence of incentives on feelings of mental effort

We considered two possible outcomes for the effect of incentives on the subjective experience of mental effort. One the one hand, incentives increase the value of the current task, which may cause participants to try harder and thus lead to greater feelings of effort, fatigue, and unpleasant affect. On the other hand, incentives may reduce the costs associated with effort expenditure and thus produce a more pleasant (less effortful) subjective experience. We found evidence to support both possibilities.

First, we found that performance incentives generally increased feelings of effort. Effort mobilization is generally considered a function of task difficulty and success importance (Brehm & Self, 1989; Richter et al., 2016). Simply put, individuals expend more effort on more difficult (but still accomplishable) tasks to the extent that task success is important. The performance incentives in the current experiments presumably made task success more important and therefore motivated a more robust mobilization of mental resources compared to when no incentive was offered. Thus, in addition to increasing objective effort expenditure (Eubanks et al., 2002; Hopstaken et al., 2015; Massar et al., 2016; Richter & Gendolla, 2009), incentives also increase subjective experiences of effort.

Second, theoretical perspectives such as the opportunity cost model suggest that feelings of effort and fatigue result from a cost-benefit assessment (Boksem & Tops, 2008; Hockey, 2011; Kurzban et al., 2013; van der Linden, 2011). Following this view, we considered that incentives may reduce the subjective costs associated with effort expenditure. We found some support for this perspective as well. The presence of incentives generally increased pleasant affect across the experiments, creating a more pleasant subjective experience of task performance compared to no incentive.

One implication of these findings is that incentives for good performance increase mental effort and task engagement without increasing aversive affective states. Presumably, the incentives make people more willing to exert effort (i.e., increasing feelings of effort) by making effort expenditure more pleasant (i.e., increasing pleasant affect). To put it plainly, some mental efforts are more pleasant than others.

Study design matters

The study design—whether performance incentives were manipulated within-subjects or between-subjects—was a crucial factor in shaping the effects of incentives on subjective experiences. The within-subjects designs had participants perform the *n*-back task both with and without an incentive on the line. With these twin experiences to compare and contrast, participants appeared to become aware that they tried harder in the incentive condition (or reduced their efforts when the incentive was removed). In Experiment 1 the incentive conditions always occurred after the no incentive condition, so time on task could have acted as a confound in the observed results. But in Experiment 4 a performance incentive increased subjective effort no matter whether it occurred first or last, suggesting that time on task does not explain the pattern. Feelings of effort increased under a performance incentive, and this was especially true when the incentive was manipulated within-subjects.

In the within-subjects designs, with an incentive at stake participants appeared to try harder by expending more effort, and they experienced the *n*-back task as subjectively more effortful. Other research has similarly observed that a within-subjects manipulation of incentives alters effort output. For instance, in one study participants repeatedly chose between performing difficult math problems or watching videos (Goswami & Urminsky, 2017). In the first round of choosing, no incentive was offered (baseline condition), in the second round participants were randomly assigned to receive a reward for math performance or not, and in the third round the reward was removed. When offered a reward for math performance, participants chose the math task more frequently relative to baseline. But when the reward was removed in round three, participants chose the math task less frequently than at baseline before eventually returning to baseline levels. These results suggested that participants expend more effort in the presence of an incentive, but then conserve effort when the incentive is removed. Effort expenditure thus appears to be sensitive to changes in incentive availability, which is more salient in a within-subjects design (see also Fairclough & Ewing, 2017).

A between-subjects manipulation of performance incentives eliminates the possibility for participants to contrast their experiences in the two conditions, and the between-subjects experiments yielded different patterns of subjective experience. Participants in these experiments (Experiments 2 and 3) generally experienced less fatigue and more pleasant affect under an incentive, suggesting that the incentive boosted positive subjective experiences. This pattern dovetails with evidence that interest in a task mitigates feelings of fatigue stemming from task performance (Milyavskaya et al., 2021). In essence, participants found a challenging cognitive task to be more interesting and engaging with a reward at stake, whereas the same task performed for no incentive felt more fatiguing and more unpleasant.

In the between-subjects designs, performance incentives appeared to reduce the costs of effort expenditure, creating a more pleasant subjective experience. But feelings of effort were not reduced by the between-subjects manipulations of incentives. According to the opportunity cost model, reducing opportunity costs with an incentive should reduce aversive experiences of effort and fatigue because such feelings represent a cost-benefit assessment (Boksem & Tops, 2008; Inzlicht et al., 2014; Kurzban et al., 2013; van der Linden, 2011). Accordingly, the current results suggest that incentives increased the benefit of effort expenditure and therefore reduced aversive subjective experiences of negative affect and fatigue. The fact that we observed this pattern only in the between-subjects designs suggests that the contrast between performing a task with versus without incentives in the within-subjects designs overrides or supersedes opportunity cost considerations.

Relations among subjective experiences

The within-person correlations among subjective experiences revealed that negative affect during task performance related to feelings of fatigue but not feelings of mental effort. Fatigue arises from prior effort expenditure and appears to represent an unpleasant subjective experience similar to being *tired*, *exhausted*, or *drained*. In the current experiments, the more effort participants exerted, the more fatigue they experienced, and the more fatigue they experienced the more unpleasant they felt. These findings are consistent with the notion that feelings of fatigue represent an unpleasant "stop emotion" that may signal to an organism that the costs of effort expenditure outweigh the benefits and suggest that it may be adaptive to stop and take a break or shift tasks (e.g., van der Linden, 2011).

Feelings of effort, on the other hand, were not significantly related to negative affect. This is surprising because effort has been construed as an unpleasant subjective state and something to be avoided (David et al., 2022; Kurzban, 2016; Shenhav et al., 2017). Indeed, the aversive nature of effort is often invoked to explain why people avoid effortful activities (e.g., Kool et al., 2010), and the recruitment of cognitive control has been associated with negative affect (e.g., Dreisbach & Fischer, 2012; Inzlicht et al., 2015). Based on the correlational patterns observed in the current research—ones that we did not hypothesize a priori—we would suggest that effort is aversive to the extent that it is fatiguing. Hence, brief bouts of mental effort may not be particularly aversive or unpleasant, and in fact they may be relatively pleasant if they yield rewards. But longer bouts of mental effort may be unpleasant at least in part because they are also fatiguing. Future research should further examine the affective implications of expending mental effort, keeping in mind that mental effort is not always unpleasant.

Other theoretical implications

Intrinsic motivation Several other theoretical perspectives have considered the effects of incentives on feelings and behaviors, so we briefly consider the implications of the current findings for these other perspectives. For example, extensive research has observed that extrinsic rewards may undermine intrinsic motivation (e.g., Deci et al., 1999). In an early demonstration of this effect, participants completed an intrinsically rewarding puzzle task initially with no reward, and then received either a monetary reward (experimental group) or no reward (control group) for completing more puzzles (Deci, 1971). Last, the reward was removed and participants had an opportunity to freely choose their behavior. Participants chose not to continue completing the puzzles at the same rate when the extrinsic reward was no longer available, suggesting reduced intrinsic motivation for the puzzle task. However, more recent evidence has suggested that post-reward reductions in engagement may be temporary and likely reflect a strategic decision to "take a break" rather than a drop in intrinsic motivation per se (Goswami & Urminsky, 2017).

Based on the results of the present studies, we would expect that any drop in intrinsic motivation for task performance to occur especially with within-subjects manipulations of incentives (as in the study by Deci, 1971). We found greater feelings of mental effort under an incentive compared to no incentive in within-subjects designs. Drops in intrinsic motivation seem less likely in between-subjects designs, because participants do not have the comparison of completing the task both with and without an incentive. Future work on the effects of incentives on intrinsic motivation should attend to the different contexts at play in different study designs.

Cognitive dissonance theory The rewards participants received in the current studies were relatively small ($5 - $8) for performing a long (approximately 25–50 min) and mentally demanding task. This combination of factors may have created a state of cognitive dissonance due to the insufficient justification provided by the incentives (e.g., Festinger & Carlsmith, 1959). Participants may have been motivated to adjust their attitudes to reduce the dissonance, such as by convincing themselves that the task was less demanding or more pleasant, which could manifest in participants' self-reports when performing for an incentive. We found evidence consistent with this possibility in the experiments using between-subjects manipulations of incentives, wherein participants reported less fatigue and less unpleasant affect under the incentive. In the within-subjects designs, performing the same task both for a modest incentive and for no incentive may have obviated the need for dissonance reduction (e.g., the incentive was sufficient to justify effort expenditure in this condition compared to the no incentive conditions). Future research should test whether larger rewards produce similar effects. Or, it may be that larger rewards provide sufficient justification for expending effort, thereby eliminating the need for dissonance reduction, which could result in more reported fatigue and more unpleasant affective states.

Ego depletion theory Many studies have found that exercising self-control on one task reduces success at further efforts at self-control, as though the initial efforts depleted some limited inner resource or strength (e.g., Garrison et al., 2019). But this evidence has been challenged on multiple grounds, and more recent preregistered studies testing large samples of participants have identified important moderators of the ego depletion effect. For example, Dang (2016) found that feelings of effort moderated the depletion effect, such that only those who reported more effort during the initial task showed a subsequent decline in performance at self-control. And Vohs et al. (2021) found that only participants who reported more fatigue following the initial task evidenced a depletion effect.

Those patterns attest to the relevance of subjective feelings stemming from effort expenditure for understanding subsequent task performance. The current findings point to a relevant factor—performance incentives—for modulating subjective feelings during mental effort expenditure. Combining the two strands of thought generates a new prediction regarding ego depletion: Depletion should be more pronounced when participants perceive no possible rewards for performing the initial task, relative to participants who receive a reward. As we found in the current between-subjects experiments, performance incentives reduce aversive feelings such as fatigue and negative affect (with no significant effect on effort). Less fatigue or negative affect following initial task performance should guard against subsequent performance decrements (Vohs et al., 2021).

Limitations

Some features of the current experiments may limit the generalizability of our findings or the conclusions that can be drawn. For instance, we relied on a single type of task (*n*-back) and tested samples that were predominantly female and WEIRD (white, education, industrialized, rich, democratic; see Henrich et al., 2010). It remains to be seen whether these results generalize to other cognitively demanding tasks or other populations. For instance, it is unclear whether the current results generalize to older populations or to individuals with poorer executive functioning, who may be more averse to mental effort expenditure (Westbrook et al., 2013; Sandra & Otto, 2018). Further, we mainly used single-item measures of effort, fatigue, and affect. We used brief measures so that we could include them during task performances with minimal interference, and to reduce the burden on participants, but future research could use more robust measurements of effort, fatigue, and affect.

Further, we did not test whether incentives led to more pleasant perceptions of the task itself, because we used measures designed to assess subjective experiences. Hence, we can only conclude that incentives produce more pleasant experiences during the task. Future research is needed to test the influence of incentives on perceptions of the task. Last, the current research used a monetary incentive to motivate performance, but it remains to be seen whether these results generalize to other types of incentives such as positive performance feedback or social approval, or more intrinsic rewards.

Conclusion

The role of incentives in motivating mental effort is well-established, but the effects of incentives on feelings of effort has received less attention. We found that the presence (versus absence) of incentives generally increases feelings of effort while also increasing pleasant affect. However, the effects of incentives also depend on context. When manipulated in within-subjects experimental designs, the presence of incentives increases feelings of effort but did not consistently influence fatigue and affect. When manipulated in between-subjects designs, however, the presence of incentives increases pleasant affect and reduces fatigue but did not influence subjective effort. Incentives may make task performance less aversive even as they increase feelings of effort.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11031-024-10083-0.

Authors contributions KG and BS conceptualized and designed the experiments. KG and JW collected the data. KG, BS, and JW were involved in writing.

Data availability The data and analysis code for all experiments are available to view here: https://osf.io/ctrjp/.

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