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Motivational processes during physical endurance tasks

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Purpose: Motivational processes are insufficiently recognized in models of human endurance. Hence, two studies examined a motivational model proposing that the quality of pre-task autonomous motivation influences performance at high intensity via the in-task temptation to reduce effort and value of goal pursuit.

Methods: The studies involved 40 participants each (Study 1:33% female, $M_{age} = 21.55$, SD = 1.97; Study 2:45% female, $M_{age} = 22.65$, SD = 2.61) completing measures of autonomous motivation prior to a 10-minute cycling task. Measures of the temptation to reduce effort and value of goal pursuit were taken every minute during the trial (Study 1) or near the midpoint of the trial (Study 2). Data were analyzed using multilevel growth and parallel mediation models.

Results: In both studies, autonomous motivation was associated with lower temptation to reduce effort and higher value of goal pursuit, which were subsequently characteristic of better performance. Study 1 revealed nuances within these relationships depending on whether task initiation or change over time was considered. In Study 2, indirect effects of autonomous motivation on performance via temptation to reduce effort ($b = 0.20$, 95% CIs 0.03-0.50) and goal value ($b = 0.26$, 95% CIs 0.01-0.44) were evidenced.

Conclusion: Two studies supported a theoretically viable model explaining the dynamics between pre-task and in-task motivation underpinning performance at high intensities.

KEYWORDS

autonomous, effort, self-concordance, self-control

1 | INTRODUCTION

Many human exploits require the ability to endure and lowering one's efforts or disengaging will lead to varying significant consequences. Despite the importance of this aptitude, it is poorly understood and what is known has typically been described from physiological perspectives. Yet, it is often a decision to reduce effort or terminate activity that impedes durability before physiological limits are reached, suggesting that psychological processes are a core component of endurance. By developing preliminary ideas,[1] the present study employs a motivational perspective to continue this agendum.

Endurance involves many processes directly or indirectly associated with discomfort. For example, affective responses to exercise are increasingly negative at intensities above lactate threshold.[2] Given this state, there will be a desire to reduce effort because humans have a propensity toward homeostasis[3] and to

All authors were students and staff at Loughborough University when the work was conducted.

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avoid discomfort.[4] Once consciously activated, this desire to reduce effort becomes a proximal temptation and competes with the more distal goal of successful performance (ie, achieving an objective). The generalizable principle of a desire-goal conflict,[5] therefore, is a core component of endurance.

Conflicting goals and temptations are dynamic and non-linear during decision making[6] and explain fatigue.[3] Examining these components during physical endurance is interesting because the act is unlike many other examples of the desire-goal dilemma. In many other scenarios (eg, resisting cake), the uncomfortable affective experience of resisting the temptation intensifies,[7] but the objective characteristics of the tempting stimulus do not. Above specific physical intensities, however, the consequences of resisting the temptation to reduce effort leads to exponential increases in many components of energy metabolism (eg, lactate concentration, respiratory frequency). This dynamic state provides a compounding reason to give into temptation, beyond the incremental negative affect associated with the desire-goal conflict itself. In other words, resisting temptation in endurance contexts has a masochistic component that is absent in most desire-goal scenarios.

Recent commentary has proposed that the *pre-task* motivational quality underpinning endurance activity impacts the *in-task* desire-goal dilemma.[1] The cornerstone of this theory and a departure from some models of endurance and self-control is that motivation is not viewed as the effort an individual is willing to exert on the task[8] or to resolve the conflict.[5] Instead, an emphasis is placed on the extent that engaging in the endurance act is consistent with the performer's sense of self. This conceptualization of motivation is informed by several theories, sharing similarities with autonomous motivation,[9] "want to" motivation,[10] and self-relevant goal pursuit.[6] The term "autonomous motivation" is used hereafter because the term has deep historical roots and broadest evidence base in sport science.

When autonomously motivated, the temptation to reduce effort will be perceived as dissonant with identity-driven values.[11] To necessarily resolve this dissonance, a lower value will be assigned to the temptation, which should manifest in greater persistence. Similarly, autonomous motivation leads to lower attraction to temptations that digress from healthy eating and personal life goals.[12] Autonomous motivation should also lead to enhanced value of the endurance goal due to concordance between identity and goal. This alignment means the performance goal is more effortlessly activated and pursued.[13,14] Thus, autonomous motivation is expected to lead to more effective performance, via greater value of the performance goal.

To summarize the present studies, the competing temptation to reduce effort and the performance goal provide focal points to investigate physical endurance. It was hypothesized that a lower temptation to reduce effort (Hypothesis 1) and higher performance goal value (Hypothesis 2) during the tasks would be associated with greater endurance performance. It was also hypothesized that pre-task autonomous motivation would be associated with lower temptation to reduce effort (Hypothesis 3) and higher performance goal value (Hypothesis 4) during the tasks. These hypotheses were investigated in two studies involving high-intensity endurance tasks. Both studies explored the relationships among autonomous motivation, temptation and goal value and performance (Hypotheses 1-4). The second study additionally examined the collective sequence (ie, indirect effects).

2 | STUDY 1

2.1 | Materials & Method

2.1.1 | Participants

Forty participants took part in the study (27 males, 13 females, *M* age = 21.55; SD = 1.97). This exceeds the minimum of 30 level-2 units (ie, participants in the present study) and five level-1 units (ie, nine measurement waves in the present study) required for minimal bias in statistical parameters.[15] Inclusion criteria required that participants were 18-35 years old and physically active (ie, a minimum of 30-minute moderate intensity activity 3 days a week for 3 months). Participants were free of pre-existing medical conditions or family history that made high-intensity exercise risky.

2.1.2 | Measures

Autonomous motivation

The situational motivational scale[16] measured participants' autonomous motivation for the cycling task. Participants rated their motivation toward the upcoming task on a 7-point scale ranging from 1 (corresponds not at all) to 7 (corresponds exactly). Scores from the four items measuring intrinsic motivation (eg, "because I think that this activity is interesting") and the four items measuring identified regulation (eg, "because I believe that this activity is important for me") were averaged. The subscales measuring non-autonomous motivation (ie, external regulation and amotivation) were completed by participants but were not used in the study. Guay and colleagues[16] evidenced the factor structure and internal consistency of the measure.

Temptation and goal value

There are no validated measures of temptation and goal value; hence, current measurement was informed by work that has examined desire using a single item[17] but with increased response options to maximize sensitivity to change. Hence, the temptation to reduce effort was measured by responses to the

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instruction "please rate how tempted you are to reduce the effort required to rotate the pedals" on a 20-point scale, ranging from 1 (not tempted at all) to 20 (likely to reduce effort almost immediately). The value of the performance goal to complete as much distance as possible was measured on a similar scale (1 = not important at all; 20 = extremely important) following the instruction "Please rate the importance of completing as much distance as possible and placing high on the leader board." These scales were completed every minute, and they were asked to respond verbally.

Performance
Participants' cycling performance was the total distance cycled (in kilometers) during a 10-minute time trial.

2.1.3 | Procedure

Following clearance from Loughborough University ethics committee, participants were provided with study details and clarification that participation was voluntary, anonymous data storage, and their right to withdraw. Participants were asked to avoid strenuous exercise, alcohol, and caffeine 24 hours before the experiment. Participants gave informed written consent and completed a general health questionnaire.

Participants first completed an incremental effort bicycle test on a stationary cycle (Monark, model 828E). Following a 5-minute warm-up, participants cycled at 80 rpm with the resistance increased every minute by 35 watts. This continued until voluntary exhaustion and the maximum watts participants attained were recorded. Similar procedures have been employed in endurance research.[18] Participants were given a 30-minute rest period, and 5 minutes before the end, participants completed a measure of autonomous motivation toward the next task.

In stage two, participants completed a 10-minute trial in which they began cycling at 90 percent of their maximum wattage from the previous test. Ninety percent was chosen because it was very likely to be unsustainable and a temptation to reduce effort would be present quickly. For example, the average time to exhaustion for trained cyclists at the same intensity was 213 seconds.[19] Participants were instructed to cycle at this intensity for as long as they were able or wanted to, but it was unlikely they would be able to maintain it for the duration. If they were to fall below the threshold, they were to continue cycling at a self-selected intensity, with the overall goal to try and cycle as far as possible. To enhance the meaningfulness of the goal, participants were told that their performance would be entered onto a leaderboard alongside other participants and they were asked to set a target position on the leaderboard. Leaderboards are regularly used to set relevant goals, particularly when goals are difficult.[20] Every minute during the trail, participants indicated the temptation to reduce effort and the performance goal value.

2.1.4 | Data analysis

MLwiN software (version 2.34[21]) was used to construct multilevel growth models.[22] This method was used because of the hierarchical structure of the data with each measurement of temptation and goal value nested within each participant.[23] Unconditional means models (ie, no predictor variables) for temptation and goal value were formed to disaggregate the variance associated with level-1 (ie, within-person) and level-2 errors (ie, between-person). To describe temporal trajectories of temptation and goal value, unconditional growth models were constructed, in which linear, quadratic, and cubic functions of time were added to the models in a stepwise fashion and evaluated based on traditional statistical significance criteria ($P \leq .05$). These models are reported in the supplementary materials (Table S1 and Figure S1).

To examine hypotheses 1-2, conditional growth models were constructed with performance (ie, distance cycled, which was grand mean centered) added to the unconditional growth models as a predictor of initial status (temptation and goal value at the beginning of the task) and linear, quadratic, and cubic rates of change in temptation and goal value. These predictors were added in a stepwise fashion, and the highest-order statistically significant term ($P \leq .05$) was retained in the final model (and, necessarily, the lower order derivatives of that term). The same procedures were then repeated, replacing performance with autonomous motivation to examine hypotheses 3-4.

2.2 | Results

2.2.1 | Preliminary analysis

Descriptive statistics for the study variables can be found in Table 1 (left hand side). The average maximum watts achieved in the fitness test was 267.25 *W* (range 147-393 *W*). Cronbach's alpha coefficient for autonomous motivation was 0.81. Intraclass correlation coefficient for temptation and goal value were 0.94 and 0.96, respectively.

2.2.2 | Hypotheses 1 and 2: Do temptation and goal value differ between high and low performers?

Table 2 reports the final models from each of the analyses. Trial performance negatively predicted the intercept, but not the rate of change of temptation to reduce effort (model 1). That is, a lower temptation at the beginning of the trial was characteristic of higher performers; however, change in temptation across the trial was consistent across high and low performers. In contrast, trial performance did not predict the intercept in goal value,

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TABLE 1 Descriptive statistics of study variables

Study variable	Study 1 Mean (SD)	Study 1 Bivariate correlations 1	2	3	Study 2 Mean (SD)	Study 2 Bivariate correlations 1	2	3
(1) Autonomous motivation (1-7)	4.21 (0.98)				4.53 (0.87)			
(2) Average temptation value (1-20)	12.24 (4.70)	**−0.32**			10.63 (5.20)	**−0.41**		
(3) Average goal value (1-20)	10.15 (4.66)	0.29	**−0.60**		12.58 (5.83)	**0.52**	**−0.70**	
(4) Performance (km)	4.93 (1.66)	0.31	−0.27	0.12	6.05 (1.18)	**0.58**	**−0.71**	**0.74**

Note: In both studies, the average of temptation and goal value across the trial was used to compute these statistics. Correlations in bold were statistically significant ($P \leq .05$).

TABLE 2 Final conditional growth models describing performance and autonomous motivation as predictors of temptation and goal value

Outcome	Substantive predictor variable: Performance — Temptation to reduce effort (model 1)	Performance — Goal value (model 2)	Autonomous motivation — Temptation to reduce effort (model 3)	Autonomous motivation — Goal value (model 4)
Intercept	**3.24 (1.49)**	**16.79 (1.10)**	**3.22 (1.40)**	**16.88 (1.09)**
Linear time	**4.51 (1.01)**	**−3.07 (0.81)**	**4.54 (1.02)**	**−3.19 (0.81)**
Quadratic time	**−0.60 (0.21)**	**0.36 (0.018)**	**−0.61 (0.21)**	**0.39 (0.18)**
Cubic time	**0.03 (0.01)**	−0.01 (0.01)	**0.03 (0.01)**	−0.02 (0.01)
Performance	**−1.07 (0.39)**	−0.06 (0.04)		
Performance × linear time		**0.20 (0.09)**		
Autonomous motivation			**−2.54 (0.70)**	**1.73 (0.57)**
Autonomous motivation × linear time			**0.21 (0.11)**	

Note: For brevity, only fixed effects of the models are reported. Numbers provided are unstandardized coefficients and standard errors in parentheses. Bold figures indicate statistical significance ($P \leq .05$).

but positively predicted the linear rate of change in goal value (model 2). This means that, although the initial value of the performance goal was similar across high and low performers, the reduction in goal value was greater in low performers. The reduction in errors of prediction from the unconditional means model to the conditional growth model (ie, equivalent to R^2 values) were 22 and 21 percent for temptation and goal value, respectively. To calculate these explained variance terms, random slopes were replaced by fixed effects.[23]

2.2.3 | Hypotheses 3 and 4: Does autonomous motivation predict temptation and goal value?

As shown in Table 2, autonomous motivation negatively predicted the intercept and the linear rate of change in the temptation to reduce effort (model 3). This means that low autonomy participants started the trial with a higher temptation to reduce effort and this temptation increased at a greater rate, compared with their autonomous counterparts. Autonomous motivation positively predicted the intercept of goal value but not the rate of change (model 4). This means that autonomously motivated athletes reported higher goal value at the start of the trial than their less autonomous counterparts, but the rate of decrease did not differ across participants. The reduction in errors of prediction from the unconditional means models to the conditional growth models were 20 and 19 percent for temptation and goal value, respectively.

2.3 | Brief discussion

This study demonstrated that high (vs low) performers had distinct motivational signatures during an endurance trial. A lower temptation to reduce effort at the start of the trial may indicate that high performers may evaluate the impending experience more positively than lower performers (eg, accepting uncomfortable sensations, less worrying about what lies ahead). In contrast, high and low performers wanted to achieve their goal equally at the beginning of the study, but this goal importance faded quicker in poorer performers. It is

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possible that poor performers reduce goal importance during the task to protect self-worth or attentional resources are dedicated to factors that reduce goal importance. Autonomous motivation may influence the motivational value of the performance goal and temptation to reduce effort from the outset, but only attentional and cognitive processes related to the temptation to reduce effort during endurance tasks.

3 | STUDY 2

Study 1 emphasized the trajectories of the temptation and goal value. The analysis required a multilevel approach because it concerned *inter*-individual differences in *intra*-individual changes in temptation and goal value. That is, do trends in temptation and goal value differ as a function of autonomous motivation and performance? In Study 2, the focus was on the overall indirect process of autonomous motivation > temptation and goal value > performance. An *inter*-individual prospective design was employed, in which study variables were measured in order of the hypothesized sequence with no multilevel structure to the data.

3.1 | Materials & Method

3.1.1 | Participants

Forty participants took part in the study (22 males, 18 females, *M* age = 22.65; SD = 2.61). The participant recruitment strategy was to mimic the number of participants in Study 1 and inclusion criteria were the same.

3.1.2 | Measures

Autonomous motivation, temptation and goal value, and performance were measured identically to Study 1. A measure of frustration regarding the task was taken to examine a different motivational process not relevant to the study hypotheses. An overview of this aspect of the study can be viewed in the Supplementary materials.

3.1.3 | Procedure

Procedures were identical to Study 1, including ethical approval and participant informed consent, apart from the 10-minute cycling trial. Participants were instructed to keep their work rate at 80% *Wmax* for the duration of the task. However, after 5 minutes they were informed that the aim was now to work at a minimum 90% *Wmax*. This was done to examine a separate hypothesis that autonomous regulation was associated with lower frustration when goal pursuit is disrupted (see Supplementary materials for more details). Temptation and goal value were measured at 4 and 6 minutes (before and after the disruption), rather than each minute.

3.1.4 | Data analysis

The Statistical Package for Social Sciences (Version 24.0) was used for all statistical analyses. The PROCESS macro[24] with 5000 bootstrap samples was used to inspect a parallel mediation model to test study hypotheses 1-4, as well as the indirect effects of temptation and goal value on the relationship between autonomous motivation and performance.

3.2 | Results

Descriptive statistics among the study variables can be found in Table 1 (right hand side). The average *Wmax* achieved in the fitness test was 217.13 *W* (range 144-290 *W*). Cronbach's alpha coefficient for autonomous motivation was 0.78. In a preliminary inspection, autonomous motivation was not correlated with change in temptation to reduce effort ($r = -0.10$, $P = 56$) or goal value ($r = 0.15$ $P = .36$) following an increase in task difficulty. Therefore, it was justifiable to use the average temptation and goal value across the two measurements.

3.2.1 | Hypotheses 1-4: Does autonomous motivation associate with performance via temptation and goal value?

Results of the parallel mediation model indicated that autonomously motivated participants reported lower temptation to reduce effort (Hypothesis 3: $b = -2.46$, 95% confidence intervals (CIs): −4.26 to −0.67; $P = .01$) and higher performance goal value (Hypothesis 4: $b = 3.48$, 95% CIs 1.59-5.37; $P = .001$). In turn, temptation to reduce effort negatively predicted performance, (Hypothesis 1: $b = -0.08$, 95% CIs −0.14 to −0.02; $P = .01$), whereas goal value positively predicted performance (Hypothesis 2: $b = 0.07$, 95% CIs 0.02-0.13; $P = .02$). Direct positive effects of autonomous motivation on performance ($b = 0.33$, 95% CIs 0.01-0.64; $P = .04$), indirect effects of temptation ($b = 0.20$, 95% CIs 0.03-0.50), and goal value ($b = 0.26$, 95% CIs 0.01-0.44) were also evidenced. The parallel mediation model yielded a large effect size ($R^2 = 0.33$).

3.3 | Brief discussion

Study 2 evaluated the idea that autonomously motivated individuals perform more optimally during endurance tasks

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because they experience higher value of the performance goal and a lower temptation to reduce effort. The results fully supported this idea by evidencing for an indirect motivational process model. Autonomous motivation predicted performance directly and indirectly via lower temptation to reduce effort and higher performance goal value.

4 | GENERAL DISCUSSION

This paper examines whether endurance partly depends on the motivational conflict between the temptation to reduce effort and the value of the performance goal. This *in-task* motivational process is proposed to be influenced by *pre-task* motivation, conceptualized as the extent a task is coherent with one's sense of identity (ie, autonomous motivation). Data across two studies represent the first empirical demonstration of this model and shed light on previously untested motivational processes as potential cornerstones of human endurance.[1] Concordance between an individual's identity and high-intensity activity represents a promising avenue for extending human capability.

A higher temptation to reduce effort was associated with lower performance. In Study 1, differences in temptation across high and low performers occurred from the outset and remained stable, implying some other explanation than attention changes during the endurance trial. Poorer performers may have anticipatory control processes biased toward proximal hedonic temptations rather than goal-oriented processes[25] or perhaps more inclination toward perceptions of threat.[22] These protective mechanisms are underpinned by a short-term focus at the expense of long-term goals and could form the cognitive basis of a greater temptation to reduce effort. In contrast to differences in temptation, Study 1 demonstrated that high and low performers valued performing well equally at the beginning of task, but high performers could maintain this value more effectively than lower performers. Poor performers may lower goal importance to protect self-worth if one perceives performance to be going poorly. Often these “defensive pessimism” strategies are viewed as a preparatory tactic before activities commence.[26] No work has considered defensive pessimism as protection during activity. Collectively, these findings imply that poorer performers engage in short-term protective cognitive processes at the expense of more distal performance achievements.

In both studies, autonomously motivated participants experienced less temptation to reduce effort. The Study 1 data showed that this temptation increased at a slower rate in autonomously motivated individuals, relative to non-autonomous individuals. During high-intensity exercise, attention is dominated by psycho-physiological sensations that are difficult to ignore.[27] Autonomous individuals may possess greater ability to disregard the incremental build-up of these cues, but this reflective process requires considerable cognitive effort and self-control.[28] More likely is that autonomous individuals appraise the sensations as a necessary part of completing their objective, whereas low autonomous individuals perceive the sensations as antagonistic to the goal. An effective integration of action (resisting temptation) and goal can create a means-end fusion proposed to enhance persistence.[29]

Autonomously motivated individuals also placed higher value on the performance goal than less autonomous counterparts. The concordance between identity-based values and task makes the performance goal highly valued.[13] Although autonomous goals are easier to pursue,[14] the rate of degradation in goal value across the trial in Study 1 did not differ as a function of autonomous motivation. Hence, pre-task autonomous motivation does not impact the goal dynamics during performance, only the goal value as the task commences. Overall, the present studies suggest that the quality of one's motivation before the task influences the quantity of motivation during it.

The individual relationships represent specific insights into motivation prior to and during acts of endurance, but they are part of a collective process. In Study 2, indirect effects of autonomous motivation on performance via temptation and goal value were demonstrated. The extent an impending endurance task is congruent with one's sense of self provides an avenue to better performance at high physical intensities. The theoretical implications of this process model are significant. Few theories of human endurance consider motivational processes, and those that do typically view motivation from a one-dimensional perspective, be it psychological drives[3] or the effort willing to be exerted.[8] The model presented here extends this work by proposing that motivation contains multiple components prior to and during endurance activities. Moreover, the quality of motivation in the form of concordance with one's sense of self is emphasized, which extends the quantity-based perspectives in other theories. This raises new fundamental pathways to potentially extend human performance and represents a gateway for more applied work.

4.1 | Future research directions

The study designs allowed the direction of relationships to be established; however, future research should experimentally manipulate autonomous motivation to establish causality. In addition, to some extent the studies demonstrate nomological validity of the measures of temptation and goal value because they are associated with other variables in theoretically expected ways. Nonetheless, the lack of other types of validity is a limitation of the temptation and goal measures that requires rectifying. From a theoretical perspective, there may be a critical point in which temptation overwhelms goal value and a reduction

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in physical effort is imminent (ie, a decision threshold[6]). This idea should be examined with continuous and sensitive measurement, which would also be able to examine the degree of oscillation between temptation and goal.[6] It would also be valuable to examine different characteristics of the endurance task. Unknown length tasks may require energy conservation[30] resulting in a lower temptation to reduce effort, whereas a known duration may require a balance where the temptation to reduce effort is neither too low nor too high.

Finally, the physiological basis of the desire-goal conflict, such as the degree of concurrency between temptation and goal value and underlying metabolic parameters (eg, blood lactate), is interesting. These physiological parameters have sensations associated with them so could plausibly act as motivational inputs to the desire-goal conflict. The interface of motivation and physiology has implications for psychobiological models of endurance and fatigue[3,8]

5 | PERSPECTIVE

The present study presents a theoretically viable, empirically supported process model that explains the dynamics between pre-task and in-task motivation underpinning endurance performance. This view combines different components of motivation (ie, autonomous motivation and temptation/goal value) to provide a thorough explanation of motivation during endurance that fits well with wider principles of human motivation.[5,9] Moreover, this model differs to other models of human endurance and fatigue[3,8] by considering the quality of motivation as an important motivational pre-cursor to endurance challenges.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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