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Article title: **On the specifics of valuing effort: a developmental and a formalized perspective on preferences for mental and physical effort**

### Point-by-point reply

----- comments Boris Cheval-----

**Dear Authors,**

**The first 2 reviewers involved in the initial evaluation of the paper were convinced by your response. This was also my case.**

**However, due to a potential COI, we have decided to ask for an additional reviewer for this additional step. This is to objectively ensure that our review process is aligned with the gold standard procedure to guarantee an unbiased decision.**

**This new reviewer has raised some very interesting points that I feel need to be addressed before I can recommend publication. Therefore, I ask for a final effort on your part to address the issues raised by this reviewer.**

**Boris Cheval**

**Dear Dr. Cheval,**

**Again, thank you very much for your careful handling of our manuscript. We are pleased to know that the reviewers found our previous revision satisfactory and we appreciate the added comments by reviewer #3 which we have perceived as constructive and helpful. We have now addressed these comments and feel this has further strengthened the paper.**

----- comments Reviewer 3 -----

**Thank you for having the opportunity to read and review this interesting paper. In this study the domain specificity of valuing effort (cognitive vs. physical) was examined based on two studies. Study 1 employed a decision task to measure preferred allocation of cognitive versus physical effort. This measure was shown to be associated with the dispositions of valuing cognitive and physical effort respectively. In the second study the authors showed that the disposition to value cognitive effort was linked to grades in mathematics but not sports. In contrast, valuing physical effort was linked to better grades in sports but not mathematics. Taken together, the results provide first results for the domain specificity of valuing effort.**

**Thank you very much for your positive evaluation of our paper and for providing actionable & helpful comments on how to further improve it! Please find below how we addressed each of the points that were raised.**

**Abstract**

**Line 24: I think that the sample in study 2 with a mean age of 15.25 years ( $\pm 1.57$ ) should not be characterized as schoolchildren. I think that adolescents would be the better characterization.**

**Good point. We have changed this accordingly**

## **Introduction**

**Lines 33-35: I think it could be helpful to refer to and discuss to the Theory of effort minimization in physical activity by Cheval an colleagues in this context. This theory argues that that individuals have an automatic attraction toward effort minimization. Furthermore, this automatic attraction needs to be overridden by controlled processes to become physically active. In how far are the assumptions of this theory relevant for the concept of valuing physical effort?**

**Thank you for pointing us to the TEMPA framework which indeed is relevant for the present paper. We have now added TEMPA at two instances in the introduction. First, we highlight TEMPA's proposition of the automatic tendency towards effort minimization when we discuss how theories of human motivation conceptualize the role of effort costs in human behavior:**

“Contemporary theories of human motivation propose that humans weigh the costs of effort against the rewards associated with its exertion <sup>12,13</sup>. For example, according to the Theory of Effort Minimization in Physical Activity (TEMPA), humans have an automatic inclination to minimize the costs of effort, and these costs are stacked against the value that engaging in an effortful task promises <sup>14</sup>. Simply put, if going for a run is instrumental for my goal to become fitter, the effort that is needed to actually go for the run is weighted against how rewarding it would be for me to reach my fitness goal.”

**Further down, when we summarize instances when effort is treated as if it is valuable, we again refer to TEMPA when highlighting individual differences in the habitual tendency to override this effort minimization tendency if they find enough reward in effortful tasks:**

“For example, people who value cognitive effort (expressed in a high need for cognition) prefer to engage in cognitively demanding leisure activities compared to people who do not value cognitive effort <sup>22</sup>. Consistent with these findings, TEMPA proposes that the automatic tendency to minimize effort varies as a function of individual differences and to some people effortful tasks might even carry enough value to habitually overcome this automatic tendency towards effort minimization <sup>14,23</sup>. Taken together, effort can be valuable and the degree to which one values (or does not value) effort corresponds to real world behavior”

**Line 56: I was wondering if people perceive the effort invested in intrinsically motivated (self-determined) physical or cognitive behaviors as less aversive than in extrinsically motivated (non-self-determined) behaviors? Is valuing the effort invested in an activity associated with the type of motivation? What if learning the language is intrinsically motivated, feels pleasant and is associated with enjoyment?**

Yes, we would expect these efforts to be valued differently indeed. This is also consistent (albeit indirectly) with our finding that students find classes more boring if they don't value the efforts that are most prototypically required in them (e.g., low VoPE -> PE class more boring). While it is likely that intrinsically motivated efforts are less boring & efforts in turn also feel less valuable in general, one can also think of extrinsically motivated tasks that feel valuable and not boring. In light of recent critiques of the "black box problem" that plagues such higher order motivation constructs (see for example Murayama & Jach, 2024, *Behavioral and Brain Sciences*) we have opted to focus on boredom as a fundamental lower order construct. Here, the specific link between boredom and value is an integral aspect of the empirical and theoretical work on what boredom is & when it occurs. However, we fully agree that, generally speaking, differences in intrinsic motivation towards a behavior should affect as how valuable the exertion of effort towards this behavior is perceived. To acknowledge this, we now write:

"If people ascribe little value to physical or cognitive effort, they will thus experience these efforts as boring, with downstream negative consequences on their attention<sup>51</sup>, motivation<sup>52</sup>, self-control<sup>13,46</sup> and performance<sup>53</sup>. Understanding, whether and to what degree people differ in their valuation of effort (both in comparison to others and across different situations) advances our understanding of boredom as a crucial aspect of human behavior. Beyond boredom as a fundamental lower order construct, it is likely that the value people ascribe to certain types of effort differs as a function of how intrinsically and extrinsically motivating they perceive these efforts to be. Unpacking the individual and cumulative explanatory power such higher order motivational constructs have with respect to how people value effort will be a fascinating question for future research. Taken together, the present research also sheds further lights on the interplay between boredom and effort, and highlights the need to investigate the link between effort valuations and other motivational constructs."

**Line 214f: The German grade system is an ordinal scale and therefore parametric statistics such as Pearson correlations might not be suitable.**

**We agree! The Pearson correlation analyses refer only to the relationship between NfC and VoPE. Apologies if this was not clearly stated in the prior version. We now make this clearer in the section where we describe our statistical approach:**

"To describe the relationship of VoPE and NfC in both samples, we computed Pearson correlations."

## **Results**

**Lines 249-252: How can the differences in the mean values between the two samples be explained? Please discuss in the discussion section.**

**As the German and English versions of the scales used different answering scales (1-7; 1-5), we feel the most likely reason for the descriptive difference between scale means across samples is due to this difference in answering scale. We would therefore prefer to not engage in any further interpretation of them. To avoid misunderstandings, we have added a sentence in the results section, highlighting this difference in assessment:**

“In study 1, participants had a mean score of  $M = 4.28 \pm 1.67$  on the VoPE and of  $M = 4.64 \pm 1.38$  on the NfC scale. In study 2, participants had a mean score of  $M = 3.33 \pm 0.91$  on the VoPE and of  $M = 3.41 \pm 0.58$  on the NfC scale. As the range of the answering scales for VoPE and NfC differed slightly between study 1 and study 2 (study 1: range = 1-7; study 2: range = 1-5), differences in mean scores cannot be meaningfully compared between samples. In both studies, the VoPE and NfC scale were weakly correlated,  $r = .18$ ,  $p = .002$  (study 1),  $r = .13$ ,  $p = .030$  (study 2). Thus, although higher VoPE scores were associated with somewhat higher NfC scores, the shared variance between both concepts is  $< 5\%$  in both samples, indicating that physical effort is valued differently to cognitive effort (Figure 2a and 2b).”

**Line 266: In the description of Figure 2 it is stated that “For study 1 the answer scales ranged from 1-7, whereas for study 2, they ranged 266 from 1-5.” Why was the answering scale different between the two studies?**

Please see also the comment above. The range of the answer scales differed between the German and English versions of the questionnaire. We had no particular reason to vary the response scale between the studies. However, as comparisons of sample means are not the focus of our research, our conclusions are not affected by this difference.

**Figure 4: In the labeling of the x-axis the abbreviation ME (mental effort) should be changed in CE (cognitive effort).**

Thank you for pointing this out. We have now changed this accordingly.

**Line 156: Please provide the median for the income of the participants.**

We have queried income with categories (such as \$5,000 to \$11,999, \$12,000 to \$19,999 etc). Therefore, we cannot compute measures of central tendency for this variable. To provide the reader with all information, we have uploaded a table with the % of responses per income category to the OSF.

**Line 301ff: As mentioned above, grades hold an ordinal measurement level. Is a linear regression analysis adequate to examine the hypothesis?**

We fully agree and we have therefore also performed an ordered logit regression analysis to account for this. As this analysis did not yield results that differed in a meaningful way from the linear model, we have decided to report the linear model for the sake of simplicity. However, we refer to the ordered logit regression in the text and we have uploaded the results of this analysis to the OSF. See below for the respective instances in the paper:

“It can be argued that these dependent variables might be better modeled in an ordinal fashion. To account for this, we replicated the multivariate linear regression analyses with ordered logit regression analyses. As this did not meaningfully change results, we will not report these additional analyses in the results section but have included the respective R code along with the results into the uploaded data analysis script to the OSF page of this paper.”

**Footnote:**

“<sup>1</sup> The ordered logit regression analyses yielded similar results. The only exception being that two effects that were on the verge of significance in the linear model were significant in the ordered logit regression (VoPE on math grade, NfC on sports grade. This does not alter any of the interpretations in this manuscript. Please find these results in the OSF page of this paper (SI 3).”

**Thanks again for taking the time to review our paper and for providing thoughtful and helpful comments. We feel this has further improved the quality of our paper.**