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On the specifics of valuing effort: a developmental and a formalized perspective on preferences for cognitive and physical effort

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Abstract

Effort is instrumental for goal pursuit. But its exertion is aversive and people tend to invest as little effort as possible. Contrary to this principle of least effort, research shows that effort is sometimes treated as if it was valuable in its own right, and people exhibit stable differences with respect to their valuation of effort. Critically, individual-difference research that investigates if this valuation of effort is domain-general or specific to cognitive or physical contexts is lacking. Simply put, do people value (or not) any effort or are preferences specific to the cognitive and/or physical domain? Here, we investigate this question using a formalized mathematical approach (study 1) and from a developmental perspective (study 2). Study 1 employed a validated decomposed binary decision task to measure preferences regarding the allocation of cognitive versus physical effort. In a sample of N = 299 paid online workers (37% female, *Mage* = 38.79 $\pm$ 11.24 years), we found that people differ markedly with respect to their preferred effort allocation. Multinomial regression analyses revealed that the disposition to value cognitive effort was linked to a preference for high cognitive effort, whereas the disposition to value physical effort was associated with a preference for physical effort. In study 2, we tested the robustness of these hypothetical preferences for effort allocations in a field context: In a sample of N = 300 schoolchildren (61% female, *Mage* = 15.25 $\pm$ 1.57 years), we found that the disposition to value cognitive effort was linked to better grades in mathematics but not sports, whereas valuing physical effort was linked to better grades in sports but not mathematics. Supporting the hypothesis that people find activities of low value boring, valuing cognitive effort was linked to less boredom in mathematics and valuing physical effort was linked to less boredom in sports. Taken together, these results suggest that people are specific in the type of effort they value (or not), and these preferences are present already at young age. This has theoretical and practical implications with respect to how people approach effortful tasks.

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Introduction

Effort is instrumental for attaining goals (Brinkmann et al., 2021; Shenhav et al., 2017; Tsai, 1932), but the principle of least effort (Tsai, 1932; Zipf, 1949) posits that people try to avoid exerting effort if possible. This is because exerting effort feels aversive (Wolff, Sieber, et al., 2021) and in turn carries an inherent cost (Kool & Botvinick, 2013; Kool et al., 2013), which is reflected in current definitions of effort (and the perception of it). Operationally, effort has been defined as a mediator between task characteristics and a person's task-specific capabilities on one side, and the achieved task performance on the other side (Shenhav et al., 2017). To illustrate, say, a runner is asked to run five kilometers in 20 minutes (task characteristics) and has a personal record of 16 minutes over this distance (capabilities). Effort is what mediates between these characteristics and the achieved running time. Simply put, for a runner with a 16 minutes record, the task to run five kilometers in 20 minutes will probably require less effort than for a runner with a 19 minutes record. Focusing on effort's inherent costliness, some research emphasizes that effort relies on finite resources (Halperin & Vigotsky, 2024), whereas other research points towards functional processing constraints that make the exertion of effort costly (Feng et al., 2014). Importantly, effort is not only conceptualized in terms of its objective properties but also with respect to how the exertion of effort feels (Halperin & Vigotsky, 2024; Steele, 2020). Current definitions of this feeling also emphasize effort's costliness by referring to the perception of effort as the "instantaneous experience of utilizing energy to perform an action" (p1 of Halperin & Vigotsky, 2024), and conceive perception of effort as a meter for the "momentary cost of effort investment" (p3 of Xu et al., 2024). This begs the question of how people choose to utilize this costly instrument.

Contemporary theories of human motivation propose that humans weigh the costs of effort against the rewards associated with its exertion (Shenhav et al., 2013; Wolff & Martarelli, 2020). 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 (Cheval & Boisgontier, 2021). 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. The same reasoning applies to effort that is exerted in the cognitive domain: If my goal is to learn Italian, then I weigh the efforts needed to master the language (i.e., memorizing new words and grammar rules) against how valuable it would be for me to actually speak Italian.

As the examples of getting fit and learning a new language highlight, effort is needed to achieve those goals. However, do these efforts necessarily have to be aversive and feel costly? Most people can probably think of people who value the effort of going for a run or studying a new language. Treating effort as something that adds value to an outcome or that is valuable in its own right is at odds with widely accepted principles of human behavior, such as the resource conservation principle (Richter et al., 2016) or the principle of least effort (Tsai, 1932; Zipf, 1949). The observation that effort can be both costly and valuable has been referred to as the 'effort paradox', and has recently started to receive increased research interest (Inzlicht et al., 2018). Studies have for example shown that effort can add value to an outcome it helped to attain. To illustrate, research that was informed by the motor sunk cost effect found that people were more confident in their choices if they had to invest more effort to indicate their choice (Turner et al., 2021). Effort can also be valuable in its own right, and under certain conditions effortful choices are preferred regardless of the reward they produce (Bernacer et al., 2019; Clay et al., 2022). Beyond experimental manipulations that test if effort can be valuable, research on individual differences shows that people exhibit stable differences with respect to their valuation of effort (Bieleke, Staehler, et al., 2023; Cacioppo & Petty, 1982). 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 (Therriault et al., 2015). 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 (Cheval & Boisgontier, 2021; Cheval et al., 2024). Taken together, effort can be valuable and the degree to which one values (or does not value) effort corresponds to real world behavior.

Effort can be exerted in the physical (e.g., going for a run) and in the cognitive domain (e.g., learning a new language). By extension effort can then also be valuable in both domains. This begs the question of how domain-general or domain-specific the valuation of effort is: Do people value (or do not value) effort in general or do they discriminate physical and cognitive effort in their valuation? Neuroscientific evidence points towards shared algorithmic and neuronal underpinnings of cognitive and physical effort regulation (Chong et al., 2017; Ritz et al., 2020). In addition, it has been shown that theories on the regulation of cognitive effort can also account for the regulation of physical effort (Manohar et al., 2015; Wolff, Hirsch, et al., 2021). However, a shared regulatory architecture does not imply the same valuation outcome for cognitive and physical effort. For example, the Expected Value of Control theory – a mechanistic account on the regulation of cognitive and physical effort – explicates different afferent streams of information that contribute to the costliness of effort (e.g., signals originating from the Insula or the Amygdala), as well as the involvement of reward structures that contribute to the value of applying effort (e.g., signals from the Orbitofrontal Cortex) (Shenhav et al., 2013). In turn, it is likely that although the underlying computation of effort as costly or valuable has the same computational properties, the inputs (e.g., the sensations that accompany the exertion of effort) and valuation weights might differ drastically between physical and cognitive effort. Thus, it is plausible that the valuation of cognitive and physical effort is rather domain-specific and does not robustly generalize to an overall preference for any effort.

Research that investigates if effort valuation is domain-specific is scarce, and the available evidence does not point towards a strong generalization of effort preferences (Bustamante et al., 2014; Chong et al., 2018; Van Yperen et al., 2021). Chong et al., compared the effort discounting patterns in the cognitive and physical domain between elite athletes and non-athletes (if effort is discounted at lower rate, this indicates that it is less aversive and more valuable) (Chong et al., 2018). They found that elite athletes discounted physical effort less than non-athletes, and that elite athletes and non-athletes differed in the way they discounted cognitive effort (concave discounting pattern in athletes and convex pattern for non-athletes) (Chong et al., 2018). In the same vein, Van Yperen et al. found that student athletes reported a greater willingness to invest effort towards sport than towards the school domain (Van Yperen et al., 2021). Importantly, this study did not assess if student athletes were valuing the exertion itself. Instead, participants were queried how willing they were to use effort as an instrument for success. Therefore, differences in the willingness to exert effort towards sports or school might also reflect differences in how valuable either goal was to them. Moving away from athletes, Bustamante et al. found that training to exert effort in the mental domain did not translate to a greater persistence in a physical effort task (Bustamante et al., 2014). Thus, the authors were interested if effort valuations would generalize across domains and found this not to be the case. Taken together, research indicates that specific populations (e.g., athletes) value efforts that are specific to them more than other forms of effort, and they also value such efforts more than other people would (e.g., non-athletes). Thus, effort valuations seem to be rather specific and do not necessarily spill over to other domains.

Clearly, research on the domain-specificity or domain-generalness of effort valuations is just getting started, and has so far primarily focused on experimental research that assesses effort preferences and generalizations in standardized lab tasks. Research outside the lab has not yet used validated measures that assess how much people value certain types of effort but has rather looked at peoples' willingness to invest effort. This is a non-trivial distinction as the former emphasizes the value of effort, whereas the latter emphasizes willingness to utilize effort as an instrument. In turn, research that investigates stable individual differences in domain-specific effort valuations and assesses how specific they are in predicting different "effort outcomes" in specific domains is lacking. This gap in the literature can be explained by the hitherto lack of a validated measure for the assessment of the value of physical effort. Fortunately, the recently developed *Value of Physical Effort* (VoPE) (Bieleke, Staehler, et al., 2023) scale represents a validated and efficient complement to the *Need for Cognition* (NfC) scale, which is an established measure for the value of cognitive effort (Cacioppo & Petty, 1982).

The Present Research

With two studies, we investigate the specificity of the VoPE and the NfC scale in accounting for preferences, correlates, and outcomes of effort in the cognitive and the physical domain.

In a first study, we investigate people's general preferences for the allocation of physical and cognitive effort. In line with classic research on the principle of least effort (Tsai, 1932), a preference for less cognitive and/or physical effort will be interpreted as a rough proxy that the corresponding effort is costly. A preference for more cognitive and/or physical effort will be interpreted as a rough proxy that the corresponding effort is valuable. This will provide first insights regarding the relative distribution of effort as something that is costly and should be avoided versus something that is inherently valuable. Importantly, we do not expect effort valuation to be domain-general. Thus, a person might strive to maximize physical effort but be neutral towards cognitive effort. In turn, we expect differences in effort preferences as a function of each effort domain, and we expect VoPE and NfC scores to predict participants' preferred effort combinations.

In a second study, we adopt a developmental perspective. We focus on developmental aspects, because experimental research shows that adolescents tend to be willing to invest more effort than strictly needed to reach a goal (Rodman et al., 2021; Sullivan-Toole et al., 2019), which might point towards less specific cost-value configurations in younger people. However, research that has investigated if adolescents already exhibit self-reported effort valuations across domains, and if such valuations covary with meaningful outcomes, is lacking. Addressing this gap, we assess if differences in the value of physical effort and cognitive effort covary with differences in school grades in school classes that are prototypically related to these types of effort: sports and mathematics. With respect to correlates of valuing effort, we further investigate if pupils who do not value physical effort find sports boring, and if those who do not value cognitive effort find math boring. This reasoning comes from theoretical work proposing that people get bored when they feel they are not utilizing their resources adequately (Wolff et al., 2024). Simply put, if one does not value physical effort, then activities that rely on this type of effort are likely to be experienced as boring.

Methods

Participants

In study 1, N = 325 participants were recruited from Amazon's website Mechanical Turk (MTurk; requirements: ≥ 100 HITs, approval rate ≥ 90%, US citizenship) and received 1 US Dollar for compensation. We used MTurk, as it allowed us to optimize project resources and sample a large enough US sample withing a relatively short timeframe. 26 participants (8%) did not respond to the instructional manipulation check item correctly or did not finish the study and were thus removed from further analyses. The remaining sample consisted of n = 299 participants (about 37% female, 0.33% divers, 0.33% preferred not to say; the remaining participants were male[i]) with an average age of 38.79 years (SD = 11.24). The majority of participants reported 13 years or more of education (87.28%), were either working full-time (65.89%) or self-employed (14.72%), and earned an income of $20,000 to $80,000 (70.91%) per year. Participants reported an average weekly training duration of M = 217 minutes (*SD* = 189) and the majority had none (63.55%) or amateur level (22.07%) experience in sport competitions. In study 2, *N* = 300 pupils (about 62% female) with an average age of 15.18 years (*SD* = 1.54) from a school in southern Germany completed a paper-and-pencil survey during class. Pupils were not compensated for their participation. In both studies, participants were only eligible for participation after having giving informed consent. In study 2, written informed consent from participants caregivers was obtained as well. Both studies were in line with the guidelines laid out in the Declaration of Helsinki and no additional IRB assessment was required as per the guidelines of the ethics committee of the authors' institution. With respect to sample size determination, we followed the recommendation by Funder and Ozer to aim for samples as large as project resources permit in order to obtain the most stable estimates (Funder & Ozer, 2019). This study was not pre-registered and therefore no power analysis for specific statistical models were performed a priori. However, as all analyses would be carried out within a regression analysis framework, we aimed for a sample size that is sufficiently large to provide high power to determine significance of small effects in regression analyses (Faul et al., 2007). All materials (questionnaires, data with full demographic information, and R-script for data analysis can be retrieved at https://osf.io/fhdgc/).

Measures and Procedure

Study 1

Value of physical and cognitive effort. The value of physical effort was measured with the VoPE scale (Bieleke, Staehler, et al., 2023). The VoPE scale consists of 4 items (sample item: "I greatly enjoy sports activities that require physical effort.") which have to be answered from 1 = Strongly disagree to 7 = Strongly agree. Scale reliability was excellent, *McDonald's omega* = .92. The value of cognitive effort was measured with the NfC scale (Cacioppo & Petty, 1982; Cacioppo et al., 1984). The NfC scale consists of 18 items (sample item: "I find satisfaction in deliberating hard and for long hours") which were answered on the same scale as the VoPE. Scale reliability was excellent, *McDonald's omega* = .96.

Preferences for physical and cognitive effort. To assess preferred effort allocations, we used a validated computational approach to measure social preferences with decomposed binary games known as the "Ring Task" (Bieleke et al., 2020; Murphy & Ackermann, 2014). In the original Ring Task, people make 24 decisions about how to allocate monetary payoffs between themselves and another person, which are then aggregated into a single score that represents one's relative preference for oneself versus the other person. To achieve this, the payoffs participants consider in each decision represent points on a circle in a Cartesian coordinate system, and the decisions can be summarized as a vector in this coordinate system. We adapted this task to the domain of physical and cognitive effort preference for our research purposes. In the adapted Ring Task, participants make binary choices about their preferred allocation of physical and cognitive effort. The range of effort values was between 0 (minimal physical or mental effort) and 100 (maximal physical or mental effort) forming a circle with a center at (50, 50) (see Figure 1a for an illustration of the instructions participants received and for an example of a choice). The angle of the vector summarizing their choices can be interpreted as relative preference for cognitive versus physical effort:

$$\theta = arctan\left(\frac{\sum(PE-50)}{\sum(CE-50)}\right) \quad (1)$$

where PE and CE represent physical and cognitive effort allocations, respectively. The resulting angle is then associated with one of eight idealized preference types that represent the eight cardinal directions from the center to the outer track of the ring (Murphy & Ackermann, 2014). Each of these eight idealized preference types can be precisely described by its location in the Cartesian plane that is spanned by the two effort dimensions (see Figure 1b). For example, some people might minimize any effort ("Minimize PE + CE"; bottom left of the figure), whereas others might only focus on maximizing physical effort ("Maximize PE"; top of the figure).

Additional measures: As additional measures, we collected demographic variables, such as age, gender, income, employment, weekly training, and whether participants had ever participated in a sporting competition. Other variables were collected, which are not relevant for this paper.

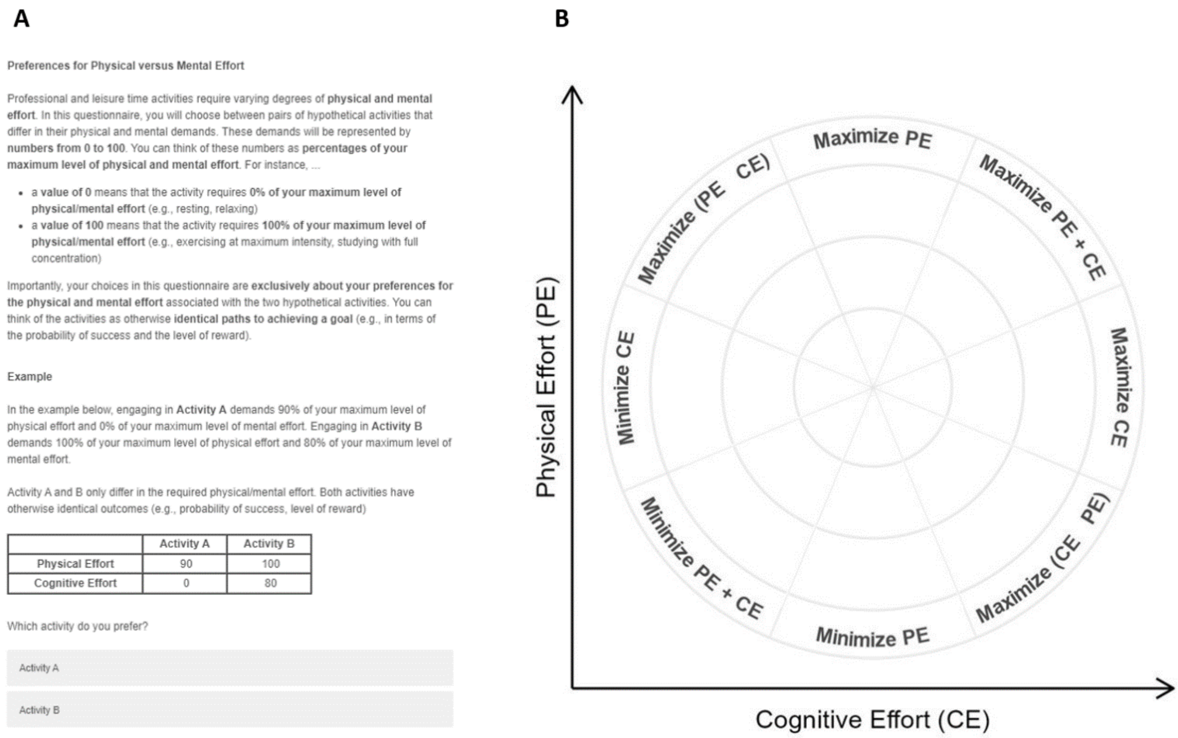

Figure 1 - Panel A shows the instructions for the Ring Task with an example task (For a full-page view of Panel A, please go to https://osf.io/uz7gt. Panel B shows the eight idealized effort preferences in a coordinate system. *Note*. PE = physical effort, CE = cognitive effort.

Study 2

To measure VoPE and NfC, we used German translations of the original scales (Bieleke, Staehler, et al., 2023; Bless et al., 1994), which exhibit acceptable and good reliability, *McDonald's omega* = .77 and .85[ii]. Answers were given on a five point Likert-type scale ranging from 1 = Strongly disagree to 5 = Strongly agree. Pupils further reported their latest grades in mathematics and sports. It has to be noted that in the German grade system, a "1" represents the best grade and a "6" represents the worst grade. Thus, we expect a negative correlation between the value of effort scale and the respective domain-specific grade. Additionally, pupils reported how boring they found mathematics and sports on a scale from 1 = does not apply to 5 = does fully apply. They further gave demographic information like age and gender.

Statistical Analyses

All analyses were conducted using the statistical software R version 4.3.1 (R Core Team, 2023). We provide the raw data and prepared data along with the utilized RScripts containing a complete list of the used R packages online (https://osf.io/fhdgc/). Data preparation and plotting was mainly done using the package tidyverse version 2.0 (Wickham et al., 2019).

To describe the relationship of VoPE and NfC in both samples, we computed Pearson correlation analyses. In addition, we conducted psychometric network analyses to assess if VoPE and NfC items constitute separable communities, utilizing the package EGAnet version 1.2.3 (Golino et al., 2022).

In study, 1, we used the Ring Task to characterize participants' preferences for physical versus cognitive effort. As the eight preference types represent levels of a categorical variable, we conducted a multinomial regression to predict the preferred configuration of cognitive and/or physical effort using VoPE and NfC as predictor variables. A multinomial regression predicts a nominal dependent variable with k levels through a series of k-1 dichotomous comparisons to a reference category. In our analyses, we chose “minimize PE + CE” as the reference category and compared it to the remaining seven configurations. Minimizing both types of effort was chosen as the reference category because it aligns with the presumed principle of least effort that is understood to mostly govern behavior[3]. The multinomial regression quantifies the likelihood of being categorized as not belonging to the reference category as a function of the predictor variables. For ease of interpretation, we use odds ratios to indicate how much the likelihood for not belonging to the reference category changed if VoPE and NfC values changed. For these analyses, we employed the packages nnet version 7.3-19 (Venables & Ripley, 2002) and VGAM version 1.1-8 (Yee et al., 2015).

In study 2, finding math and sports boring, as well as grades in math and sports were the dependent variables of interest. To assess the link between VoPE and/or NfC with each of these variables, we conducted a multivariate linear regression analysis with VoPE and NfC as predictor variables. 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.

Results

Descriptive statistics

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).

To further investigate if NfC and VoPE scales represent differentiable constructs, we conducted exploratory graph analyses. For both studies, the exploratory graph analysis for the VoPE and NfC items formed three clusters (Figure 2c and 2d): One VoPE community and two NfC communities. (With the exception of two items in study 2, community membership for the NfC items could be fully explained by the direction of item wording.) Bootstrapping indicated that the communities are stable (1000 iterations), as all items were assigned to the same communities in 100 % of the cases for study 1. For study 2, the VoPE items were 100 % stable, whereas the NfC items showed a less stable community assignment (range between 50 % to 85 %).

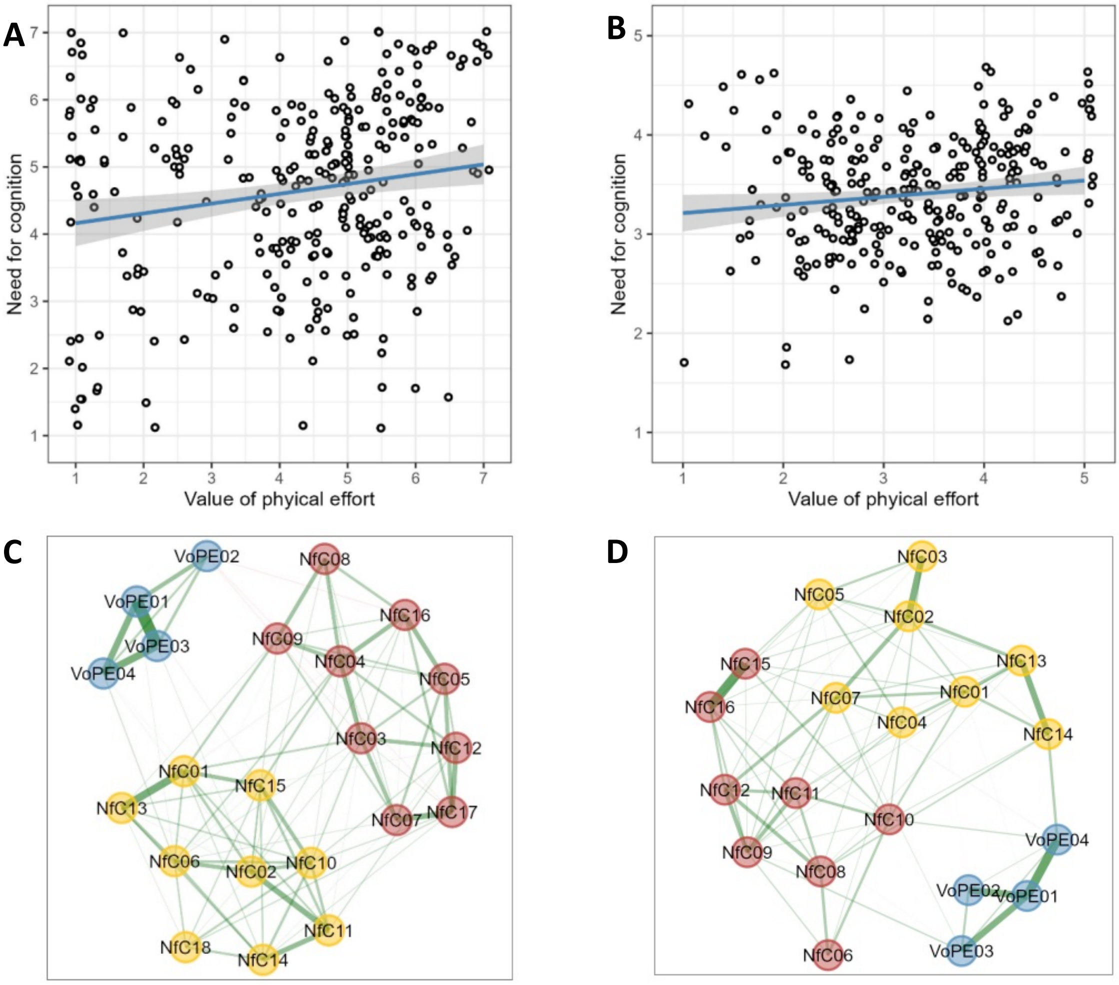

Figure 2 - Panel A (study 1) and B (study 2) show scatterplots depicting the relationship between the VoPE and the NfC scores. Panel C (study 1) and D (study 2) depict the estimated networks for the VoPE and NfC items. For study 1 the answer scales ranged from 1-7, whereas for study 2, they ranged from 1-5. Complementing the raw data, the regression line along with the 95% confidence interval is included into Panel A and B. Blue community = Value of Physical Effort Scale, red and yellow communities = Need for Cognition Scale. The red and yellow communities primarily differ with respect to positive and negative item wording.

Value of effort and effort preference (Study 1)

In study 1, each person was categorized into one of eight idealized effort preference types (i.e., the preferred configuration of cognitive and physical effort). The absolute frequencies of the assignments are shown in Figure 3. A preference to minimize physical effort was displayed by 21% of participants, 8% preferred to minimize cognitive effort, and 18% prefered to minimize both types of effort. In support of the idea that not everyone minimizes effort, 15% of participants showed a preference to maximize cognitive effort, 6% preferred to maximize physical effort, and 16% preferred to maximize both types of effort.

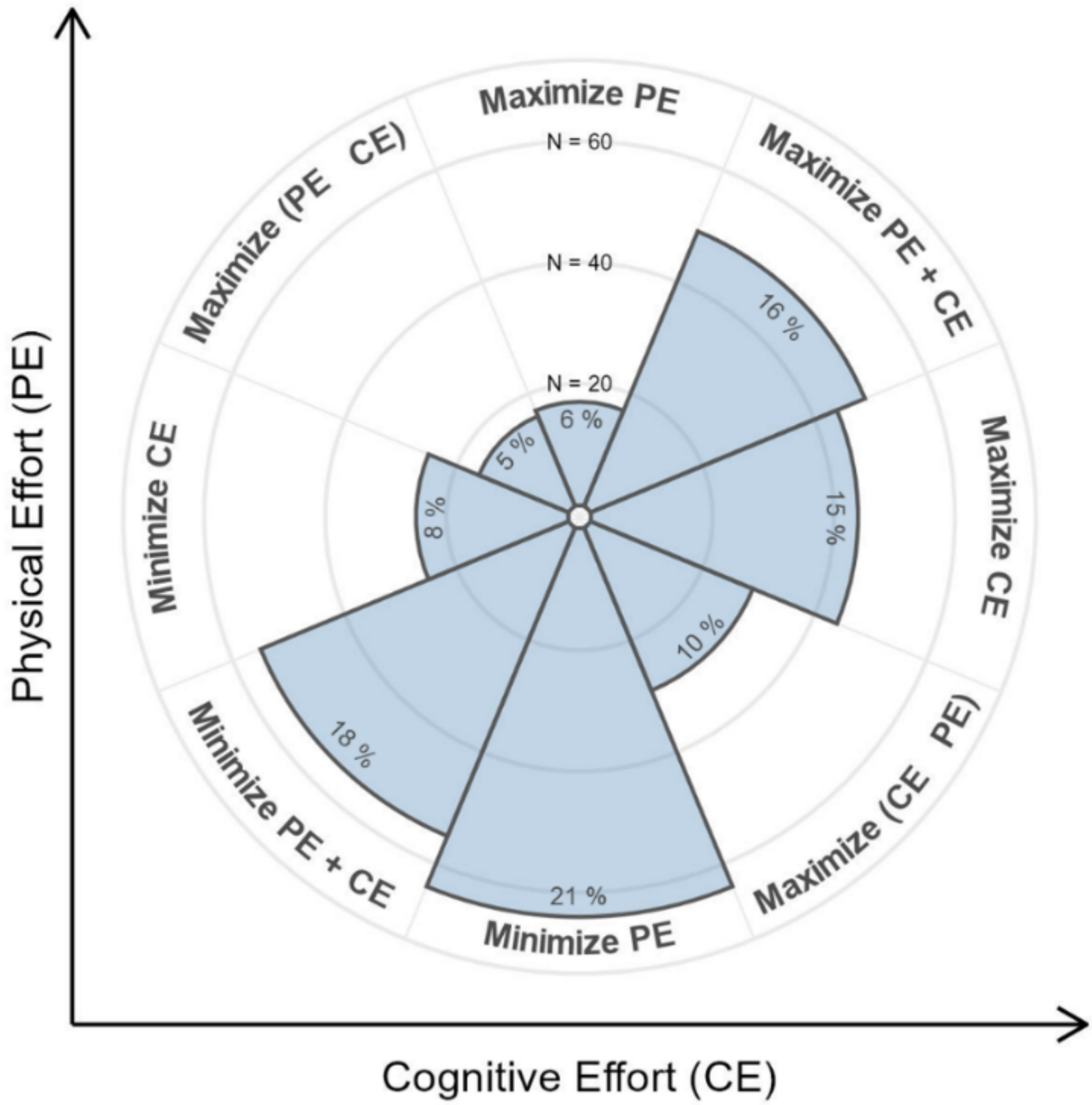

Figure 3 - Circular histogram showing the absolute frequencies and percentages of the eight idealized effort preference configurations. Each slice represents one configuration. The size of the slices corresponds to the absolute number of participants per preference configurations (see circular grid).

Results of the multinomial regression analysis reveal a rather consistent mapping of VoPE and NfC scores to the types of effort preferences that were identified with the Ring task (Figure 4). To illustrate, people with higher scores on the VoPE scale are more likely to belong to categories that maximize physical effort and people with high scores on the NfC scale are more likely to belong to categories that maximize cognitive effort. In line with this, people who preferred configurations in which the difference between cognitive and physical effort demands was maximized (e.g., "Maximize CE – PE") displayed correspondingly large differences in their NfC and VoPE scores. Please see Table 1 on the OSF for the full numerical results of the multinomial regression. Here, we provide all estimates, along with corresponding *p*-values and odds ratios for both predictors for each of the effort preference types, compared to the reference category "minimize PE + CE" (https://osf.io/fhdgc/).

Value of effort, school grades, and boredom (Study 2)

A multivariate linear regression analysis indicated that the VoPE and NfC are significant predictors of boredom in math and sports, as well as of math and sports grades, $F(4, 267) = 53.226$, $p < .001$ and

$F(4, 267) = 28.238$, $p < .001$. As Figure 5 shows, NfC but not VoPE is a significant predictor for the grade in math, whereas VoPE but not NfC is a significant predictor of the sports grade. In both subjects, grades are better for pupils that score high on the corresponding scales. For finding math boring, both predictors become significant. However, regression coefficients for NfC are stronger than for VoPE, and the respective 95% confidence intervals do not overlap (Figure 5). If pupils score high on either scale, they find math less boring. For finding sports boring, only the VoPE is significant with a negative association. This implies that pupils who value physical effort tend to find sports not boring. Please see Table 2 on the OSF for the full numerical results of the multivariate regression analyses[iii]. Here, we provide all estimates, along with corresponding *p*-values and confidence intervals for both predictors and for each of the four dependent variables (https://osf.io/fhdgc/).

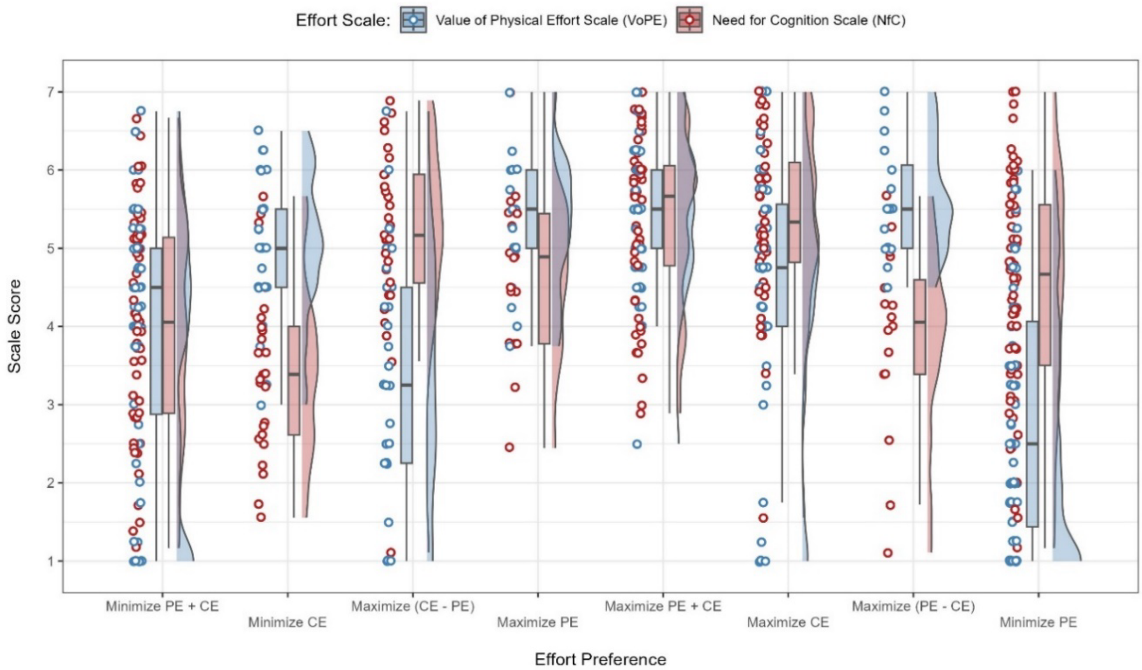

Figure 4 - Individual scale scores on the VoPE and NfCS (circles), boxplots, and density distributions for each preference configuration. VoPE and NfC scores map well on the specific effort requirements of the preferred effort configurations, as evidenced by high values in configurations where high effort is required, low values where low effort is required, and moderate values when this effort type is not involved in the preferred effort configuration (for example, VoPE scores are similar for “Minimize CE” and "Maximize CE”). *Note*. PE = physical effort, CE = cognitive effort.

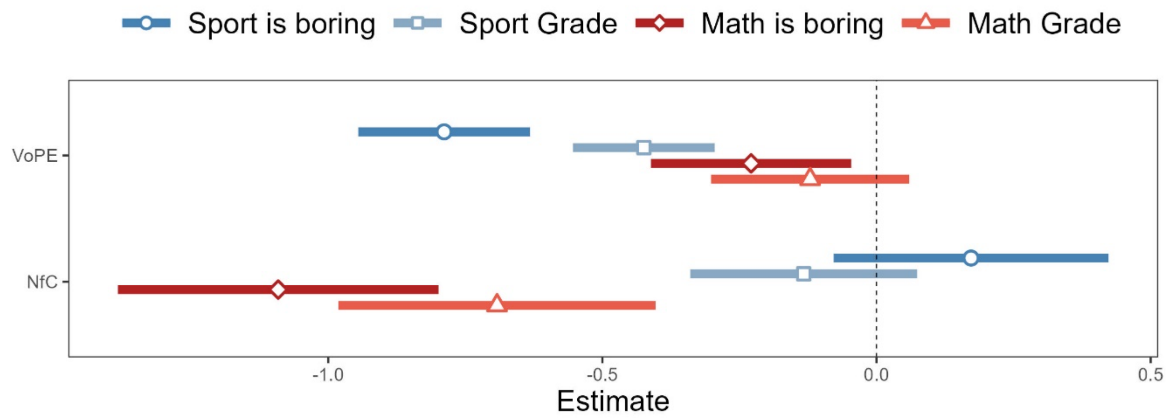

Figure 5 - Multivariate regression weights for both the VoPE and the NFC scale, for each outcome. Regression coefficients for sports-related variables are stronger for the VoPE and weaker for the NfC scale. This pattern is reversed for math related variables. Note. Grades range from 1 to 6, with 1 representing the best and 6 the worse grade. Error bars represent 95% confidence intervals around the regression estimates.

Discussion

With two studies, we investigated the specificity in people's valuation (or lack of valuation) of physical and cognitive effort. Value of physical effort was measured with the newly developed VoPE scale and was contrasted with the value of cognitive effort, which was measured with the established NfC scale. Across an adult (study 1) and an adolescent (study 2) sample, we found that that VoPE and NfC were only weakly correlated and psychometric network analyses revealed that VoPE and NfC items belonged to separable communities. These results indicate that people differentiate between these types of effort and value them differently. Our main analyses revealed that VoPE and NfC were specifically linked to choices (study 1), as well as to experiences and outcomes (study 2) that were representative of the type of effort they reflected. In study 1, we used decomposed binary decisions to assess which physical and cognitive effort configuration people preferred. Consistent with the hypothesis that differences in VoPE and NfC scores reflect differences in the preferred types of effort, multinomial regression analyses revealed that people who scored high on VoPE tended to make choices that would require higher physical effort. Likewise, high NfC scores were linked to a preference for choices that required high cognitive effort. Interestingly, NfC and VoPE seemed to predict choice behavior separately, which was for example reflected in high scores for NfC and VoPE in people who preferred to maximize cognitive and physical effort, and low scores for those who preferred to minimize both types of effort. In study 2, we assessed if NfC and VoPE scores would statistically predict grades and boredom in math and sports. Consistent with the hypothesis that valuing types of effort would be linked to low boredom in tasks that require this type of effort, we found that high VoPE and NfC scores covaried with less boredom in sports and math, respectively. Likewise, high VoPE and NfC scores were linked to better grades in sports and math, respectively. Importantly, VoPE was specifically associated with boredom and grades in sport, whereas NfC was specifically associated with boredom and grades in math.

Implications

The idea that effort might not be used purely for instrumental reasons but might also carry an intrinsic value is not new (Inzlicht et al., 2018; Stähler et al., 2023). However, research on individual differences between the valuation of effort across different domains had so far been lacking. The small correlations between measures of cognitive and physical effort as well as their distinct network communities in the present research can be seen as initial evidence that people do not evaluate the value of effort in a uniform way. Instead, people might like both types of effort, or none at all, or just one but not the other. How can we explain the existence of domain-specific preferences for effort? To answer this question, it seems important to think about why people would value effort in the first place. According to the theory of learned industriousness (Eisenberger, 1992), the valuation of effort can be interpreted through the lens of conditioning. Accordingly, people might initially use effort in an instrumental fashion (i.e., to attain certain goals). If effort repeatedly yields rewards, people will start to value effort in its own right. For instance, children who receive rewards for a certain type of effort (e.g., good grades after learning for a math exam, praise for their athletic training) should increasingly value this effort. Importantly, this value of effort turns into a secondary reinforcer that becomes rewarding by itself, even when the effort is no longer rewarded.

If some people value effort regardless of its instrumentality as a means for goal attainment, this poses intriguing questions about the relationship between effort, motivation, and task difficulty. For example, Motivation Intensity Theory proposes that the amount of effort a person should mobilize towards a task is a function of task difficulty and potential motivation (Richter et al., 2016; Brinkmann et al., 2021). Accordingly, depending on how motivating a task is, people tend to mobilize more effort, while trying to conserve resources as to not overexert themselves. A large body of research is consistent with the propositions of Motivation Intensity Theory (Richter et al., 2016). Intriguingly, if effort can be valuable in its own right, then this suggests that its mobilization is motivating too. In this scenario, not only the motivating downstream properties of what the task is allowing one to achieve (e.g., winning a race or bragging rights for training harder than everyone else) define how much effort one should mobilize, but the effort itself would contribute to the motivation as well. Consequently, task difficulty might not set the ultimate upper boundary for how much effort one should mobilize; rather, people might exert more effort than required. Evidence for such a decoupling of effort mobilization from outcome-specific motivation and task difficulty comes from research in the sports context showing that people overshoot required effort targets (Brinkmann et al., 2021) or from athletes who overexert themselves in ways that are detrimental to their long-term performance (e.g., the phenomenon of overtraining). The interpretation that these are cases of people valuing effort – and in turn being motivated by its mobilization – is a highly speculative one. It is also plausible that other concurrent factors motivate, and thereby license, excessive effort mobilization. To better understand this, it is important to not only track preferences for more or less effort, but to also assess the motivation to do so. Unfortunately, our study did not include a measure of motivation and further research is needed to address this limitation.

Whether effort's reinforcing properties generalize or remain domain-specific is a fascinating open research question: does learning to like effort in one domain (e.g., physical effort) generalize to other domains (e.g., cognitive effort)? While research in patients with eating disorders suggests that anorectic patients might actually value exerting effort across different domains (Haynos et al., 2021), research in non-clinical settings and on interventions that were designed to promote generalization of effort valuation from the physical to the mental domain (and vice versa) has yielded inconsistent results so far (Bustamante et al., 2014; Chong et al., 2018; Lin et al., 2024; Van Yperen et al., 2021). Thus, further research is needed to understand how principles such as learned industriousness can explain individual differences in effort preferences across domains.

From a methodological and a conceptual perspective, it is noteworthy how well aligned our different measures of the value of effort (questionnaires, decision tasks) and its behavioral consequences (boredom, grades) were. The choices in study 1 are a very proximal indicator of peoples' effort preferences, whereas topic-specific boredom and grades are much more distal proxies of one's effort preference. While the former might be considered as somewhat sterile and inconsequential (participants only indicated their preference for a hypothetical effort configuration), the latter might be perceived as rather inaccurate, since liking the effort to do something does not necessarily translate to performing it well. We believe that the consistency of the present results across the vastly different methodological approaches in study 1 and study 2 offers some interesting first implications for further directions on the generalization of effort across a wide range of effort valuation proxies. For example, preferences assessed with the VoPE scale and the NfC scale corresponded closely to the preferences for physical and mental effort determined in the Ring Task in Study 1. This provides a first insight into the validity of the Ring Task as a measure of the value of effort. Future research could therefore use the Ring Task to study preferences for effort using actual (rather than hypothetical) incentives by implementing participants' choices. For instance, participants could be told in advance that one of their decisions they make will be randomly selected and then implemented by giving them as task with the corresponding mental and physical demands. This would go beyond the focus on self-reported preferences in questionnaires. Second, preferences for cognitive versus physical effort were meaningfully associated with boredom and grades in Study 2. This indicates that effort preferences matter for decision-making and behavior in daily life already at a young age. From a more applied perspective, it could therefore be worthwhile to assess (and foster) young peoples' specific effort valuations. However, it is important to note that while the consistency in results across different methodological approaches offers some intriguing implications for our understanding of effort generalizations, further research needs to test how effort valuations translate to different more or less direct proxies of effort preferences.

The present research has intriguing implications for current theorizing about the role of boredom for human behavior (Bieleke, Wolff, et al., 2023). Converging evidence suggests that boredom signals that an activity does not fully utilize someone's cognitive and/or physical functions, prompting them to engage in different activities instead (Wolff et al., 2024). A better understanding of when we get bored is highly relevant because research shows that boredom is a driving force for many adaptive and maladaptive behavioral choices (Bieleke et al., 2024), and has even been identified as a general confound in behavioral science research (Meier et al., 2024). Boredom arises when we engage in activities that are of low value (Martarelli et al., 2023; Pekrun et al., 2010). 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 (Eastwood et al., 2012), motivation (Bench & Lench, 2019), self-control (Bieleke, Wolff, et al., 2023; Wolff & Martarelli, 2020) and performance (Wolff et al., 2023). 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 (Murayama & Jach, 2024) 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.

Limitations and Future Directions

Our research has limitations that should be taken into account. First, we employed a cross-sectional study that does not permit to draw causal conclusions. For instance, it might be that a low value of cognitive or physical effort is the cause of boredom and worse grades in Study 2. Alternatively, experiencing boredom in class and obtaining bad grades might reduce the value of effort, and reciprocal causal effects are plausible as well. Future research might use longitudinal study designs to capture the temporal dynamics of these effects, or experimentally vary the value of physical and/or cognitive effort to investigate its effects on boredom and performance. Second, decisions in the Ring

Task and responses to the VoPE and the NfC scale are hypothetical. As mentioned above, it would be interesting to see how aligned these hypothetical responses are to actual behavior (e.g., by incentivizing the Ring Task). Similarly, school grades are a proxy of actual behavior, as the effort invested into school tasks does not necessarily lead to better grades. Third, we moved from a unitary perspective on the value of effort to a distinction between cognitive and physical effort in this study. However, it is conceivable that even more fine-grained distinctions might be worth studying. For example, a hobby runner might enjoy the kind of physical effort that pertains to endurance training but dislike the physical effort that pertains to strength training. Similarly, someone might enjoy solving challenging math puzzles but dislike reading sophisticated books. How nuanced the human preferences for effort are is an open question.

Another open question is whether our knowledge about the value of effort can be leveraged to make effort more valuable. For instance, children who ascribe little value to physical effort might receive an intervention aiming at increasing it, which might then lead to reduced boredom and better performance in sports classes. Developing such interventions would be a promising route for future research. However, it would also require to address the fundamental question of how people come to value effort in the first place. For instance, it might be that students develop a preference for certain kinds of efforts because they are highly instrumental for attaining their goals. Increasing the value of less instrumental efforts might result in non-optimal effort allocations, raising important ethical concerns that should be addressed.

Conclusion

Taken together, the present research highlights important differences in how people value cognitive and physical effort, that the value assigned to effort in a specific domain (i.e., cognitive or physical) maps directly onto choices, experiences, and outcomes in activities that require this type of effort. Accordingly, researchers should be specific about the kind of effort they are addressing in their research. Importantly, we showed across adolescent and adult samples that these differences in the value of cognitive and physical effort can be reliably measured with self-report measures and decision paradigms. Crucially, this suggests that even broad questionnaires on the value of physical and cognitive effort are consequential in predicting important real-life outcomes, feelings, and choices. Therefore, further research on the value people ascribe to things is highly warranted.

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Conflict of interest disclosure

The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation to the content of the article.

Data and Supplementary information availability

All materials, data, scripts, and supplementary analyses are available online on the Open Science Framework at https://osf.io/fhdgc/ (Stähler et al., 2023).

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[i] Please note, that in the questionnaire we asked for gender but provided the answering options female/male/other/prefer not to say.

[ii] Please note that German validation of the NfC scale consists of 16 items and not of 18 items like the English version does.

[iii] 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 logit regression VoPE ond 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).