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The Effort Paradox: Effort Is Both Costly and Valued

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Abstract

According to prominent models in cognitive psychology, neuroscience, and economics, effort (be it physical or mental) is costly: when given a choice, humans and non-human animals alike tend to avoid effort. Here, we suggest that the opposite is also true and review extensive evidence that effort can also add value. Not only can the same outcomes be more rewarding if we apply more (not less) effort, sometimes we select options precisely because they require effort. Given the increasing recognition of effort's role in motivation, cognitive control, and value-based decision-making, considering this neglected side of effort will not only improve formal computational models, but also provide clues about how to promote sustained mental effort across time.

> The real price of every thing, what every thing really costs to the [person] who wants to acquire it, is the toil and trouble of acquiring it.
>
> -Adam Smith

> Satisfaction lies in the effort, not in the attainment, full effort is full victory.
>
> -Mahatma Gandhi

The Paradox of Effort

Effort (see Glossary), be it mental or physical, is a common feature of daily life and is encountered every time we need to push ourselves. We regularly face activities requiring exertion of some kind or another, be that running to catch a bus, learning how to play and master the latest video game, or sticking to an unpleasant diet. Effort has a distinct phenome-nology, feeling difficult and aversive [1–3]. As such, humans and other animals tend to avoid effort, including the effort that comes from merely thinking things through [4,5]. In a science with very few laws [6,7], psychology has offered the law of least work:

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given a choice between similarly rewarding options, organisms learn to avoid those that require more work or effort [8]. Contemporary theoretical and empirical work in cognitive neuroscience and economics has chiefly served to confirm and reinforce this view, concluding that effort is costly. Here, however, we suggest this is only half the story.

While it is clear that people will work hard to obtain something of value, what has been largely overlooked is the notion that working hard can also make those same things more valuable. Effort can even be experienced as valuable or rewarding in its own right. While humans and other animals readily apply more effort for better outcomes, they sometimes view the same outcomes as more rewarding if more (not less) effort was used to attain them. As a few examples: mountaineers value mountain climbing precisely because it is so arduous and effortful [9]; through a process of **learned industriousness**, effort itself can become a secondary reinforcer and be rewarding by itself [10]; and objects that one effortfully crafts and assembles oneself (e.g., IKEA furniture) are valued more than the same objects that come preassembled [11]. Current work demonstrates that effort's positive impact on value manifests biologically [12,13] and is basic and early-developing, occurring in children and non-human animals [14–16].

While classic economics recognizes and accounts for effort, for 'toil and trouble' [17], it typically does so as a cost. If a consumer product requires effort (e.g., effort and time to travel to and from a store in a neighboring town), it should be valued less than the same product that does not require effort (e.g., delivered directly to one's home). And, according to classic models, people would prefer to pay a lower price for the former product because it requires that they personally toil and exert effort. Sometimes, however, the very opposite occurs. Similarly, while early psychological models of **motivation** did account for variability in people's preferences for engaging in effortful tasks [18], they assumed that this stemmed from differences in how people value the potential product of their effort rather than how they value the effort itself.

In this Review, we try to correct a theoretical blind spot by focusing on effort's added value. Despite the rich evidence that effort can add value, this evidence has not been integrated into dominant models of effort in neuroscience, economics, or cognitive science, where research into mental effort has arguably grown the most over the past decade [1,19–22]. Such models, including our own [23,24], generally assume that effort is inherently costly, and limit their predictive power to situations and personality types for whom this applies, omitting many well-documented cases where this assumption is violated (e.g., people who seek out rather than avoid effort [25–27]). Considering the effort paradox, therefore, can advance effort theorizing and its widespread applications.

Here, we integrate ideas from two distinct areas that have traditionally theorized about effort separately (see [28]), but which would benefit from greater dialogue. After briefly examining the prevailing view of effort as costly, we review the many ways in which effort also adds value, something that has been mostly ignored in recent work. Critically, we review not only how effort increases the value of the goals we effortfully pursue, but also how the effort needed to reach a goal can be rewarding in its own right. We start by defining what we mean by effort.

Effort Defined

Effort refers to the subjective intensification of mental and/or physical activity in the service of meeting some goal [10]. As such, it is the process that mediates between how well an organism can potentially perform on some task and how well they actually perform on that task [19]. For example, a person might have the ability to perform algebra, but fail to solve simple algebra problems due to insufficient mental effort [5]. Although related, effort is not the same as motivation, which is a force that drives behavior by determining both a direction (e.g., goal) and the intensity or vigor with which this direction is pursued [18,21]. Effort refers to the intensity or amplitude of behavior, but does not refer to any specific goal.

Effort is a volitional, intentional process, something that organisms apply, and as such, it corresponds to what organisms are actively doing and not to what is passively happening to them [29]. Effort is distinguishable from **demand** or difficulty: effort corresponds to the intensity of mental or physical work that organisms apply toward some outcome, whereas demand or difficulty refers to a property of the task itself (e.g., holding seven items vs. three items in working memory), especially how error-prone it is [30]. Although effort typically tracks demand (with people working harder when the task is more difficult) this relationship breaks down when incentives are too low or when demands are too high [31]. Finally, it is important to distinguish effort from associated mental constructs, such as boredom (Box 1).

It is worth noting that both actors and observers readily perceive the exertion of effort. Effort is typically accompanied by distinct phenomenology [1], meaning actors recognize when they are applying it themselves. Effort can also be visible to others [32,33] and is difficult to fake [34,35], making it plain to observers whether someone is exerting themselves or not. The fact that effort is easily recognized in self and others gives it important signaling functions; for example, communicating dedication, intention, and commitment [36–38].

Effort Is Costly

The notion that effort is costly (that organisms find it aversive and tend to avoid it) is supported by many lines of evidence. Tasks that require effort typically increase sympathetic nervous system activity, including increasing blood pressure, ventilation, sweating, pupil dilation, and plasma norepinephrine release [39–42]. Critically, this sympathetic nervous system activity reflects an aversive response: Effortful tasks prime an aversive affective response [43], evoke contraction in the **corrugator supercilii** that is otherwise associated with negative affect [32,44], and produce self-reported feelings of anxiety, stress, fatigue, and frustration [45,46]. Effort is also tracked by activity in the **anterior cingulate cortex** [19,40,47], and several studies have provided evidence that those effort signals are associated with the aversiveness of effort [24,25,48–50].

Behaviorally, there are clear signs that organisms often dislike and devalue hard work. Effort (both mental and physical) is typically avoided: when given tasks that offer equal rewards but different levels of demand, organisms usually learn to avoid the more demanding one. Just as rats will typically learn to avoid the more physically demanding arm of a maze [8], they will also learn to avoid more cognitively demanding choice options [51]. What is more, willingness to exert effort usually decreases as a function of the amount of effort already applied [52,53]. While there is some controversy about how much effortful work is needed before people become unwilling (or unable) to exert effort [54–56], it is clear that effort expenditure does eventually decline with time on task [4,57–60]. Another indication that effort is costly comes from the finding that people are often willing to accept fewer rewards to avoid effort [61,62]. That is, just as people discount rewards by their associated delays [63,64], so too do they discount rewards by the amount of cognitive or physical effort required to obtain them (i.e., **effort discounting**) [21,65].

Effort Adds Value

Despite growing and prominent work in cognitive neuroscience detailing effort's substantial costs [19–21], it is clear that effort also adds substantial value, both to the products of effort and to effort itself (Table 1).

Dissonance, Sunk Costs, and State-Dependent Learning

An early indication of effort's perceived value came from classic work in social psychology on **cognitive dissonance** and **effort justification** [66,67]. This work has repeatedly demonstrated that the more effort is exerted to obtain things, the more value they are assigned retrospectively. For example, a person who worked hard to gain entry into a group will like that group more than a second person who did not work hard to acquire group membership, even though both people are evaluating the same group [68]. More recent work on the **IKEA effect** similarly suggests that consumers will pay more money for objects they effortfully built themselves than the same objects built instead by experts [11,69]. Critically, neoclassical economic theory suggests that when one is required to work harder to join a group or to build furniture, those activities and objects should be liked less, not more [17,70,71]. These valuation effects were assumed to reflect (in part) post-hoc justifications for the efforts having been exerted (i.e., 'this object or outcome must be valuable if I put effort into obtaining it').

Although the proposed mechanisms differ, similar effort–value associations emerge when actors infer greater valuation of objects after perceiving themselves working hard to obtain those objects [72]; when nonrecoverable investments of effort (i.e., sunk costs) motivate higher valuation [73–75]; or when people are less willing to part with monetary endowments won through effort than with equivalent windfall gains [76–78]. Moreover, evidence of effort's added value has also been demonstrated in the human brain: receiving rewarding feedback for effortful performance amplifies the hemodynamic and electrophysiological signals generated by brain areas sensitive to reward (e.g., subgenual anterior cingulate cortex, caudate, nucleus accumbens, striatum, feedback-related negativity/reward positivity), an effect that is muted or sometimes absent for non-effortful performance ([12,13,79–82]; but see [50]).

These effort–value associations have also now been demonstrated in several non-human species [83–85]. For example, by analyzing operant behavior (e.g., lever-pressing) and licking frequency, multiple labs have found that rats place more value on food rewards that follow high effort than identical foods that follow low effort [14,86,87]. Conceptually similar results were found with pigeons [84], starlings [88], and even invertebrates, such as locusts [85]. Given that dissonance relies on a deliberate justification process [66], it is unlikely to explain the positive valuation of effort across these different species. Instead, animal researchers have proposed alternative accounts based on state-dependent learning and contrast effects. According to these accounts, value is derived via a contrast between the objective value of an object and the organism's state when learning about and acquiring the object [89,90]. Consequently, exerting effort produces an aversive state that makes subsequent rewards appear more valuable by contrast.

Martyrdom for Charity

Distinct from cognitive dissonance and effort justification, where value is thought to accrue from one's previous exertion of effort, preliminary work on the **martyrdom effect** suggests that value can also accrue from one's anticipated future effort [91,92] and from the effort exerted by others [92,93]. According to this work, willingness to contribute to a charitable cause increases when the fundraising process is expected to be painful and effortful rather than easy and enjoyable. As a result, people donate more money to a charitable cause (e.g., a cancer charity) when fundraising involves completing a 5-mile run versus attending a picnic [91]. Similarly, when prospectively deciding how much money to give in a public goods game, people donate more if giving requires performing some effortful and painful task (e.g., keeping hands immersed in ice water) compared with when donations are free of effort and pain [91]. These findings suggest that we are therefore able to generate positive associations with effortful actions we have not yet taken (or will not take ourselves), which raises the question of how these effort–value associations might be learned in the first place, and how they might generalize.

Learned Industriousness

While experimental tasks typically take great care to independently vary effort and reward (or hold reward constant [8]), in the real world, greater effort typically begets greater reward. Because animals seek to maximize rewards, they will often voluntarily engage in effortful tasks that promise rewards [62], whether it be foraging for better foods or studying for higher grades. If high effort is consistently paired with high reward, this can form a conditioned association, with effort itself taking on the status of a secondary reinforcer. Just as a bell can signify that food is on its way, the sensation of effort could signify that reward is imminent [10]. The result is that effort itself is learned to have value; or, at the very least, it becomes less aversive as organisms learn to tolerate effort in the service of reward [94].

Through this process of learned industriousness, organisms internalize the value of effort and become more willing to exert it. Moreover, they learn to generalize the effort–reward association to novel tasks that might have unique demands. For example, rats that are reinforced for exerting high intensity force on a lever are more likely to persist on an unrelated runway traversal task than rats reinforced with low-force lever presses ([95]; see also [96]). Similarly, college students and preadolescent children who are rewarded for completing cognitively demanding tasks subsequently exert more effort and persist longer on unrelated tasks, relative to those who were instead rewarded for completing easy tasks [97,98].

Need for Cognition

Animals vary in the extent to which they associate effort with reward. For humans, some truly enjoy cognitive effort for its own sake, preferring to think deeply about things; others are more miserly, avoiding mental exertion whenever they can. This variation in **need for cognition**, a trait that can be reliably measured and that is stable over time, describes people's intrinsic tendencies to engage in and enjoy effortful cognitive activities for their own sake [26,99]. Those high in need for cognition assign higher value to mental effort, require fewer incentives to engage it, and actually seek it out rather than avoid it [25,61,100]. While it is unclear what determines this variation, plausible contributors include differences in personal learning histo-ries, tolerance of frustration, and connection to cultures that expressly place value on hard work (e.g., Protestant work ethic) [26,28,70,97,101].

Synthesis: When and Why Effort Adds Value

It is clear that effort acts not only as a costly deterrent, but that it can also add substantial value. This latter, counterintuitive effect manifests in many forms, which raises many interesting and important questions concerning the nature of the effort–value relationship (Table 1).

What Is Being Valued – Effort Itself or Effort's Product?

A critical question concerns the target of the effort–value association: Is the value associated with effort ascribed to effort itself or to the product of effort (Box 2)? There is abundant evidence that effort increases the value of its products [11,28,66,67,69,72–75,102,103]; that is, people ascribe greater value to goods and outcomes (e.g., group membership, furniture, coffee mugs, etc.) that they worked for compared with identical goods and outcomes that they obtained without effort (e.g., by chance, as windfalls).

Separate from these findings, there is also evidence that people can ascribe value to effort itself [9,10,26,70,71,104]. For example, although anecdotal, mountaineers and other endurance athletes report valuing their sport precisely because it demands a great deal of effort [9]. When rats and children are rewarded for exerting effort in one task, they are more likely to apply effort in other tasks, suggesting that effort has become a secondary reinforcer for them [95–98]. Finally, some people intrinsically pursue and enjoy effortful cognitive activities for their own sake [25,26]. Nonetheless, there is more work supporting value for the products of effort than for the value of effort itself. A challenge for future research will be to disentangle the relative contri-butions of these two different channels to determine the extent to which effort valuation reflects a positive association with effort itself (e.g., learned industriousness) or an amplification of the products of effort (e.g., effort justification or contrast effects).

When Does Effort Increase Value?

Another important factor concerns the timing of effort valuation. Does effort accrue value retrospectively (i.e., only after the effort has been exerted), concurrently with the exertion of effort, or prospectively (i.e., in anticipation of future effort)? Once again, the answer seems to be all three. Most studies have demonstrated retrospective valuation; people assign greater value to objects, actions, and outcomes associated with past efforts, relative to equivalent objects, actions, and outcomes that did not require effort [11,28,66–69,72–75,102,103]. Retrospective revaluation is in fact the dominant mechanism underlying several popular theories and phe-nomena linking effort to value (e.g., cognitive dissonance, sunk cost effects; see Table 1), which require that the effort be previously invested (and thus constitute a nonrecoverable expenditure of time and energy) for it to influence value.

However, there is also evidence that people sometimes derive value from effort itself, absent of any tangible products [9,10,104], revealing a concurrent effort–value relationship. For example, during states of flow, people derive pleasure from challenging tasks as they are exerting effort, indirectly suggesting that effort adds value concurrently [104]. More direct evidence comes from work on learned industriousness: because effort is a secondary reinforcer, it adds value both concurrently and prospectively [10]. More recently, researchers have found evidence that effort can be positively valued in anticipation of its exertion. For example, the prospect of exerting effort in the future for a prosocial cause has been shown to increase people’s willingness to contribute to the cause, even before they have exerted any actual effort [91,92,105].

In sum, although retrospective effort–value associations have received the most attention from researchers, there is also evidence that this is not the only possibility: the relationship between effort and value can also be concurrent or prospective. Nonetheless, much less research has been carried out to examine whether effort adds value concurrently or prospectively, so more work is needed in these areas. Another challenge for future research will be to determine the process or processes that lend value to effort, while being open to the possibility that one process might contribute to effort being valued retrospectively and that a second process might contribute to effort being valued prospectively.

What Is the Shape of the Effort–Value Relationship?

Another important question concerns the shape of the relationship between the amount of effort exerted and the value accrued. In particular, we can ask whether this relationship is continuous (e.g., additional increments of effort are generally associated with greater value, for a wide range of effort) or categorical (e.g., going from no effort to some effort yields a boost in value, but further increasing effort provides no additional value). To the extent that the relationship is continuous, is it monotonic (e.g., more effort always produces equal or greater value) or not (e.g., inverse U-shaped)? Although many classic psychological theories (e.g., cognitive dissonance) predict that the effort–value relationship should be fairly continuous [10,66,89], this is not always the case. For example, we speculate that the martyrdom effect might be an example of a categorical effort–value association [91,93]. The willingness to donate increases when the fundraising process goes from effortless (e.g., a charity picnic) to effortful (e. g., a charity run); but additional increases in effort beyond some positive amount (e.g., varying the number of miles to be run) do not seem to matter much [91,93]. Although a categorical effort–value association is an intriguing possibility, more research is needed to carefully test this proposition by parametrically varying effort requirements and examining their effects on valuation.

When Does Effort Not Increase Value?

A final question concerns some potential moderators of the effort–value association. One obvious moderator is the amount of effort demanded. People are only willing to exert effort up to a limit [31,106] and any goods or goals that require further effort beyond this limit will be devalued rather than being sought after. Thus, excessive effort demands can break the effort– value link. Similarly, although unrewarded effort can be especially disappointing [11,18,79], people might retrospectively devalue those efforts to avoid such disappointment and feelings of dissonance [67,107].

Another moderator suggested by several independent streams of research concerns the justification for (or justifiability of) the effort. For example, many of the classic studies on effort justification indicate that people are less likely to ascribe greater value to an effortful task if they receive sufficient incentives to complete it [67]. The reason for this is that in such cases, people attribute their effort to the incentive rather than to the intrinsic desirability of the task. As another example, while people are generally willing to donate more to charity when the fundraising process is effortful and presented in isolation (suggesting that effortful fundraising events are valued more than non-effortful ones) they are at the same time less likely to participate in effortful fundraisers when there is a salient, effortless means of fundraising for the same cause [91]. In other words, it feels meaningless to exert effort when an effortless alternative is readily (and obviously) available.

Summary

Although effort adds value, we are still learning about precisely when, why, and how this occurs. Effort adds value to the goals that we effortfully pursue [67], but effort can be rewarding in its own right [10,99,104]. Effort is not only valued in retrospect, but can feel rewarding while it is being exerted [95,104,108], and these rewarding experiences can also be anticipated when making decisions about future actions [91–93].

Implications of Effort Being Valued

Although today's dominant models in economics and cognitive neuroscience generally assume effort acts only as a cost [19,20,23,70,71], we hope that our analysis of the effort paradox makes clear that this view is incomplete. Effort's added value cannot be ignored; therefore one theoretical implication of our review is that models of effort, including formal computational models (e.g., [23]), need to consider both effort's costs and its potential to create subjective value beyond the production of tangible products (Box 2).

An understanding that effort is valued has a critical role to play in promoting sustained mental effort across time, whether in the context of schoolwork, self-control, or emotion regulation [109–111]. Positive associations with effort can serve as a counterweight to its intrinsic costs and over time support more habitual exertions of effort [10]. These 'effortful habits' may manifest in a variety of forms, including more sustained attention to one's tasks, more goal-directed decisions, better learning outcomes, and perhaps even improved mental health [112,113]. Notably, the kinds of training suggested by learned industriousness [94,95,108] differ in important ways from the types of practice-based approaches that have been at the center of research on cognitive training, which have largely failed to generalize across cognitive skills [114,115]. Notably, learned industriousness is thought to increase effort willingness by repeatedly pairing effort with reward such that effort becomes a secondary reinforcer, which differs considerably from cognitive training that is based purely on practice effects. This suggests new training possibilities that we hope researchers will explore (see [116]).

The value of effort also partly explains why some people are more apt than others to run marathons or play Sudoku in their free time. While people sometimes do this to signal something about their character [117], they also do it for the pleasure that effort affords [25,26]. The value of effort also helps to explain the benefits that can accrue to consumer goods that require effort on the part of the consumer, such as 'do-it-yourself' products [11,69]. A similar account could explain the surprising popularity (and fundraising success) of charity events that require those raising money to expend substantial effort to reach their goal [91–93]. Together, these findings hint at the kinds of policies that may be most effective at increasing charitable giving and potentially nudging people toward products that are more beneficial for themselves or for society at large.

Concluding Remarks

Over the past few years, work on the cognitive neuroscience, economics, and psychology of effort has intensified. Were a person to solely consult this recent and influential literature [1,19,20,24,55], they would be exposed to all manner of evidence illustrating effort's costs. However, as we build toward a rational and mechanistic account of effort [19], it is important to consider the abundant findings indicating that effort is intrinsically valued and that it boosts valuation.

It has long been understood that people will exert more effort for larger rewards. But these classic views also predict that, for a given reward, adding effort reduces value [4,8] so that people should prefer paying a premium to outsource effort to others whenever they can afford to do so [16]. By contrast, the literatures we reviewed here have shown that even for equivalent rewards, children, adults, and many non-human animals will sometimes value them more if these rewards require effort.

In this Review, we have tried to correct a theoretical blind spot by focusing on effort's added value. People and non-human animals alike tend to associate effort with reward and will sometimes pursue objects and outcomes because of the effort they require rather than in spite of it. This association between effort and value raises many interesting possibilities, including suggesting several ways to increase people's willingness to exert effort (see Outstanding Questions). We hope our attempts to shine light on this neglected side of effort and integrate it into current theorizing, including formalizing effort's value in computational terms (Box 2), will stimulate new theoretical and empirical research into the effort paradox.

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Glossary

Anterior cingulate cortex

the rostral portion of a thick belt of cortex that lies dorsal to the corpus callosum. Research suggests roles for anterior cingulate cortex in effort avoidance, reward-based decision-making, cognitive control, and motivation. Such roles are consistent with the view that the ACC monitors for signals relevant to the expected value of control

Cognitive dissonance

mental distress experienced when a person simultaneously holds contradictory beliefs, ideas, or values, which then motivates rationalization of past actions

Corrugator supercilii

a small narrow muscle close to the eye, located at the medial end of the eyebrow. It draws the eyebrow downward and medially, resulting in the appearance of frowning. The corrugator is regarded as the principal muscle in the expression of negative affect and is reliably activated by tasks high in effort

Demand

a property of a stimulus that determines how much mental or physical labor will be required (i.e., level of difficulty or challenge), such as the weight of an object that needs to be pushed. Related to, but distinct from effort, which corresponds to the amount of labor the organism engages in

Effort

intensification of either mental or physical activity in the service of meeting some goal (e.g., increasing the force applied to an object). Related to, but distinct from, demand or difficulty, which corresponds to a property of the stimulus not of the organism

Effort discounting

decreased liking (or valuation) of objects that are contingent on effort. The more effort something requires, the less organisms value it

Effort justification

when people justify their past efforts by increasing their liking of objects that they obtained through those efforts

IKEA effect

increased liking of objects that people successfully assemble and build themselves compared with identical objects that come already assembled

Martyrdom effect

increased willingness to donate to a pro-social/charitable cause when the fundraising process is effortful or painful

Motivation

a (psychological) force that drives behavior and that consists of a direction (e.g., a goal) and an intensity or amplitude with which this direction is pursued (i.e., effort)

Learned industriousness

through learning of conditioned associations with reward, effort becomes less aversive and sometimes even rewarding

Need for cognition

stable individual trait that governs a person's tendency to engage in and enjoy effortful cognitive activity. Some people are cognitive misers (i. e., low in need for cognition) who avoid effortful cognition, while others are cognitive maximizers (i.e., high in need for cognition) who actually enjoy and seek out cognitive effort

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Box 1.

Mental Effort and Boredom

One of the situations in which people seek out effort is when the alternative is to perform a task that is too easy, and therefore understimulating. Such tasks are experienced as boring, and engaging in a more effortful task can avoid this negative affective state, thus imbuing this effort with positive value. However, whether effort per se is needed to avoid boredom depends critically on the underlying cause of boredom. Theories abound on this front [118], including proposals that boredom results from an undirected desire for engagement and stimulation [119,120]; a mismatch between desired and actual levels of arousal, or more generally between skill level and the challenges of one's current task [104]; and/or an inability to sustain attention [121]. A common feature of these accounts is the sense that boredom can be resolved by increasing engagement with a second task.

Alternatively, boredom may signal states of low reward rate or low information availability, leading organisms to engage in less trivial activities to gather more reward and/or information [122–126]. Preferences for less boring tasks may therefore arise from similar mechanisms that lead individuals to prefer more rather than less novel stimuli [127,128], which typically provide new information. However, to the extent that boredom instigates the search for more information or reward, effort might not always be up to the task. That is, when performing a boring task, switching to a more difficult task may not provide any more reward or information content. Conversely, attaining more information or reward could theoretically be achieved by switching to a task that is as easy, but with more frequent rewards and/or prediction errors (which connote information availability) [124].

Complicating matters further, despite often being trivial and repetitive, boring tasks can also be experienced as effortful. That is, boring tasks sometimes require effortful control to stay on task, for example, in the case of lapses in sustained attention or when control is required to stay on task rather than disengage or perform a different task [118,121,126]. Boredom could thus be theoretically decoupled from, and in different instances positively or negatively related to, experiences of mental effort or fatigue [104,126].

Box 2.

Formalizing the Value of Effort

The allocation of effort can be operationalized as a value-based decision, with the type and amount of effort determined by weighing attendant costs and benefits [19,20,129]. For instance, early psychological models of motivation proposed that the decision to engage in an effortful task should be a function of the incentives for a task and one's perception of their likelihood of achieving the goal in question [18,130]. Recent work has applied principles from reinforcement learning and control theory to formalize and extend these earlier accounts (e.g., to integrate representations of effort costs), providing a normative account of the overall expected value (EV) of a given allocation of effort [23,131] (see also [55,132,133])

$$EV(effort, state) = \left[\sum_i \Pr(outcome_i \mid effort, state) \times Value(outcome_i)\right] + Value(effort) \quad \text{[I]}$$

The bracketed part of this equation determines the expected product of a given level of effort, weighing the value of each potential outcome by how probable (Pr) the person is to reach that outcome after exerting a given amount of effort (e.g., how likely they are to be correct if they exert low vs. moderate vs. high effort). Outcomes can be positive or negative, material (e.g., money), or social (e.g., reputation). The right-most part of the equation accounts for the value of the given level of effort. People can determine how to allocate their effort by choosing the effort with the highest EV in their current state (Figure I)

While this is just one of many possible models of effort allocation, it is instructive for understanding how one might operationalize the two principle ways, described in the main text, that effort can accrue value. First, effort can be assumed to contribute to the product (outcome) of effort [11,28,66,67,69,72–75,102,103]:

$$Value(outcome_i) \leftarrow Value(outcome) + w \times effort \times Value(outcome_i) \quad \text{[II]}$$

In this case, a person obtains the reward they would have otherwise received for reaching a given outcome, but in addition to this they experience a ‘bonus’ proportional to the effort they invested in reaching their goal (i.e., w reflects how much this individual weighs effort in this calculation). Under this formulation, both positive and negative outcomes would be magnified by the amount of effort exerted, such that winning becomes sweeter (and losing more bitter) the more effort you exerted prior to reaching that outcome [12,79].

The value of effort can also be treated as an intrinsic property of the effort itself rather than a property of its product [9,10,26,70,71,104]:

$$Value(effort) = Reward(effort) - \mathrm{Cost}(effort) \quad \text{[III]}$$

Here, some amount of reward (and cost) scales with the exerted effort itself. One key distinction here is that this effort-centered reward occurs prior to and irrespective of the outcome, just as the costs of effort are assumed to be experienced whether or not the effort achieves its goal. Conversely, the product-centered reward described above is weighed by the likelihood of, and incentive for, reaching that outcome. These two mechanisms thus make divergent predictions regarding how effort allocation (and experience) should vary with elements of a task (e.g., incentives, performance-contingency), providing a quantitative approach to comparing the two potential accounts of positive effort valuation (Figure I).

Outstanding Questions

What determines whether effort is costly, rewarding, or both?

To what extent do effort's positive and/or negative associations generalize across types of effortful tasks, or even across mental and physical forms of effort?

How well can previous studies disso-ciate influences of product-centered and effort-centered effort values? Can tasks be developed that sepa-rately investigate these two influences and individual differences in sensitivity to each? How well can such individual differences in effort valuation be distin-guished from individual differences in goal valuation (e.g., related to achieve-ment, failure, rejection, and social desirability).

Do different mechanisms underlie the retrospective versus prospective valu-ation of effort?

Can effort become a habit? Can we train people (and other animals) to reli-ably increase their willingness to exert effort to buffer against effort discount-ing? Can such increases be sustained even over the long term?

Can cognitive training regimens that focus on conditioning reward associa-tions (e.g., learned industriousness) outperform those that focus on prac-ticing a skill, when considering gener-alization across skills? What insights can the field learn from the largely unsuccessful brain training literature when considering new training approaches?

What is the association between frus-tration tolerance and effort discount-ing? Can we decrease effort discounting (and demand avoidance) by increasing tolerance of frustration or even tolerance of pain?

Is effort less valuable to people who do not consistently have their efforts paired with rewards (e.g., those low in self-efficacy or with an external locus of control)?

Are certain groups of people more likely to experience unrequited or unrewarded effort (e.g., those low in socioeconomic status)? And, if so how does this affect their effort willingness over development?

Highlights

Prominent models in the cognitive sciences indicate that mental and phy-sical effort is costly, and that we avoid it. Here, we suggest that this is only half of the story.

Humans and non-human animals alike tend to associate effort with reward and will sometimes select objects or activities precisely because they require effort (e.g., mountain climbing, ultra-marathons).

Effort adds value to the products of effort, but effort itself also has value.

Effort's value can not only be accessed concurrently with or immediately fol-lowing effort exertion, but also in antici-pation of such expenditure, suggesting that we already have an intuitive under-standing of effort's potential positive value.

If effort is consistently rewarded, peo-ple might learn that effort is valuable and become more willing to exert it in general.

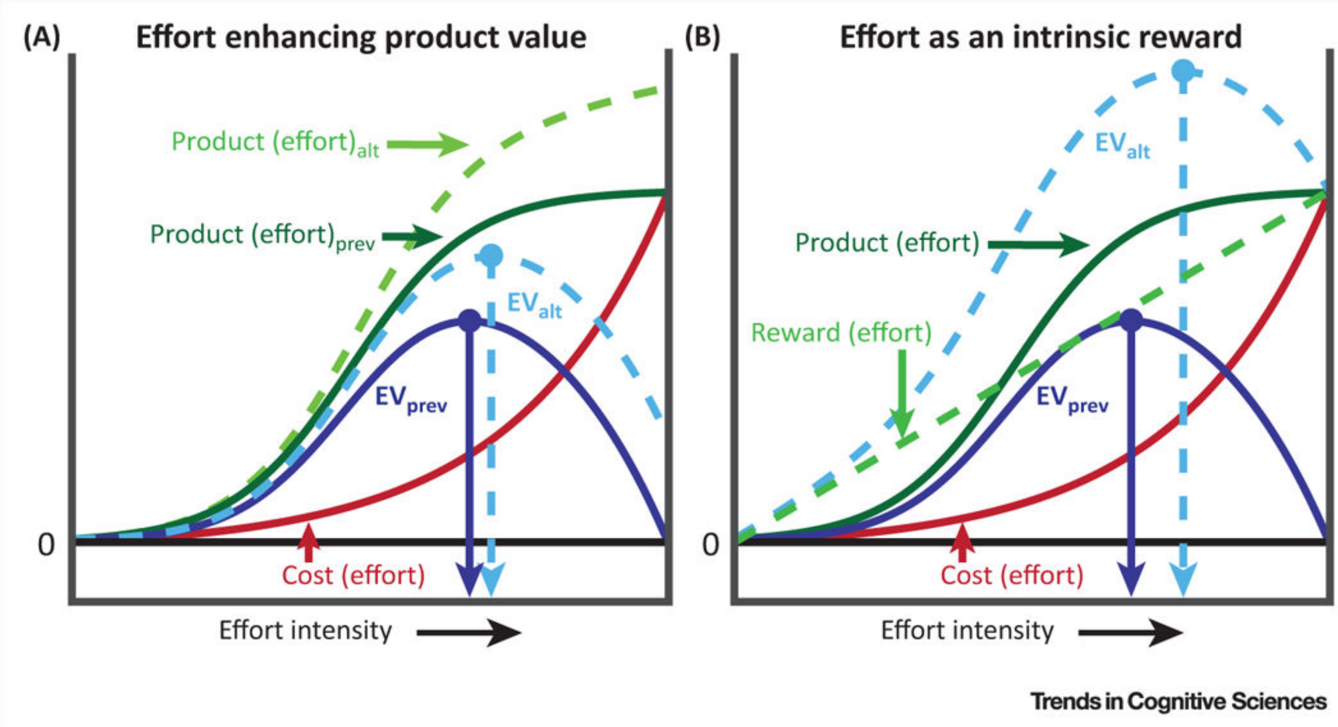

Figure I. Two Alternative Formulations for the Positive Valuation of Effort.

Previous work has suggested that the expected value of effort (EV_{prev}; dark blue lines) is the difference between the expected product of investing that amount of effort (i.e., the likelihood of reaching your goal multiplied by the incentives received when the goal is reached; dark green lines) and the cost of exerting that same intensity of effort (red lines). The individual can (in principle) select their optimal effort investment by locating the effort intensity that maximizes their EV (unbroken vertical arrow). This framework can accommodate two alternate ways of valuing effort (shown in green broken lines): (A) as an amplification in the value of the product of effort with increasing effort intensity (from dark green to light green values), and/or (B) as a positive value that increases with effort intensity (counteracting effort costs), separate from the positive value expected as the product of effort. Effort's reward function is assumed to be linear in this example, but the actual forms of this function and the cost function remain to be determined. Each of these alterations results in an alternate set of EV values (EV_{alt}; broken blue lines) and corresponding changes in the optimal level of effort.

Table 1.

Effort As Value: Theories and Phenomena

Theory and phenomenon	Brief description	What has increased in value: product of effort or effort itself?	Does effort increase value retrospectively, concurrently, or prospectively?
Cognitive dissonance and effort justification [12,66,67,80,112]	Individuals like objects and outcomes more when they are obtained through effort. This attitude change reflects a motivation to justify the past effort.	Product of effort	Retrospective
Self-perception theory [72]	Individuals infer that an object or outcome is something they must like more if they previously exerted effort to obtain it; that is, actors draw inferences about how much they like something from the amount of effort they previously exerted for it.	Product of effort	Retrospective
IKEA effect [11,69]	People value products that they successfully build or prepare themselves more than identical products that are ready-made or prepared by others.	Product of effort	Retrospective
Sunk cost effect [73–75]	Individuals are more likely to continue pursuing or consuming an option the more effort has already been invested to obtain it.	Product of effort	Retrospective
Earned income vs. windfall gains [76–78,103]	Monetary gains that were earned through effort (e.g., labor) are valued more, saved more, and shared less than windfall gains that were obtained without effort.	Product of effort	Retrospective
Contrast effect [14,15,84,89]	By contrast with the negative affective state produced by effort (or other aversive states like pain), items encountered following effort expenditure are perceived to be more valuable.	Product of effort	Retrospective
State-dependent valuation [85,88,90]	Conceptually related to contrast effects. Organisms infer the value of an object or outcome based on their hedonic states at the time they encounter it. If they encounter it in an aversive state (e.g., while tired and hungry from exerting effort) the relative value of the object/outcome is higher compared with what it would have been had they encountered it in a positive state (e.g., while fully rested and satiated).	Product of effort	Retrospective
Martyrdom effect [91–93]	Willingness to donate to a pro-social/charitable cause increases when the fundraising process is effortful, compared with when donations will be raised with little or no effort.	Product of effort and effort itself	Prospective
Learned industriousness [10,95,97,98]	To the extent that effort tends to be rewarded, effort itself comes to predict reward (as a secondary reinforcer), thereby reducing its aversiveness.	Effort itself	Concurrent and prospective
Need for cognition [26,61,99,100]	A personality trait that predicts a person’s tendency to engage in and enjoy effortful cognitive activity (e.g., problem solving).	Product of effort and effort itself	Concurrent and prospective
Contra-freeloading [83]	Many animal species will choose to work for food even when they can obtain identical food without effort.	Product of effort and effort itself	Prospective

Theory and phenomenon	Brief description	What has increased in value: product of effort or effort itself?	Does effort increase value retrospectively, concurrently, or prospectively?
Flow [104]	Performing a mentally effortful activity in which one is fully immersed produces positive feelings of energized focus and enjoyment in the activity.	Effort itself	Concurrent