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Willpower with and without effort

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Abstract

Most authors who discuss willpower assume that everyone knows what it is, but our assumptions differ to such an extent that we talk past each other. We agree that willpower is the psychological function that resists temptations – variously known as impulses, addictions, or bad habits; that it operates simultaneously with temptations, without prior commitment; and that use of it is limited by its cost, commonly called effort, as well as by the person's skill at executive functioning. However, accounts are usually not clear about how motivation functions during the application of willpower, or how motivation is related to effort. Some accounts depict willpower as the perceiving or formation of motivational contingencies that outweigh the temptation, and some depict it as a continuous use of mechanisms that interfere with reweighing the temptation. Some others now suggest that impulse control can bypass motivation altogether, although they refer to this route as habit rather than willpower.

It is argued here that willpower should be recognized as either or both of two distinct functions, which can be called *resolve* and *suppression*. Resolve is based on interpretation of a current choice as a test case for a broader set of future choices, which puts at stake more than the outcome of the current choice. Suppression is inhibiting valuation of (*modulating*) and/or keeping attention from (*filtering*) immediate alternatives to a current intention. Perception of current choices as test cases for broader outcomes may result in reliable preference for these outcomes, which is experienced as an effortless *habit* – a successful result of resolve, not an alternative method of self-control. Some possible brain imaging correlates are reviewed.

1. Introduction

Scientific interest in willpower has grown in recent years.[1] It figured prominently in the Victorians' quest for social improvement, but waned during the early twentieth century – perhaps, partly because of its lack of precision. "Will" itself gets applied to at least three somewhat independent functions: the initiation of movement, which corresponds to the Cartesian connection of intention with action; the ownership of actions, which gives you the sense that they come from your true self (Wegner, 2002)[2]; and the maintenance of resolve against shortsighted choices. When you will your hand to pick up a chocolate, will makes your hand move, and there is a "you" that feels like it's doing the willing, but you may also be failing to exert your will not to eat chocolate (discussed in Ainslie, 2004).

The third usage becomes more specific if converted to "willpower," but it still means different things to different authors. Internal self-control has been described in many ways over the years. The topic has many clinical implications, so it is often discussed by authors who are not concerned with motivational bookkeeping.[3] However, in a model where choice is determined by the competition of internal interests that depend on prospective reward, the possibilities for how one interest survives against more strongly motivated competitors are limited. They can be illustrated by the analogous problem of how one interest in a legislature can keep an unpopular measure from being voted down: It can tack the proposal onto a larger bill that is more popular; or, while it holds the floor, it can avoid recognizing opposing parties. In the news, we see legislators use either or both, and nothing else. Analogously, if we want to model willpower as a phenomenon within the competitive marketplace of reward, we have only two kinds of mechanisms. In keeping yourself from eating the chocolate, you can *resolve* not to eat it on the basis of larger incentives, and/or *suppress* urges to eat it to defend a current intention. The present author has always written about willpower as synonymous with resolve, but a great deal of different usage, as well as recent brain imaging, call for looking at how this mechanism co-exists with suppression.

Resolve is way of managing motivation to maintain the plan that seems best from a broad perspective in the face of expected temptations – options that might become dominant during future valuations. Because revaluations will inevitably occur, successful resolve must include means to maintain its motivational dominance over time. Suppression is a way of gating out alternatives to a current intention while ignoring their possible value; it is necessarily unstable. Consistent long-term choice depends on resolve, but in recent academic discussions on willpower resolve has often been replaced by, or confounded with, suppression. Loosely

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speaking, most philosophy (sect. 3.2.4) and the game-theoretic approach to reward theory (sect. 3.2.1) have equated willpower with resolve, whereas most experimental psychology (sect. 2.1), including brain imaging (sect. 4) has equated willpower with suppression. Economists have recently proposed theories using each model (sects. 2.1 and 3.2.2), and clinically-oriented social psychologists, although less systematic, have described elements of resolve (sect. 3.2.3). Recently, a third phenomenon, habit, has been proposed as a beneficial alternative to willpower (sect. 3.3). This article will propose how the motivational bases of these three processes determine their distinct and sometimes symbiotic operations.

Choices that evoke willpower typically compare options that pay off over different time courses, with poorer but faster paying ones weighed against the better but slower paying. In the laboratory, these options are usually offered as a smaller, sooner (SS) reward versus a larger, later (LL) one, with a fixed lag between the times when they are available and a variable delay before the SS reward. Preference for the fast-paying option is often temporary – only when the SS reward is close – the familiar phenomena of temptations, urges, or *impulses*, against which willpower is marshalled. Conversely, there are temptations to gain sooner relief from aversive experiences that will be worse if delayed, the net effect of which is the same as the choice between SS and LL rewards.[4] The consequences of impulsiveness may be trivial, as in preference for fast payouts in video games that reduce your score (Wittman, Lovero, Lane, & Paulus, 2010), in preoccupation with video games themselves (Griffiths, 2008), or in everyday procrastination. But impulsive preference patterns are also evident in such consequential problems as drug addictions, bad health care decisions, unsafe sex, and failures to save for the future. Failures to prepare for the future may include participation in social decisions with shared impact, such as those about climate change (Gollier & Weitzman, 2010), population policy (Keiner, 2006), and social investment (Arrow, 1999). Such problems have made impulse control a major topic in behavioral science, reflected in the many synonyms that imply one sub-agent within the person acting on another: self-control, self-regulation, self-command, self-denial, self-discipline, self-mastery, self-restraint, and self-government.

After reviewing the common explanations for how SS options tend to get chosen over LL options (sect. 2), this article will examine the mechanisms by which internal interests based on LL rewards have been proposed to counteract this tendency: suppression (sect. 3.1), the operational cost of which is often called effort (sect. 3.1.1); resolve (sect. 3.2), for which the mechanism of recursive self-prediction (sect. 3.2.1) has support in behavioral economics (sect. 3.2.2), social psychology (sect. 3.2.3), and philosophy (sect. 3.2.4), and is argued to be observable directly (sect. 3.2.5); and habit (sect. 3.3), in which the routine simplification of action (sect. 3.3.1) is distinguished from the outcome of resolve (sect. 3.3.2) and its failure (sect. 3.3.3). Suppression has at least one apparent correlate in brain activity, and it is argued that future research could show resolve by an inverse of this correlation (sect. 4). A concluding essay relates willpower to the evolutionary problem of achieving consistent choice as foresight increases (sect. 5).

George Ainslie Although trained as a psychiatrist, George Ainslie designed the first demonstrations of hyperbolic delay discounting at the Harvard Laboratories of Experimental Psychology. This likely root of people's inconsistent preferences over time became one leg of behavioral economics, although it represents an economic approach to psychology rather than vice-versa. Ainslie has presented further research and theory about its implications in two books (*Picoeconomics: The Strategic Interaction of Successive Motivational States within the Person* and *Breakdown of Will*, both for Cambridge University Press), in recurring seminars on irrationality organized by Jon Elster and by Don Ross, and in numerous articles and book chapters relating it to topics in psychology, philosophy, economics, and law.

2. Theories about impulses

Arguments persist about the nature of impulsive motives – why willpower is necessary to begin with. Impulsiveness was not contemplated in behavioral and economic models during most of the twentieth century, which depicted all organisms as naturally maximizing their expected utility ("expected utility theory" or "rational choice theory" – Posner, 1998; Samuelson, 1937; Sugden, 1991). It was evident even then that people tend not to do this. Furthermore, the frequent failure of education to produce consistent choice has argued for more than a wandering mind or weakness of intellect, but rather for a robust process of temptation by options that are preferred only temporarily.

Current theories of impulsiveness extrapolate from three kinds of experimental finding.

2.1 Visceral factors

Arousal of emotion or appetite increases preferences for SS rewards. For instance, sexual arousal changes self-reported preference not for just bad sexual choices (Ariely & Loewenstein, 2006) but for SS money rewards as well (Van den Bergh, Dewitte, & Warlop, 2008), one of many "carryover" effects that have been reported (Lerner, Li, Valdesolo, & Kassam, 2015; Luo, Ainslie, & Monterosso, 2014). Such findings have led to general theories that arousal of emotions or appetites – "visceral" processes – is generally responsible for impulsive choices (Loewenstein, 1996; McClure, Laibson, Loewenstein, & Cohen, 2004). Because distinct brain centers are active during arousal of some appetites/emotions, their motivational effect is often proposed to be a separate, "hot" kind of reward that is discounted for delay faster than more rational, "cool" rewards,[5] making their evaluation "myopic" (Loewenstein, O'Donoghue, & Bhatia, 2015; Metcalfe & Mischel, 1999; van den Bos & McClure, 2013), and leading to temporary preference for them. Figure 1A depicts the values of an SS and alternative LL reward as the discounted sum of hot and cool values for each, but this depiction may be oversimplified. Data are lacking on the form of value discounting from hot versus cool rewards, including how the duration of the arousal affects them, and how a reward that depends on arousal is evaluated before the arousal happens; other models could account approximately for the arousal effect shown here. Furthermore, it is now clear that the single-choice comparisons depicted in Figures 1 and 2 are themselves oversimplifications – that people usually try out choices several times mentally before the prospective value of one reaches a threshold for action, a noisy process called drift diffusion (Pedersen, Frank, & Biele, 2017). The figures should, therefore, be understood as a central tendency or median in such clusters of vicarious trials.

2.2 Hyperbolic delay discounting

Granting a role for visceral factors in some impulses, this category is still too narrow to account for all cases of temporary

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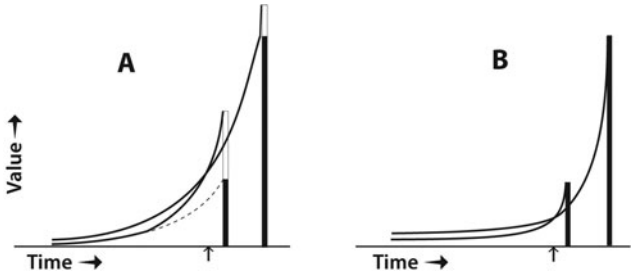

Figure 1. Value of a prospective smaller, sooner (SS) reward, rising temporarily above the value of an alternative larger, later (LL) reward (at arrow) as both rewards get closer. (A) Discounting exponentially, the value of each reward's "hot" component (clear bar) is added to the value of its more slowly discounted "cool" component (filled bar). The dashed line shows the value of the SS reward's "cool" component alone; the slight "hot" value of the LL reward would be hard to distinguish from the summed curve. (B) Discounting hyperbolically when each curve has the same impatience factor (k).

overvaluation of SS alternatives. This occurs in many situations where differential appetite is not a factor: variously because there is substantial delay before the SS as well as the LL outcome (Green, Myerson, & Macaux, 2005); where there is so little delay before the LL outcome that both occur during arousal (Wittman et al., 2010); or where arousal is not involved – as in simple procrastination (Ainslie, 2010a). Authors have sometimes noted that "near-term impulsivity can be expressed for monetary rewards at delays of several months" (McClure & Bickel, 2014, p. 67), thus recognizing such glacially slow impulsivity that visceral arousal is unlikely to be a factor.

Even without visceral factors, the shape of the discount curve describing how delay affects expected reward predicts a universal tendency toward impulsiveness. Experiments across species have found that the value of various rewards declines with delay in a hyperbolic curve (Green & Myerson, 2013; Johnson & Bickel, 2002; Kirby, 1997; Shapiro, Siller, & Kacelnik, 2008), even over tens of milliseconds (Haith, Reppert, & Shadmehr, 2012); Wulff & van den Bos discuss alternative interpretations (2018). In hyperbolic curves, the value of prospective events is plotted against their delay as an inverse proportion, with an impatience factor (k) in the denominator.[6] Hyperbolic discount curves describe the observed changes of preference from LL to SS rewards as the common delay before both options gets shorter (Fig. 1B).

The observation of hyperbolic delay discounting in nonhumans and children (Beran, 2018, pp. 121–186; Green, Myerson, & Ostaszewski, 1999; Scheres et al., 2006; Steinberg et al., 2009) suggests that it is an inborn psychophysical tendency.[7] It is true that many people learn consistent financial planning, and with many experimental designs grown subjects do not report overvaluation of SS options. When investigators have focused on individual differences in adults' financial preferences, the reports of about half of subjects fit exponential (rational) discount curves better than hyperbolic ones (Harrison, Hofmeyr, Ross, & Swarthout, 2018; Hofmeyr et al., 2017). However, these subjects presumably developed from children who discounted hyperbolically, arguably by developing compensatory techniques rather than by learning to modify directly the inborn mechanism of reward (discussed in Ainslie, 2001, pp. 35–38).

2.3 Habit

According to folk psychology repeated choices in the same direction gather "force of habit" from repetition alone, and then require willpower if you want to change them. The reports of some addicts, for instance, that they no longer experience a choice about whether to go on consuming has led to speculation that drug "habits" are just that – "trenches … like the ruts carved by rainwater in the garden" through sheer repetition (Lewis, 2017). It has been suggested that drug addicts' particularly entrenched habits are caused not just by the well-recognized cumulative dopaminergic increase in the rewarding power of drugs (Holton & Berridge, 2013; Volkow et al., 2010), but also by drug-induced damage to the brain mechanism that shifts between habitual and deliberate ("model-based") choice (Ersche, Roiser, Robbins, & Sahakian, 2008; Everitt & Robbins, 2005). In this view, addictive behaviors may no longer even be based on motivation, but are released automatically (or robotically) by stimuli associated with consumption.

3. Theories about impulse control

Authors have described two general kinds of tactics to counteract impulses: forestalling them in advance and acting while they are present. Means of forestalling changes of preference in advance (for instance, Duckworth, Gendler, & Gross, 2016) are straightforward, and are not usually counted as forms of willpower. More puzzling have been means that act simultaneously with the impulse, any of which is apt to be called by that name. Willpower is the process of overcoming a seemingly superior, currently available SS reward to get an LL alternative – tacking against the wind, as it were. Published proposals invoke three kinds of mechanisms:

- While intending to wait for an LL alternative, a person may block or otherwise interfere with revaluation that might lead to change of intention, and continue blocking it while the SS reward would be superior. Call this *suppression*.
- While evaluating immediate options a person may perceive herself to be facing greater incentives than are literally at stake in the current choice. I will argue that *resolve* is intention that is stabilized by avoiding a perceived risk to such incentives. Authors have described resolve in many different terms, including broad choice bracketing, self-efficacy, high level construal, implementation intention, non-reconsideration, and cognitive re-framing. Sections 3.2.2–3.2.5 will cover how these proposals are related to this perception of risk, sometimes with an admixture of suppression.
- A person may somehow bypass valuation entirely, as is sometimes supposed to occur in *habit*.

Of course, the pathway to an impulse control mechanism is itself choosable, and thus must originate through a prediction that its value will exceed its cost in the marketplace of reward.[8] The expected *value* of control can be conceived as the aggregate of amounts of reward by which the LL course of action will eventually exceed the SS course. The *cost* has two components: short-term loss and operational expense. The short-term loss is the amount by which the discounted value of the SS option temporarily exceeds that of the LL option – usually greatest when the SS reward is close. This temporary SS-over-LL value defines the motivational force of the impulse. The operational expense is the additional amount of reward, if any, that will be lost by trying to counteract this force (Shenhav and colleagues [2017] propose a taxonomy). Both kinds of costs have sometimes been called *effort*. In models proposed by some economists effort is simply a

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reflection of the temporary SS-over-LL value – the short-term loss (Fudenberg & Levine, 2006, p. 1455; Gul & Pesendorfer 2001, 2004). But short-term loss is just the size of the challenge. I will use *effort* to describe only operational expense – the loss of reward from using a particular mechanism of impulse control *per se*. This expense varies greatly with the details of the three mechanisms that have been proposed.

3.1 Suppression

It is not clear what keeps the steps of even an ordinary intention together from moment to moment, against continual distractions. Such microscopic continuity seems not to have been analyzed in motivational terms, despite being implicit in the many executive functions studied by psychologists (e.g., Miyake & Friedman, 2012). Although theorists have sometimes imagined that ongoing behavior is revalued continuously, this would be extraordinarily expensive of cognitive capacity, and should prevent the smooth execution of intentions. Excessive revaluation has been blamed for stuttering, for instance (Civier, Tasko, & Guenther, 2010), poor singing technique (Hoch & Lister, 2016, pp. 76–78), and probably other forms of self-conscious awkwardness and pathological doubt. On the contrary, moment-to-moment execution seems to occur routinely without revaluations. If you intend to jump over a puddle on the sidewalk, some kind of editor normally suppresses urges that might distract you – to scratch an itch, to glance behind you, even to revalue your choice too late. This is the function which, if you only half want to jump over the puddle, keeps you from only half jumping over it – whichever side wins stiff-arms the other. Such suppression gives intentions a limited flywheel property, like the power of a chairman to defer votes. It does not depend on further valuation; indeed it may depend on avoiding revaluation.

In recent decades, suppression of impulses has taken an outsized role in theories of willpower, probably because it lends itself to experimental manipulation. The marshmallow-type temptation experiments of Mischel and colleagues elicited a subject's intention to wait for an LL food reward, then observed how she tried to avoid the revaluation that would shift her choice to the SS alternative. Subjects' attempts to avoid arousing appetite ("hot thinking") and to divert attention have stood up in subsequent research as the two basic pillars of suppression (Mischel et al., 2011). To test the limits of suppression, experimenters have often set subjects a task that entails monotonously repeated actions – for instance, press a button if you see x but not y (many examples in Ackerman, 2011; Hagger, Wood, Stiff, & Chatzisarantis, 2010; Kurzban, Duckworth, Kable, & Myers, 2013). Social psychologists' interest picked up with the finding that subjects' work on an unattractive task apparently reduced how long they performed an unrelated task that required similar behavior (Baumeister, Gailliot, DeWall, & Oaten, 2006; Muraven & Baumeister, 2000). Furthermore, if subjects were put to the same task later, they were reported to perform longer than they did previously, a practice effect. Perhaps sustained suppression *was* willpower!

These authors hypothesized that will is a discrete faculty like a muscle, but with its own sequestered motivation, specialized in maintaining a preference over repeated choices. Some economists also adopted a separately motivated faculty of will – by analogy, sometimes explicitly, to Baumeister's will-muscle (Benhabib & Bisin, 2005; Fudenberg & Levine, 2006; Gul & Pesendorfer, 2001; Loewenstein et al., 2015; several discussed in Ainslie, 2012, pp. 21–26). These models depict a fuel-like motivation that supplements the otherwise inadequate value of the LL option. The motivation was consumed as it operated, just as glucose is consumed by a flexed muscle. The moment-to-moment depletion of this motivation was said to be what was experienced as effort. However, subsequent research has shown that mere expectation of an impending effortful task has the same effect as completing it: Subjects who expect to be in an effortful situation show the same reduction in self-control as if they had already undergone the effort, which rules out literal exhaustion (or "depletion") as a mechanism (Muraven, 2006). Furthermore, the attenuation effect itself is now in question: Re-running ego depletion procedures while correcting for various sources of bias has produced evidence that the effect is small or even non-existent (Hagger et al., 2016; Xu et al., 1014), although some methodological dispute remains (Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2019). But to the extent that the attenuation effect is real, it must be simple willingness, not willpower, that is depleted. That is, the suppression task stops being worth the effort.

3.1.1 Why is suppression effortful?

Theorists have struggled to explain the cumulative cost of effort in motivational terms, with the sheer burden of information processing usually found to be an inadequate cause (Shenhav et al., 2017). In the laboratory, effort is often studied by the *fatigue* it accumulates (Ackerman, 2011). Hockey reviews the long history of fatigue theory, and complains that most authors have been misled by the analogy to engines running out of fuel (2011). He suggests that the process of self-control might become increasingly aversive because of an "effort monitor":

> Maintaining a specific cognitive goal means necessarily suppressing all others … It is argued that the fatigue state has a metacognitive function, interrupting the currently active goal and allowing others into contention (Hockey, 2011, p. 173).

Boksem and Tops suggest a similar mechanism that evaluates whether "energetical costs … exceed perceived rewards of task performance," and if so generates "a drive to abandon behavior" that can be called fatigue (2008, p. 135). In a more detailed proposal,

> many experiences, particularly the more or less unpleasant sensations discussed here (e.g., effort, boredom, fatigue), can be profitably thought of as resulting from (1) monitoring mechanisms that tally opportunity costs, which (2) cause an aversive state that corresponds in magnitude to the cost computed, which (3) enters into decision making, acting as a kind of a "vote," influencing the decision ultimately taken (Kurzban et al., 2013).

In short, it has been suggested that "mental effort reflects the opportunity costs associated with allocating a valuable but limited resource – the capacity for control" (Shenhav et al., 2017, p. 106).

However, in these models effort and the resulting fatigue are said to be mechanisms that protect long-term reward, and their aversiveness grows as time is wasted. But wastes of time do not typically feel effortful, and often do not fatigue. Nor is it clear why a special mechanism is needed to generate aversion to diminished prospects – what would this concept add to avoiding loss of prospects *tout simple*? By contrast, I would argue that current mental activity is a source of reward in its own right, based on the game-like properties of imagination (Fox et al., 2018; see Ainslie, 2017), and that its restriction by continuous vigilance

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against impulses imposes a direct cost. Various much-studied routine tasks are indeed effortful because they occupy your attention, but this simply keeps you from activities that are richer in current reward. Discomfort accumulates while whatever interestingness the task originally had habituates, as shown by its partial relief if some variety is added to the task (Converse & DeShon, 2009; Hockey, 2011).

In any case, suppression entails operational expense. The very experience of asking yourself whether a particular suppression is worth the effort demonstrates the limited stability of this mechanism: Suppression is subject to intermittent revaluation, so it cannot sustain an intention over long periods of time. In close contests, a drift diffusion model of noisy choice (Pedersen et al., 2017) predicts that LL intentions may get random turns on top, and thus repeated chances to renew suppression, perhaps leading to the common impression that a weaker alternative is holding a stronger one at bay. That is, the threshold for calling on suppression may be lower than the relevant threshold for action. However, reliance on suppression is still just a game of keep-away with SS alternatives, and these can use suppression in turn. To be a robust tactic against impulsive choice suppression must be directed by motivation – which, if it wobbles amid moment-to-moment suppression, must be stiffened by resolve.

3.2 Resolve

In ordinary speech, resolve just means firm intent,[9] but what makes one intention firmer than another? The connotation is not "riding on a great wave of motivation," but rather "standing against contrary waves." That is, resolve is intent that is maintained by an enforcement mechanism. The classical strategy of achieving stable intentions, of "continence," has been to recruit a set of similar motives that would stand on the side of the intention in question. Referring to dispositions to choose as "opinions," Aristotle said, "We may also look to the cause of incontinence scientifically in this way: One opinion is universal, the other concerns particulars …" (ca. 350 B.C.E./1984: *Nichomachean Ethics*, 1147a, pp. 24–28). It was going by universal "opinions" that made you continent.[10] For the experts on will in Victorian times the active ingredient was to "unite … particular actions … under a common rule" (Sully, 1884, p. 663). This was a process of forming resolve by valuation, of bookkeeping in an open marketplace: "Both alternatives are held steadily in view, and in the very act of murdering the vanquished possibility the chooser realizes how much in that instant he is making himself lose" (James, 1890, p. 534). Weakness of will – *akrasia* – was failure to think categorically, a deficiency still implicated by modern theorists (Heyman, 1996; Read, Loewenstein, & Rabin, 1999). Psychologist Howard Rachlin, for instance, has pointed out that seeing particular choices as part of larger, "molar" patterns may in itself predispose the actor to more LL choices, just as someone would be esthetically deterred from changing single notes in a symphony (1995). But what gives a molar pattern its edge? These descriptions are agnostic about why someone should have a different preference in a single choice than in a set of similar choices to be made all at once. More importantly, they do not identify what induces – or constrains – a person to view her current choice as part of a larger category, rather than evaluating it by itself.

3.2.1 A behavioral reward model: intertemporal bargaining

A model based on behavioral studies of discounting delayed reward offers an explicit answer to these questions.

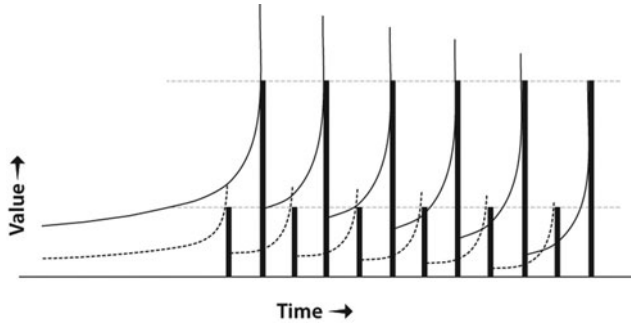

Figure 2. Hyperbolically discounted values of six prospective LL rewards and six SS alternatives, added cumulatively at each moment on the time axis when the remaining series might be chosen. Before the first pair, the LL series is always dominant.

Hyperbolic discount curves offer a motivational basis for the two key properties of willpower in classical accounts – that is, of resolve: (1) increased preference for LL alternatives when choosing between whole categories, and (2) incentive to refer individual choices to such categories. (1) In cases where a single SS reward has more present value than an LL alternative, the sum of hyperbolic curves from a whole series (or *bundle*) of the same SS rewards often has less present value than the summed series of their LL alternatives, even when the first SS reward would be immediate (Fig. 2).[11] Therefore, uniting bundles of choices "under a common rule" should indeed result in more patience. Valuation of conventionally (exponentially) discounted choices in bundles would not increase LL choice (see Ainslie, 2001, pp. 81–84 or 2005, pp. 640–641). (2) The obvious limitation of just assembling a bundle of future choices is that a combination of SS reward in the current choice, to be followed by LL rewards ever after, will always have more prospective discounted value than a series of all LL rewards. A plan that permits the current SS reward will always win. Something needs to enforce the common categorization in the face of immediate temptations. The experience is commonplace. Why not eat this piece of chocolate – it will barely show? Why not dip into savings to buy a fancy car – there will still be plenty left? What would be the harm? The harm, of course, would be to the credibility of your diet or mental savings account (see Thaler & Shefrin, 1981), and thus to your expectation of getting their objectives.

The incentives created by hyperbolic discount curves face you with an intertemporal variant of repeated prisoner's dilemma, with the result that interpretation of your current choice as a *test case* – as a cooperation or defection – often has more motivational consequence than the outcomes literally at stake (Ainslie, 1992, 2005, 2012).[12] This *intertemporal bargaining* centers on the conflict between valuing the present option just for itself versus also valuing the present choice as evidence for how you will choose in a bundle of similar future choices. It does not matter that the negative effects of some habits, such as smoking, do not come repeatedly and soon after the positive ones, hangover fashion, but only in the far future (as Rick & Loewenstein [2008] have objected). The prospect of future health still forms a stake that is at risk in every choice that the person sees as evidence of her pattern of future choices. Importantly, however, the terms of intertemporal bargains remain fluid, so she can propose changes at the moment of choice – say to allow a cigarette on her birthday – as long as she can distinguish her proposed exceptions from excuses that would be too common (see a discussion of bright lines, Ainslie, 2001, pp. 94–100).

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The test cases in such *recursive self-prediction* may be defined by explicit self-enforcing contracts (see Telser, 1980) – *personal rules* for what choices would be lapses; or they may just emerge from your vague awareness that you are apt to go on doing what you see yourself do this time. You might conceive the stake in such implicit contracts to be self-esteem, good character, pride in grit, a good relationship with God, the approval of a dead relative, or even the obedience to social instructions – to the extent that those no longer carry external sanctions. But the functionality of such concepts is to be a stake against impulses. For instance, the once-common device of oaths fits this description (Ainslie, 1975, p. 483; citing Lewis, 1838, pp. 4–9). Thus, recursive self-prediction may take a form that is displaced away from any explicit self-knowledge, further muddying the already controversial definition of "metacognition" (Beran, Perner, & Proust, 2012; Carruthers, 2009).

The perceived implications of a given kind of test case are apt to grow with experience, making it part of a web of negotiations between impulses and resolutions that may either reduce or magnify a case's effect. For instance, if a student tries to speak up in class but chickens out, this may seem a minor failure among more important issues. Alternatively, it may bode poorly not only for future speaking attempts, but also for facing her shyness about school in general, or her fear of strangers, or still wider fears. She may notice an incentive not to try again, so as not to put her courage in other situations at risk. She is then apt to identify a boundary to her self-testing – "I can't talk in class" – that describes a circumscribed trait or symptom about which her resolve no longer has any credibility that she can put at stake (see Ainslie, 2001, pp. 148–149). As a person monitors her attempts to control impulses with recursive self-prediction, she creates a history of successful and failed commitments that entangle her. Her cumulative commitments and failures of commitments are precedents that make her rigid in much the way old economies or bureaucracies become rigid (Olson, 1982; see Ainslie, 2015). Where the impulsive reward itself grows stronger, as after repeated use of some addictive substances (Volkow et al., 2010), this encapsulation effect will be especially hard to overcome.

The process of recursive self-prediction that underpins resolve is observable in common experience (see sect. 3.2.5), but has been little discussed. It has been hiding in plain sight, just as the game of prisoner's dilemma itself hid until described in so many words in 1950 (Poundstone, 1992). Nevertheless, many motivational scientists besides behavioral reward theorists have adopted models that are compatible with recursive self-prediction, and a few include this mechanism explicitly.

3.2.2 Behavioral economics

Most economists' interest in willpower has extended beyond models of suppression, beginning with Laibson's golden goose (1997) and the game-theoretic model of O'Donoghue and Rabin (1999). The "motivated choice bracketing" of Read et al. (1999) is a restatement of the principle that choices are apt to be more patient if made between whole categories of outcomes ("bracketed broadly") than between single pairs ("bracketed narrowly"). An agent may construct goals (Hsiaw, 2013) or reference points (Kőszegi & Rabin, 2009) that represent expectations about her future choices, and that constrain future behavior by the threat of disappointing these expectations. These concepts move toward an enforcement principle for broad bracketing, because their agents are aware, if "sophisticated," that larger categories of prospective rewards depend on current choices. Read and colleagues actually mention the test-case contingency in their review of possible mechanisms (1999, p. 191). Early in economists' discussions of willpower Bénabou and Tirole accepted the self-enforcing contract model and most of its implications (2004).[13] Theirs has been the most complete expression of the recursive self-prediction model in terms of economics, short of wholescale adoption (as in Ross, Sharp, Vuchinich, & Spurrett, 2008, pp. 62–75).

3.2.3 Social psychology

In addition to suppression models, there is a vast social psychology literature on willpower, often in other terms – "willpower" was thought until quite recently to be the stuff of self-help books, not a scientific concept. Where willpower has been discussed again, it is mostly described as an "executive function," strengthened by mental exercises in working memory and inhibitory control, adequate sleep, and mindfulness training (Hofmann & Kotabe, 2012). Most authors have proposed no mechanisms beyond simple intention, but they sometimes suggest elements that are components of recursive self-prediction. For instance, integrative self-control theory depicts "iterative reprocessing" of valuations when the opportunity for an impulse choice is close, but not the role of the choice as a test case (Kotabe & Hofmann, 2015). The health belief model includes perceived probability of success as a itself a factor in the success of an intention (Brewer & Rimer, 2015); this dynamic was proposed in general terms in Bandura's concept of "self-efficacy" (1986). The "active self-regulation" of temporal self-regulation theory demands both "inhibition of pre-potent responses" and "enough behavioral precedent" (Hall & Fong, 2015) – arguably suppression and recursive self-prediction, respectively.

One group of social psychologists developed models that imply, more or less specifically, alliance of the current LL option with a set of other LL options. Trope and Liberman depict a person's viewpoint at greater psychological distances as a higher level of "construal," more abstract and conducive to impulse control (2010). "Abstract" implies categorical or more inclusive, and thus a counting together of more examples. Gollwitzer's "implementation intentions" involve simply declaring an if–then intention, the specificity of which creates a tendency to be followed: "The strategic automaticity created by implementation intentions should free cognitive capacity … behavior is directly controlled by situational cues" (Gollwitzer, Fujita, & Oettingen, 2004, p. 213; research reviewed in Gollwitzer & Sheeran, 2006). The authors say that the declaration creates an automatic connection – something like a micro-habit – which seems to stand outside of motivation (sect. 3.3.2); but it could be argued that the specificity focuses resolve, so that the choice is liable to be evaluated as a test case. Certainly such a process occurs when subjects are induced to reconstrue a laboratory temptation task as a "test of willpower," which is reported to increase their patience (Magen & Gross, 2007). Fujita describes recursive self-prediction in so many words:

> [A key] factor appears to be whether people identify a behavior as a unique singular act or representative of a broader pattern… When people focus on what is idiosyncratic and distinct about a situation rather than how that situation is similar to and related to others, they are less likely to consider the broader implications of their actions. As a result, they do not code their behavior as a self-control failure…:If instead, people understand their behavior in terms of a broader pattern, they are more likely

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> to understand that their behavior represents a self-control failure… (Fujita, 2011, p. 360).

3.2.4 Philosophy

Philosophers have dealt with *akrasia* since ancient times (sect. 3.2). Much of this discussion has revolved around how an agent can be, or can seem, divided (well critiqued in Stroud & Svirsky, 2019). Dealing with impulse control specifically, the most frequent interpretation invokes Watson's concept of intending not to reconsider what a rational decision-maker "in a cool and non-deceptive moment – articulates as definitive of good, fulfilling, and defensible life" (Watson, 2004, p. 25; for instance, Bratman, 1999; McClennen, 2007). However, in Richard Holton's view resolution operates through a sophisticated form of suppression, really precommitment: If you know the pathways by which your revaluation makes comparisons, you should flag dangerous pathways and avoid them early, much as Ignatius Loyola said you should avoid imagining sinful acts (Holton, 2003, 2009, p. 421; cf. Duckworth et al., 2016). Some authors would include a power to reconsider such resolutions during temptation: Peterson and Vallentyne would allow reconsideration on the basis of rational rules:

> Rational resoluteness … is a kind of conditional resoluteness … the disposition to comply with adopted plans when (1) it was rationally permissible to adopt the plan at the time of adoption, and (2) the agent has acquired no new unanticipated information that, if available to the agent at the time of the plan's adoption, would have undermined the rationality of adopting that plan (Ferrero, 2010; Peterson & Vallentyne, 2018 argues similarly).

Bratman has revised his earlier advice of non-reconsideration (1999) to allow resoluteness subject to redefinition – or rationalization – constrained by the fear of regret (2014), which might include perceived threat to one's ability to use resolve.

Some philosophical writing has depicted impulse control as a procedure rather than a logical judgment. When dealing with the practicality of "synchronic" (simultaneous) self-control, authors have categorized proposed methods as actional and non-actional. Actional methods include such descriptors as blocking, direct inhibition, and distancing, roughly the category of suppression (Sripada, 2014). Non-actional methods entail cognitively re-framing the categories of outcomes that could motivate resolve, for instance, mentally grouping a beckoning temptation with threats rather than with pleasures (Kennett & Smith, 1997). But as Sripada has pointed out, neither method by itself contains the motivation to be initiated while under the influence of the temptation (2014). Generally, this motivation has been supposed to be something like "rational pressure in favor of constancy" (Bratman, 2017), which might imply seeing rational rules for self-control themselves to be at stake. Many philosophers have considered a recursive self-prediction model, and some have found their mechanisms compatible with it (e.g., Elster, 2015, pp. 270–281; Hanson, 2009, pp. 13–73; McClennen, 2016[14]; Mele, 1996; Ross, 2007).

3.2.5 Evidence for recursive self-prediction

Authors still complain, "we are unaware of recent empirical research on personal rules as a self-control strategy for students" (Duckworth, Taxer, Eskreis-Winkler, Galla, & Gross, 2019) – or indeed for anyone. Recursive self-observation is always going to be a challenge for the laboratory, although familiar in common experience.[15] Where momentary self-prediction is touch-and-go, it will be hard for an outside observer to record. Russell provides an example:

> I suspect that I may be getting seasick so I follow someone's advice to "keep your eyes on the horizon" … The effort to look at the horizon will fail if it amounts to a token made in a spirit of desperation … I must look at it in the way one would for reasons other than those of getting over nausea … not with the despair of "I must look at the horizon or else I shall be sick!" To become well I must pretend I am well (1978, pp. 27–28).

Many marginally voluntary processes are modulated recursively by self-observation. Anger, panic, nausea, sleep (in insomniacs), urination (in men with prostatic hypertrophy), and even recalling an elusive memory are promoted by signs that they are already happening, a phenomenon first described by Darwin, James, and Lange. Where the problematic urge is subject to deliberate control, as with a temptation to waste money or take drugs, obeying it is apt to be accompanied by an awareness that "I must expect to go on choosing this," which may recruit enough motivation to reverse the choice. Experimental examples of this reversal when choosing between bundles have been reported, but the results with short series using relatively small rewards have not been dramatic (Hofmeyr, Ainslie, Charlton, & Ross, 2010; Kirby & Guastello, 2001).

The dependence of resolve on a stake of self-expectations is most obvious in the case of relapse into addiction. When someone gives in after a period of successfully resisting temptations, she experiences a sudden, dramatic fall in her perceived ability to resist the next ones, an experience that has been called the abstinence violation effect (for alcoholics, see Curry, Marlatt, & Gordon, 1987; for dieters, see Polivy & Herman, 1985; for binge eaters, see Grilo & Shiffman, 1994; for child molesters, see Hudson, Ward, & France, 1992; for smokers, see Shiffman et al., 1997). True, recovering alcoholics have long believed that they have a biological susceptibility that causes a single drink to lead to irresistible craving; but it has been shown experimentally that it is the belief that they have had a drink of alcohol, not the alcohol itself, that is followed by craving (Maisto, Lauerman, & Adesso, 1977).

The reader can verify the specific role of self-expectation by thought experiments such as Monterosso's problem[16]:

> Consider a smoker who is trying to quit, but who craves a cigarette. Suppose that an angel whispers to her that, regardless of whether or not she smokes the desired cigarette, she is destined to smoke a pack a day from tomorrow on. Given this certainty, she would have no incentive to turn down the cigarette – the effort would seem pointless. What if the angel whispers instead that she is destined never to smoke again after today, regardless of her current choice? Here, too, there seems to be little incentive to turn down the cigarette – it would be harmless. Fixing future smoking choices in either direction (or anywhere in between) evidently makes smoking the dominant current choice. Only if future smoking is in doubt does a current abstention seem worth the effort. But the importance of her current choice cannot come from any physical consequences for future choices; hence the conclusion that it matters as a precedent (Monterosso & Ainslie, 1999).

The difficulty of observing recursive self-prediction experimentally is illustrated by a recent attempt in an economics laboratory: Two hundred adult subjects performed long, boring tasks on two successive occasions a week apart. Two days before each task they were

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asked to say how much of it they intended to perform, and to guess how much they actually would perform. Before the first task the subjects were asked how much they expected to correct their intentions/estimates for the second task between tasks, expectations that would show an awareness of "the autocorrelation of intertemporal decisions" (Yaouanq & Schwardmann, 2019). They showed little of this awareness. However, subjects were not told to control themselves, so they probably did not see their reported intentions as resolutions. In any case, this has been the only experiment so far to try making self-prediction externally visible.

3.2.6 Resolve may entail a different kind of effort

Effort is the operational expense of impulse control. Resolve becomes effortless to the extent that you are confident of maintaining it. Even with temptations that arouse an appetite, the unambiguous belief that you will never give in can make impulse control easy. In natural experiments, Dar and colleagues have found that Orthodox Jews who never smoke on the Sabbath and flight attendants who never smoke during flights have no urge to smoke during those times, while still having strong urges at other times (Dar, Stronguin, Marouani, Krupsky, & Frenk, 2005; Dar, Rosen-Korakin, Shapira, Gottlieb, & Frenk, 2010). Such examples elucidate willpower-as-resolve – the perception of incentives that commit you, even when, as with the religious, you choose and maintain the incentive structure yourself. People high in the self-reported trait of self-control have reported fewer problematic desires in their everyday lives, and they make conscious use of self-control less often (Tangney, Baumeister, & Boone, 2004).

On the other hand, marginally permissible temptations create an operational cost for resolve – the stress of managing the risk to a broader category of expected reward implied by a current choice. This stress occurs to the extent that the membership of your current choice in a bundle of SS/LL choices is open to doubt – that is, where the SS option in a current choice is a somewhat credible exception to your rule. In that case you face a legalistic task, the cost of which is not only the attention demanded by the required argument but also facing the danger that you may lower your prospect of a bundle of LL reward, if you claim an exception and later find that you have fooled yourself. Then you are at risk of an abstinence violation effect, or perhaps just a lower prospect of getting your long-term reward. This loss may provoke regret or guilt. Therefore, negotiation with competing options is sometimes also called an effort – for instance, in William James' famous discussion of a drunkard's excuses for drinking: "The effort by which he succeeds in keeping the right *name* ['being a drunkard'] unwaveringly present to his mind proves to be his saving moral act" (1890, p. 565, his emphasis; see also Hockey, 2011, pp. 174–177).

We have many SS/LL conflicts that do not rise to awareness during the average day. "The lion's share of our everyday desires does not stand in conflict with our values and self-regulatory goals" (Hofmann & Kotabe, 2012). However, even prosaic choices often have conflictual histories. The truce lines of old battles (sect. 3.2.1) become unremarkable, even when large incentives are at stake – life savings, the risk of cancer, beliefs about personal identity (Berkman, Livingston, & Kahn, 2017). Hundreds of small intertemporal conflicts are similarly avoided mindlessly: Someone may variously wait until after dinner to eat dessert, do the more boring of two tasks first, put on a condom, pick up a fallen object as soon as it falls, and make other categorical responses that were once formed to combat the pervasive incentive to procrastinate. Their status as intertemporal bargains is evidenced only by the unease that comes from not performing them, which can be attributed, in turn, to the asymmetrical damage done to prospective impulse control.[17] Similarly, Fujita points out that with successful reconstruals and implementation intentions, "no temptation impulse should be experienced" (2011, p. 359). Significantly, he alludes at several points to self-control occurring "without conscious deliberation (p. 355)." These patterns sound like habits, a word that is coming back into vogue.

3.3 Habit is an outcome, not a mechanism

"Habit" has been put forward in the recent self-control literature as the most successful impulse control strategy (Carden & Wood, 2018; Gillebaart & Adriaanse, 2017; Neal, Wood, & Drolet, 2013). However, this usage is misleading. To discuss the role of habit in self-control, we should first distinguish three kinds: routine habits, good habits, and bad habits.

3.3.1 Routine habits

These are subroutines that you learn for navigating familiar paths to reward with a minimum of attention. Repeatedly rewarded behaviors get more and more efficient and require less and less attention. We use many of these to get dressed and drive to work while thinking of something else. Engagement in a habit is accompanied by a shift of neural activity in midbrain striatal areas from "planning" or "voluntary" to "habitual" systems, which has been suggested to imply a committing effect (Everitt & Robbins, 2013). A similar shift has been described from "goal-directed" or "model-based" to "model-free" systems (Voon et al., 2015).[18] However, the habitual or model-free system does not hold the process of choice captive. Brain imaging shows flexible transitions between these processes (Gershman, Markman, & Otto, 2014; Kool, Cushman, & Gershman, 2018; Otto, Gershman, Markman, & Daw, 2013), and there is electroencephalography (EEG) evidence that these systems stay in operation simultaneously (Sambrook, Hardwick, Wills, & Goslin, 2018). Most importantly, multiple attempts to make human subjects resistant to new learning through sheer repetition have overwhelmingly failed (de Wit et al., 2018). In normal subjects, any contrary incentive restores the model-based system – You can easily put on clothes in a different order or take a different route to work if you just pay attention. Although routinely habitual behaviors are sometimes called automatic or robotic, "mindless" would better characterize their persistence without having momentum.

Some authors have proposed that brain damage from addiction may make routine habit resistant to change, thus preserving it as an explanation for why addictions persist in the face of contrary incentives (e.g., Everitt & Robbins, 2005, 2013). In making frequent choices to get small amounts of money in the laboratory, addicts have been observed to show more model-free behavior than non-addicts (Voon et al., 2015). However, this difference has been small, as it has been even in patients with gross lesions in the brain centers active during choice (Fellows & Farah, 2005). A recent review of the literature about inflexible ("stimulus-bound") habit in humans found small increases in subjects with several kinds of psychopathology, but could not distinguish in those subjects between "excessive habit formation [and] weak goal-directed control" (Watson & de Wit, 2018, p. 35).[19] We might wonder whether slightly decreased flexibility of choice between small rewards in the laboratory reflects inability to weigh the major consequences of addiction.

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3.3.2 Good habits

These are those behavior patterns preserved by resolve – keeping a diary every night, jogging every day, or getting out of bed when the clock radio plays a certain theme every morning. The resolve need not be deliberate, perhaps just a sense that you won't go on making a particular choice if you don't do it this time. You can tell that a habit is good rather than routine when a very few choices in the contrary direction are sufficient to change it. Because of this, you sense that you need an excuse to skip it on a particular day, lest it be harder to begin again. Accordingly, you feel a rush of pleasure when an external circumstance prevents you from doing it today. This rush of pleasure is evidence that the habit is not something you simply prefer; nevertheless, abandoning or "breaking" the habit feels like a loss. Of course, when you do not expect much benefit from the habit, the pleasure or the loss will be small. The habits that subjects choose casually for an experiment do not elicit the amounts of differential motivation at play in addictions or tests of character. Habits such as always drinking a bottle of water with lunch or eating fruit (as in Lally, Van Jaarsveld, Potts, & Wardle, 2010) shade into routine habits such as always dressing in a particular order or taking a particular route to work, the benefit being just not having to stop and choose. Sobriety may be a routine habit for someone who is not tempted to drink too much, but a good habit of great significance for a recovering alcoholic.

Some authors lump even good habits of great consequence together with routine habits. They point out that a person who habitually resists a temptation in a particular circumstance stops feeling tempted there – never thinks of smoking during a flight, for instance. Therefore, highly credible resolve does engender a routine habit of sorts, to avoid considering rewards that will never happen. But this habit will persist routinely only as long as the tempting reward indeed does not happen.[20] The important question is how such abstention is achieved to begin with.

In a recent review, Duckworth and colleagues comment, "the conceptual parallels between plans, personal rules, and habits may belie antagonistic underlying processes" (2019). However, the argument I have presented is that good habits require intertemporal bargains – the motivation for an LL choice in their specific context by fear of breaking up the pattern of LL choices on which a larger reward is seen to depend. "If I don't study (or go running, or …) at eight o'clock today, I'll be less likely to do it tomorrow." Admittedly, when this logic has prevailed for some time a person will stop going through it, and behave mindlessly. It can even look as although "action control is transferred to environmental stimuli" (Lally, Wardle, & Gardner, 2011). But the crucial factor in a good habit is not the frequency of repetitions but the *in*frequency of lapses – instances of non-performance without an excuse. The notion of excuses is meaningless for routine habits, but is at the very heart of the intertemporal bargain in good habits. If I don't go running when it's stormy, or don't study when I have to supervise my sister, the strength of my good habit shouldn't be affected. But if I just don't feel like doing it, or reach too far for excuses, my motivation will soon come down to the whim of the day, even if I've run or studied a great number of times before. When I have lost the protection of confident resolve – perhaps experienced as "ingrained" habit – I will pass into a middle ground: Impulse control now takes effort (Galla & Duckworth, 2015), in the sense either of tenuous intertemporal bargaining or increased use of suppression or both in tandem. Or I may abandon the good habit altogether.

The asymmetrical vulnerability of good habits to lapses has long been known. "Every gain on the wrong side undoes the effect of many conquests on the right" (Bain, 1859/1886, p. 440). To extinguish your weighing of alternatives you have to choose consistently over many trials, or, rarely, discover a radically new way of evaluating your rewards – reported sometimes by addicts who quit overnight (Heyman, 2009; Miller & C'de Baca, 2001; Premack, 1970, p. 115). Before a good habit starts to feel routine, there is usually a long period where temptations arise but are deterred by a recognition that they are test cases – that is, by resolve. Therefore, the good habits that have been recently proposed as an effortless alternative to willpower (Carden & Wood, 2018; Duckworth et al., 2019; Gillebaart & Adriaanse, 2017; Neal et al., 2013) are actually *a form of* willpower, and are effortless only when unchallenged – either by an unusually strong temptation or by ordinary temptations that come with middling-good excuses.

3.3.3 Bad habits

These are just impulsive behaviors that occur repeatedly. Although someone may call an activity that she actually prefers a bad habit – cracking her knuckles or putting her feet on the furniture, or even drinking too much or smoking – the term has motivational meaning only when she would prefer at a distance to avoid the behavior. She may never have tried to control it, or may have come to terms long ago with failing to do so. However, a new failure may endanger her resolve in other areas, as described in section 3.2.1. This risk is apt to deter attempts at breaking bad habits. Too many failures may snowball into lost credibility for almost any resolve, as in some cases of addiction, a bankruptcy that in combination with the cumulative dopaminergic potentiation of addictive reward (Volkow et al., 2010) might fairly be called a disease (discussed in Ainslie, 2011).

3.4 The functional relationship of resolve, suppression, and habit

In earlier writings where I described recursive self-prediction and its consequent intertemporal bargaining, I imagined resolve to be synonymous with willpower (Ainslie, 1975, 1992, 2001, 2017), so I made no attempt to relate it to suppression or habit. Recent proposals about habit and recent reports of brain imaging have suggested a way to integrate the three phenomena. Essentially, habit reflects bargains between impulses and resolutions that are no longer contested, and suppression is not only an *ad hoc* device but also a tool to help implement resolve. That is, resolve and suppression are symbiotic, in that suppression has only local effect without resolve, and the implementation of resolutions can be augmented against momentary urges by suppression. The only one of these strategies that is intrinsically effortful is suppression, but intertemporal bargaining may sometimes become effortful either by costing a great deal of attention or by evoking fear for your larger expectations of self-control. What brain imaging has been done on willpower is consistent with this view, and to some extent actually suggests it.

4. Evidence from brain imaging

Some aspects of impulse control have become visible to functional magnetic resonance imaging (fMRI) and EEG in humans, and to microelectrode recording in primates. The hyperbolic shape of the underlying delay discount curve seems to be well supported by

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fMRI of reward areas, not just when subjects choose money at delays of weeks (Kable & Glimcher, 2007), but also when they choose small amounts of money at delays of seconds – periods so short as to suggest the prizes are not just secondary rewards but primary, game-created prizes (Wittman et al., 2010).

A subject's awareness of SS/LL choice seems to induce reduction of relative SS value even when no outcome depends on it. At least, young American adults choose LL rewards more than would be expected from activity observed in brain reward centers when the same outcomes are anticipated singly (Luo, Giragosian, Ainslie, & Monterosso, 2009). This finding suggests a readiness to counter impulsiveness in the presence of intertemporal contingencies *per se*, but does not reveal a mechanism.[21] Actual trials of willpower evoke suppression, as was pointed out above (sect. 3.1). They are attended by increased activity in particular centers, especially in the dorsolateral prefrontal cortex (dlPFC; Figner et al., 2010; Hall & Fong, 2015; Kober et al., 2010; Luo, Ainslie, Pollini, Giragosian, & Monterosso, 2012). In a primate study minutely monitoring attention during a food-getting task, dlPFC activity was observed to accompany suppression of distracting stimuli (Suzuki & Gottlieb, 2013). In humans, transcranial magnetic stimulation of the dlPFC in real time increases LL choice (Cho et al., 2010), and its disruption increases SS choice (Figner et al., 2010). The observation that subjects' valuations of the alternatives stayed the same during the procedures in the latter two studies implies that dlPFC activity need not change valuations to be effective (but see Hare, Camerer, & Rangel, 2009); rather, a direct self-control process may be occurring (see Scheres, De Water, & Mies, 2013).

In humans, EEG that allows tracking over milliseconds has shown two specific steps in suppression: A food-temptation experiment shows LL choices to begin with "attention filtering," followed, still within half a second, by "value modulation" – suppression of reward center activity – both of which are moderated by the dlPFC as located electronically by distributed Bayesian source reconstruction (Harris, Hare, & Rangel, 2013). The short latency of both kinds of responses from the presentation of the options indicates that they are part of the decision itself. A step-by-step description of a subject's choice would thus be: (1) intention to exert control at a given moment, then (2) filtering attention, (3) inhibiting appetite, and (4) behavioral response.

Moving beyond mere localization, it is now possible to detect the *functional connectivity* of the dlPFC with reward-related centers as subjects resist temptations in real time. dlPFC activity is accompanied by reduction of activity in the ventromedial (vmPFC) and orbital PFCs (Hare et al., 2009; Hare, Hakimi, & Rangel, 2014; Lim et al., 2016; Monterosso & Luo, 2010). In a recent example of smokers who were trying to quit, only those whose brains showed connectivity between the dlPFC and the insula during an actual chance to smoke were able to resist it (Zelle, Gates, Fiez, Sayette, & Wilson, 2017). Clinically minded experimenters have even begun to use a newly-developed biofeedback technique based on fMRI to teach increased functional connectivity between the dlPFC and vmPFC (Spetter et al., 2017); they report that it reduces high-calorie food choices.[22]

Because resolve is a matter of framing and monitoring choices, it might not be accompanied by measurable brain activity any more than other semantic content is. However, to the extent that resolve permits a given amount of LL choice to be made with less suppression, its operation should be reflected in reduced activity in the dlPFC and other centers that filter attention or inhibit appetite. Certainly, such a reduction occurs with physical commitment to LL choice: Male subjects who could choose higher-valued erotic images after delays of up to 10 seconds versus less-valued images immediately, in one condition could choose to commit themselves to wait, and in another condition had both options continuously open (Crockett, Braams, Clark, Tobler, & Robbins, 2013). Counting only the trials that resulted in LL choice, the authors found less dlPFC activity both while a subject chose commitment and afterward.

Another finding from the same experiment points to where active choice of impulse control may be observable: Subjects showed increased activity in the frontal cortical pole specifically while a subject was choosing the commitment option. In a similar temptation experiment, stimulation of the frontal pole by transcranial direct current (tDCS) increased subjects' choice of the commitment option, while having no effect on choice rates when uncommitted (Soutschek et al., 2017). The frontal pole has been implicated in the highest levels of abstraction (Smith, Monterosso, Wakslak, Bechara, & Read, 2018). The foregoing experiments suggest that it is active in planning impulse control but not in suppression, and thus might be a candidate for formulating and monitoring the intertemporal bargains that form resolve. Scenarios created in episodic memory areas might also serve this function. They are widely reported to be involved in counteracting the overvaluation of the near future (Benoit, Gilbert, & Burgess, 2011; Bulley, Henry, & Suddendorf, 2016; Peters & Büchel, 2010; Schuck, Cai, Wilson, & Niv, 2016). The question that needs follow-up is whether internal commitment by intertemporal bargains has the same reducing effect on dlPFC activity as external commitment has.

Some recent experiments are steps in this direction. In intertemporal choices of cash, reframing subjects' options just by showing each zero-paying alternative reduced dlPFC activity during LL choice while also increasing occurrence of this choice (Magen, Kim, Dweck, Gross, & McClure, 2014). The authors called the frames that listed the zero-pay events "sequences," even though the same two single outcomes were being compared. The authors' original concept was to evoke people's well-known preference for improving sequences of outcomes (Magen, Dweck, & Gross, 2008), but it seems more likely that it suggested abstract and perhaps budgetary decision bases. In any case, just listing the zero-pay outcomes has been confirmed to increase LL choice, to increase activity in "imagination centers" and decrease activity in the dlPFC and caudal ACC during LL choice (Jenkins & Hsu, 2017). These experiments tested just preference, not impulse control, but they suggest how re-framing can reduce the role of the dlPFC while increasing LL choice.

These results support separate roles for valuation and suppression in impulse control. Next, we need to look at brain imaging specifically during resolve: testing whether frontal pole and/or imagination center activity was high, and dlPFC activity low, during *internal* commitment, that is, during commitment by an intertemporal bargain. Such testing would first require comparison of stand-alone SS/LL reward choices versus actual bundles of these choices. If LL choice was greater in the bundle condition, we could then measure brain activity during an SS/LL choice that the subject was apt to see as a test case for a larger bundle, and compare it with activity in a condition where she would not take this view. Suggesting such a view with respect to arbitrary bundles, as in Kirby and Guastello (2001) and Hofmeyr et al. (2010), would probably again produce a small difference; but it would be difficult in the laboratory to call on a subject's real life test cases, such as the moral and characterological choices

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envisioned by Bodner and Prelec ("self-signaling" – 2003). A creative experimenter might look for examples where an existing strongly held rule was time-dependent – not to smoke on the Sabbath or eat meat on a Friday – and measure a subjects' PFC activity when confronted with temptations on the different days.

5. Conclusions, in evolutionary context

In human evolution, the influence of future expectations on current preference has been at least as great an advance as speech, tool use, or theory of mind, and it is ultimately a resource for all of those. Until the emergence of foresight, contingencies that were at all remote shaped behavior only by the natural selection of inborn instincts, for instance those that attached present reward to the necessary components of migrating, nesting, and reproducing. The role of foresight was limited by organisms' capacity to detect contingencies – associations of events – spanning more than seconds to minutes.[23] Bigger brains meant more foresight, but even the great apes still show signs of looking ahead for no more than a few hours, for instance in anticipating the use of a tool (Mulcahy & Call, 2006; Osvath, 2009).

It once seemed that long-term choice was simply a quantitative development: the evolution of more powerful predictive ability that could detect reward differentials when they were attenuated by longer delays. However, adaptation to increases of time scale turns out to need more than an increase of predictive power. As with so many evolutionary metrics – wing span, leg strength, heat dissipation – a vast increase in scale has introduced at least one qualitatively different problem. To the extent that an organism replaces instinctive preference with foresight, effective reward-getting demands consistent preference over time. The inherited process by which delayed prospects attract vertebrates' preferences does not itself produce this consistency. Data from a range of species show that the internal market value of a delayed prospect is discounted in inverse proportion to that delay – hyperbolically – as if this function had been simply copied from other psychophysical functions for assessing quantities such as weight, brightness, and temperature (Gibbon, 1977).

Orthodox theory holds that hyperbolic discount functions are maladaptive on their face and thus should have been selected out in evolution. However, the fact remains that nonhuman animals regularly show preference for SS over LL rewards, temporarily. They are often motivated to suppress this imminent preference (as at arrow in Fig. 1B): A dog waiting for a fetch signal or a rat facing shock on the path to food can be seen straining against urges. A pigeon rewarded with grain for *not* pecking a key over a few seconds can be seen pecking at the wall next to the key or turning around during that time (Ainslie, 1974), behaviors similar to Mischel's 4-year-olds trying not to eat the marshmallow (Mischel & Ebbeson, 1970). These are clearly effortful behaviors, and even pigeons can learn to increase them up to a point (Ainslie, 1982), but such mechanisms do not offer even moderately long-term stability. They are easy to study in the laboratory and are reliably accompanied by dlPFC activity, making suppression the experimental paradigm of impulse control. But suppression is only one route to willpower.

Philosophical opinion from Aristotle on down has been that impulses are best managed when the current choice appears inseparable from a larger category of choices. Hyperbolic discount curves describe both temporary preferences (Fig. 1B) and the potential effectiveness of discerning test cases for series of similar choices (Fig. 2), the use of which is here argued to be resolve. The logic of intertemporal bargaining also determines how effortful resolve will be. When a person sees that a rule defines a clearly dominant strategy, choice should become regular and effort should not arise. But where the rule can be argued various ways, the resulting doubt and attempts to overcome it create a cost that could also be called effort, although of a different kind than that of suppression. A successful bargain will come to be experienced as an effortless habit, but habit is not itself a mechanism of consistency.

Brain imaging is well adapted for tracking suppression, but is just starting to suggest processes accompanying resolve. In SS/LL choice experiments, subjects' choices of precommitment are accompanied by reduced brain dlPFC activity, but this has been studied only in the case of external precommitment. Resolve is hard to study in the laboratory, not least because it has implications for the whole web of an individual's intertemporal bargains. However, reports of frontal polar and default area activity during choice of precommitment suggest that these areas may also take part in resolve.

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Notes

1. Google Scholar reports a rapid increase in articles related to "willpower," increasing by a factor of about 2.5 in every decade from the 1950s until 2010, then, perhaps saturated, increasing by only 60%: 139 articles on "willpower" in the 1950s, then 401 in the 1960s, 1,200 in the 1970s, 2,740 in the 1980s, 6,650 in the 1990s, 18,100 in the 2000s, and 29,900 for 2010–2019.
2. Many of the references of which I was author or co-author are downloadable from http://www.picoeconomics.org.
3. In a review of 3,000 articles on "health behavior theories," all the most durable ones in the literature – viz. the "health belief model," "theory of planned behavior (TBP)," "theory of reasoned action," "integrated behavioral model," and "transtheoretical model" – none include a motivational enforcement mechanism (Glanz et al., 2015).
4. There is often an initially rewarding component in aversive experiences, as seen in *urges* to panic, rage, or rehearse traumatic memories. Then, in addition to choices between aversive options, there is a very short-term positive option within the nearer one – to give in to the urge that brings it on (discussed in Ainslie, 2009; see Schultz, 2016, about the possibly related dopamine effect of "salience").
5. A conventional – exponential – discount curve usually describes consistent preference over time, but combined curves with different exponents could cross as an SS reward gets closer: Present value = Hot value when immediate × $(1 - \text{Hot discount rate})^{\text{delay}}$ + [Cool value when immediate × $(1 - \text{Cool discount rate})^{\text{delay}}$].
6. Present value = Value when immediate/$(1 + [k \times \text{delay}])$.
7. The steepness of delay discount curves varies widely among individuals (Kable & Glimcher, 2007; van den Bos, Rodriguez, Schweitzer, & McClure, 2014), and to some extent this variability is hereditary (Anokhin, Golosheykin, Grant, & Heath, 2011). However, the decreasing steepness of the curves with maturity (Green, Fry, & Myerson, 1994; Green et al., 1999) suggests that people learn to compensate for this endowment. In a rare longitudinal, within-subject experiment on quitting smokers, subjects were found to have shallower curves after a year of abstinence (Secades-Villa, Weidberg, García-Rodríguez, Fernández-Hermida, & Yoon, 2014). Another indicator that spontaneous discounting is hyperbolic, or is at least described by curves

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with relatively high tails, is that many goals which are so distant as to have almost no present value if discounted conventionally do, in fact, attract investment (avoiding climate change, financial security in old age, the welfare of grandchildren generally; Cropper & Laibson, 1998; Gollier & Weitzman, 2010; Gowdy, Rosser, & Roy, 2013).

8. Many authors have pointed out that choice among all alternative behaviors that can be chosen in each other's place must be based on a common currency (Ainslie, 1992, pp. 28–32; Benhabib & Bisin, 2005, p. 480; Cabanac, 1992; McFarland & Sibley, 1975; Montague & Berns, 2002; Shizgal & Conover, 1996). Call it *reward*. There is evidence that paths to alternative rewards compete by vicarious trial and error (VTE; Redish, 2016; Schacter, Addis, & Szpunar, 2017) until one passes a threshold (Pedersen et al., 2017; Wu & Glimcher, 2018) and becomes an *intention*. Habits might be held to lie outside the marketplace of reward, but I will argue against this possibility presently.

9. "Firmness of purpose or intent; determination" in "*Dictionary.com*"; "strong determination" in *the Cambridge Dictionary*.

10. Aristotle's detailed mechanics and the sparse writings of others who wrote before the Victorians are well covered in Charlton (1988, pp. 38–65).

11. Such summation of power does not require numeric calculation of the expected rewards. The calculation happens intuitively, within the basic operation of the reward mechanism, as shown by the fact that even pigeons are sensitive to sums of temporally spaced rewards (Mazur, 1986), and rats show the predicted increase in patience when choosing bundles of such rewards (Ainslie & Monterosso, 2003). Imagination obviously alters rewards that are expected in the far future, and even recent experiences turn out to be recorded as impressions rather than moment-to-moment transcripts (Kahneman, 2000).

12. The philosopher Michael Bratman and others have objected that intertemporal bargaining does not create a true prisoner's dilemma, because you are never motivated to retaliate against a past defection (Bratman, 1999). However, it is realistic to see a past defection as evidence that future selves will not cooperate, and thus to have less incentive for present cooperation, which amounts to the same outcome.

13. However, Bénabou and Tirole sought to preserve the general form of the exponential curve, with its implication of a natural stability of intentions over time. This required them to base impulses on visceral arousal, which, as I argue above, is a limited explanation.

14. McClennen holds that a present self's more empathic attitude toward future selves would soften the *realpolitik* of prisoner's dilemma incentives, but the underlying enforcement mechanism seems to be the same as mine (McClennen, 2007).

15. It has even been proposed that people discover their own intentions by looking at what they believe is their recent behavior (Carruthers, 2009).

16. The subtler examples of Kavka's and Newcomb's problems are proposed in Ainslie (2007); another example in Bratman (1999, pp. 35–57).

17. As with treaties between nations, there are only a few kinds of breach that can't be repaired at the cost of further negotiation. Such *atomic* lapses might include the first drink by a recovering alcoholic or a reprehensible act that shatters one's perceived character.

18. From ventral to dorsal striatum in rats, or the analogous dorsomedial to dorsolateral striatum in humans – Dolan and Dayan (2013, p. 219).

19. The authors made the important distinction, often overlooked in the habit literature, between "habit learning," which just means "model-free" trial-and-error learning, and "stimulus-boundness," meaning unresponsiveness to changed or devalued outcomes. The latter phenomenon can be induced by overtraining (prolonged repetition) in nonhumans, but the only human example the authors could find after extensive search was a report of brief persistent responding on a concurrent variable interval schedule – where subjects were satiated by one reward but where continuing to work for it did not lead to reduced delivery of the other reward (reported by Tricomi, Balleine, & O'Doherty, 2009).

20. Sometimes the appetite itself stops being aroused, which by a similar logic might be because of conditioned extinction, or, more controversially, because of the arousal itself having extinguished as a motivated behavior that was maintained by reward (see Ainslie, 2010b).

21. This tendency might reflect the same cultural preparation that seems to lead subjects not to report hyperbolic delay discounting when offers are made in terms that connote financial planning (as in Harrison, Lau, & Rutström, 2005), and not to discount large sums of money as steeply as small sums (the "magnitude effect"; Ballard et al., 2017). Just as nonhuman subjects do not show the magnitude effect, they might be found not to show the relative devaluation of SS options in choice versus non-choice presentations. Testing for these phenomena in non-WEIRD subjects might also be informative (Henrich, Heine, & Norenzayan, 2010).

22. It is not yet clear that this activity is clinically effective (Thibault, MacPherson, Lifshitz, Roth, & Raz, 2018) or better than just mentally suppressing appetite (Hare, Malmaud, & Rangel, 2011). The tedium that would limit the sustainability of either, as in other laboratory willpower tasks, has not been measured.

23. Some innately defined life-and-death events could narrow the focus of attention to permit longer-term associations, notably in learning bait shyness (poisoning) over delays of hours (Revusky & Garcia, 1970).

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Open Peer Commentary

Willpower through cultural tools: An example from alcoholics anonymous

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Abstract

We argue that a closer look at the practices and tools that humans use to support willpower, and the cultural contexts in which they are employed, can broaden the applicability of Ainslie's theory and facilitate the development of more effective self-control techniques. To support our argument, we examine Alcoholics Anonymous's method of temptation resistance known as "playing the tape through" (PTT).

In "Willpower with and without effort," George Ainslie clarifies the resolve and suppression mechanisms involved in the manifestation of willpower. However, Ainslie's article underplays the importance of cultural contexts and framing in understanding how individuals perceive the associated costs and benefits of self-control. The article acknowledges some cultural institutions that orient and strengthen willpower, but throughout our evolutionary history a host of specific practices have culturally evolved to support willpower. A closer look at these practices, and the cultural contexts in which they are employed, can broaden the applicability of Ainslie's theory. Here, we examine Alcoholics Anonymous's (AA) method of temptation resistance known as "playing the tape through" (PTT) and explore its resonance with Ainslie's framework.

One of the key tenets of recovery in AA is complete abstinence from alcohol. AA argues that, for alcoholics, consumption of a single alcoholic beverage guarantees the onset of a drinking binge (Wilson, 1976). That first drink triggers a bottom-up signal from the amygdala which overrides the alcoholic's conflict detection system, thereby allowing compulsion to overpower reasoning at the neurological level (Bechara, 2005; Derks & Scheepers, 2018). Essentially, AA asserts, alcoholics have no ability to moderate while drinking. Accordingly, alcoholics must avoid *any* consumption of alcohol or risk falling into old, destructive behaviors.

The PTT method is a relapse prevention technique involving exertion of willpower, specifically resolve, over temptations. Resolve entails a cost–benefit analysis of the hypothetical outcomes of exercising self-control versus conceding to compulsion (sect. 3.2). PTT enables alcoholics to compare the net benefits of abstinence and relapse and use this assessment to decide their next step. The need for PTT is triggered by an alcoholic's cravings for alcohol, often resulting from rumination on the positive foresights of drinking with simultaneous repression of the risks. This phenomenon, coined "euphoric recall" by Gorski (1988), constitutes the beginning of "the tape."

The first phase of PTT involves conceptualizing the images and feelings associated with relapsing. As if watching a mental "tape," the alcoholic visualizes the entire scenario from the first sip through the consequences that follow. The alcoholic then

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identifies the costs *and* benefits of the hypothetical situation. Relapse often leads to a rapid downward spiral rampant with costs and the alcoholic quickly finds herself reliving the experiences which originally convinced her to get sober. Common ramifications include mental and physical turmoil, loss of loved ones, arrest, and hospitalization (Wilson, 1976). Although the costs of relapse are immense, if the alcoholic chooses to drink she would be rewarded with almost-instant gratification as the alcohol takes effect. The alcohol-induced influx of dopamine and serotonin temporarily increases feelings of happiness and peace whereas the increase in GABA lowers inhibitions, relieving anxiety and increasing confidence (Banerjee, 2014). PTT forces the alcoholic to identify and assess the costs and benefits of relapsing, which are specific to her personal experiences with drinking.

The second phase of the PTT method involves considering the implications of remaining abstinent through use of the previous start-to-finish visualization process. Similar to the preceding phase, the alcoholic recognizes the costs and benefits of maintaining sobriety. Remaining abstinent in the presence of cravings can be very uncomfortable (Kavanagh et al., 2013). Thus, the predominant short-term cost of remaining abstinent is enduring the discomfort until cravings subside. Although choosing abstinence can be temporarily costly, benefits can include enhanced cognitive skills, financial security, and improved social, psychological, and legal outcomes. The alcoholic identifies the costs and benefits of remaining abstinent to assess its worth as an option.

In the final stage of PTT, the alcoholic practices resolve by comparing the values of relapsing and remaining abstinent to determine which option produces the greatest ultimate rewards. Delivering quick relief with long-term expenses, relapsing provides smaller, sooner (SS) rewards. Remaining abstinent has short-term costs with long-term benefits. Thus, demonstrating self-control generates larger, later (LL) rewards. Ainslie (sect. 3.2.1) argues that bundles of LL rewards gradually produce greater gains than bundles of SS rewards. Choosing abstinence, through techniques such as PTT, ultimately produces greater benefits than relapsing. Furthermore, through engagement in intertemporal bargaining, the alcoholic often realizes relapsing in the present could negatively impact her ability to exercise self-control in future decisions about drinking, eventually resulting in larger costs and more lost benefits (sect. 3.2.1). Completing PTT, the alcoholic reviews these factors and often chooses abstinence over relapse. If cravings persist, alcoholics may reimplement the PTT method, among others, to continue systematically assessing their options. Note that suppression, the act of disregarding any option except self-control, is not included in PTT, because the method requires active consideration of all options, including relapse.

Consistently practicing resolve through PTT can prompt alcoholics to habitually choose abstinence over relapse. Over time, the alcoholic may conclude that relapse is not a promising option. Meanwhile, abstinence is reinforced through the accrual of LL reward bundles, ultimately leading to the formation of this "good habit." *Complete* abstinence is the most important determinant of habit maintenance (sect. 3.3.2). Relapsing, even once, can drastically reverse progress, and prolonged practice of recovery mechanisms, such as PTT, is required again to regain habitual abstinence. Many long-term AA members have practiced PTT enough to internalize the results and no longer need to consciously review them. Nevertheless, predisposition toward abstinence can waver in alcohol-salient situations, so conscious, repetitive enactment of the PTT method is valuable at any stage in recovery (Kavanagh et al., 2013).

Alcoholics must exert considerable willpower to remain sober. Little is known, however, about the cross-cultural variation in popular relapse prevention methods, such as PTT. The relevance and efficacy of each method may depend on cultural traditions, beliefs, and taboos. Further research should identify and compare relapse prevention methods across cultures, using Ainslie's framework to analyze differential expression of willpower. It is hoped that such study will help to refine existing self-control techniques or develop new methods to combat addiction in all its forms.

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Willpower needs tactical skill

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Abstract

Ainslie advances our understanding of self-control by theoretically unifying multiple forms of willpower. But one crucial question remains unanswered: How do agents pick the right forms of willpower in each situation? I argue that willpower requires *tactical skill*, which detects willpower-demanding contexts, selects context-appropriate tactics, and monitors their implementation. Research on tactical skill will significantly advance our understanding of willpower.

Self-control literature has recently shifted from explanations appealing to a unique resource (Baumeister, Bratslavsky, Muraven, & Tice, 1998) or process (such as inhibition; Diamond, 2013), toward a recognition that self-control relies on a multiplicity of strategies and processes (Duckworth, Gendler, & Gross, 2016; Hennecke & Bürgler, 2020). Currently, the challenge is finding unifying threads in this multiplicity (Inzlicht, Werner, Briskin, & Roberts, 2020;

Sripada, 2020). Ainslie's target article contributes to this trend toward a much-needed unification of the self-control literature. His account subsumes current willpower research onto the phenomena of suppression, resolve, and habit, and holds that suppression and resolve are complementary willpower tactics, whereas willpower-as-habit results from repeatedly successful resolve.

One key outstanding gap is explaining how agents can select among diverse willpower tactics and find appropriate tactics for each specific situation. This ability to choose the right tactics is crucial given the diversity of situations calling for self-regulation (from addiction to procrastination, from managing anger to trying to develop good habits). Here I argue that, given the multiplicity of willpower tactics and the plurality of regulation challenges, willpower exertion requires skillfully identifying, selecting, and monitoring the implementation of appropriate tactics for each particular context. This *tactical skill* (the skillful management of willpower tactics) is a central component of willpower that remains to be fully theorized and studied.

To illustrate how crucial tactical skill is for willpower, consider that the two tactic types Ainslie presents are themselves *families* of diverse strategies. On the one hand, suppression can take the various forms of response modulation (e.g., inhibiting one's urge to eat another cookie to limit calorie consumption), attentional deployment (e.g., distracting oneself from the package of cookies), or cognitive reappraisal (e.g., imagining the cookies are plastic models instead of real cookies) (Duckworth et al., 2016). These are all forms of suppression: Strategies for resisting temptations that gate out alternatives to the agent's intention without altering the valuations of the alternatives.

On the other hand, resolve (i.e., resisting temptation by representing the present situation as a test case for the fulfillment of a more abstract commitment or goal) can be instantiated in multiple psychological processes. These include forming implementation intentions (commitments that create an if–then link between a certain context and the performance of a certain behavior; Gollwitzer & Sheeran, 2006); instituting bright lines (unique, unambiguous rules that allow no motivated reinterpretations or exception-justifying rationalizations; Ainslie, 2001); and representing the situation using high-level, as opposed to low-level construals (i.e., describing objects and events abstractly, in ways that apply to multiple instances beyond the current one; Fujita, Carnevale, & Trope, 2018; Fujita, Trope, Liberman, & Levin-Sagi, 2006). Additionally, it has been recently shown that a greater tendency toward forming detailed plans is associated with greater self-control (Ludwig, Srivastava, Berkman, & Donnellan, 2018; Sjåstad & Baumeister, 2018). This is also an instance of resolve: seeing the specific situation not in isolation but as a crucial step in a broader action pattern. These are not just different descriptions of the same phenomenon: they are different psychological processes. Although the theorist can group them together as "resolve," the agent must choose which specific strategy to implement when faced with a given temptation.

The great diversity of regulatory processes, and the need to select appropriately among them in diverse contexts, makes the ability to choose the right tactics necessary to reliably exert successful willpower. *Tactical skill* is the complex ability to (1) accurately detect when a willpower tactic is called for, (2) identify appropriate tactics for the given context, and (3) monitor tactic implementation, evaluating whether to maintain or stop the tactic, or whether to switch to a different one, as implementation unfolds. Tactically skillful agents display regulatory flexibility: the ability to adjust one's regulatory processes to the specific demands of the environment (Bonanno & Burton, 2013). Evidence that individual differences in tactical skill correlate with differences in long-term goal achievement has recently begun to emerge, both for emotion regulation and self-control (Bürgler, Hoyle, & Hennecke, 2020; Southward, Altenburger, Moss, Cregg, & Cheavens, 2018).

Ainslie does acknowledge that specific tactics must also be selected. He claims this is done via calculations of the expected value of each tactic, and information-accumulation processes of drift diffusion and vicarious trial and error. Although these are all good candidates for the subpersonal mechanisms underlying tactic selection, two dimensions remain under-defined. First, tactic management is a crucial dimension for finding individual differences in the policies and rules that govern reinforcement-learning and decision-making mechanisms. Such individual differences would amount to differences in value-based decision-making processes (Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, 2017). Methods for assessing these differences are yet to be created. These methods would assess differences not in how people discount larger-later rewards generally, but in how they assess the costs and the expected value of implementing one willpower tactic relative to another. Although research on metacontrol has usefully identified individual differences in the balance between cognitive stability or flexibility, or model-free (habitual) versus model-based (cognitively effortful) problem-solving (Boureau, Sokol-Hessner, & Daw, 2015; Hommel, 2015), what remains to be studied is how we value and select among *different model-based strategies*, such as willpower tactics.

Second, the phenomenology of self-control can be more substantially studied. It is commonly stated that self-control is experienced as effortful, but it is reasonable to expect that not all tactics will be experienced as equally effortful in all contexts. In fact, the feeling of effort itself plays a role in decision-making by indicating the expected costs and benefits of a willpower tactic given past experience (Kurzban, 2016). As an affect-involving metacognitive state (Carruthers, 2020), agents can use feelings of effort to guide their tactical decision-making. Tactical skill would thus rely crucially on the ability to effectively integrate affect-involving metacognitive information into these decisions (Bermúdez, 2020). Studying such affective metacognitive processes should therefore shed light on how tactical skill works, and thereby on how effective willpower is reliably implemented.

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It's not a bug, it's boredom: Effortful willpower balances exploitation and exploration

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Abstract

The continuous revaluation of rewards lies at the core of Ainslie's account of willpower. Yet, he does not explicate the underlying experiential mechanisms. We draw upon theoretical, neuroscientific, and computational evidence to demonstrate that boredom evokes revaluation. By biasing behavior toward exploration, boredom necessitates effortful willpower to balance it against exploitation, thereby rendering suppression a highly adaptive function of willpower.

In the target article, Ainslie differentiates between effortless ("resolve") and effortful ("suppression") functions of willpower. Our focus is on suppression, which is thought to stabilize ongoing behavior against revaluations instigated by hyperbolic discounting. Crucially, suppression is conceived as a fragile and costly mechanism that needs to be "stiffened by resolve." Here, we argue that hyperbolic discounting and the fragility and costliness of suppression are both adaptive features that aid humans in navigating exploration–exploitation tradeoffs. Drawing upon theoretical, neuroscientific, and computational evidence, we argue that boredom is an experiential mechanism that drives revaluation and interacts with suppression in orienting goal-directed behavior. Incidentally, boredom has already been discussed in the context of willpower (e.g., Ainslie, 2013), but only as one mechanism among many and without a dedicated theoretical framework that explicates its unique functional relevance: (1) boredom instigates the revaluation of potential rewards, (2) increases the costs of the resulting suppression, (3) and thereby biases behavior away from exploitation and toward exploration. Thus, we extend Ainslie's proposal by explicating boredom as a powerful mechanism that drives hyperbolic discounting and by highlighting why suppression is a highly adaptive mechanism that has consequently been favored by evolution.

Ainslie identifies hyperbolic discounting as an "inborn psychophysical tendency" that manifests itself in the dynamic revaluation of rewards. However, although he is explicit about the experiential mechanism that tracks the temporal dynamics of task-induced costs (i.e., effort), the target article remains silent on the mechanisms that underly revaluation. One ubiquitous experience linked to revaluations by recent research on willpower is boredom (Wolff & Martarelli, 2020). Boredom emerges in situations that are perceived as meaningless and/or as misfitting one's mental resources (Westgate & Wilson, 2018). Its experience serves as a dynamic (Mills & Christoff, 2018), functional signal that an ongoing behavior decreases in value, prompting people to seek more rewarding alternative behaviors (Bench & Lench, 2019). In line with this, neuroscientific research has shown that boredom, but not suppression, increases reward sensitivity (Milyavskaya, Inzlicht, Johnson, & Larson, 2019). This logic can be extended to long-term goals, whose pursuit should then decrease in value relative to alternative goals that promise immediate gratification. Thus, boredom can be assumed to instigate the exact revaluations that underly hyperbolic discounting, which may lead to impulsive behaviors that must be suppressed to avoid what willpower research generally refers to as self-control failure. Consequently, boredom directly contributes to the demand for suppression (Wolff & Martarelli, 2020).

In line with the literature, Ainslie argues that effort serves as a dynamic signal to quantify the ongoing costs of suppression (Shenhav et al., 2017). He attributes these costs to the need for "continuous vigilance against impulses" and suggests that "wastes of time do not typically feel effortful." Although we agree with the first, we object to the latter assertion. Boredom does not constitute an affectively neutral signal; instead, it is an aversive sensation that increases the effort to continue with a course of action (Eastwood, Frischen, Fenske, & Smilek, 2012). Therefore, we argue that experiencing boredom does contribute to the costs of suppression by making it more effortful to persist (for initial experimental evidence, see Bieleke, Barton, & Wolff, 2020) – up to the point that people even become willing to trade boredom for pain (Wilson et al., 2014). Consequently, boredom not only devalues the pursuit of ongoing (long-term) goals, it simultaneously

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increases the costs of suppressing the pursuit of alternative (short-term) goals. This twofold effect makes the experience of boredom a powerful mechanism behind the disengagement from goal pursuit. Neuroscientific evidence provides tentative support for the implied interplay of boredom and suppression: Boredom has been linked to activation changes in the ventromedial prefrontal cortex (Mathiak, Klasen, Zvyagintsev, Weber, & Mathiak, 2013), an area that is involved in valuation processes (Gläscher, Hampton, & O'Doherty, 2009) and that plays a key role in indicating that a change in behavior is required (Domenech & Koechlin, 2015). Crucially, information from such valuation areas is integrated by the dorsal anterior cingulate cortex, whose role in specifying control commands and in relaying those commands to executive areas like the lateral prefrontal cortex is well established (Shenhav, Botvinick, & Cohen, 2013). Thus, the ventromedial prefrontal cortex's sensitivity toward rewards and the dorsal anterior cingulate cortex's role in weighing prospective rewards against the costs of suppression is in line with the proposed twofold effect boredom has on goal pursuit.

Understanding boredom in terms of a functional signal that facilitates the disengagement from ongoing goal pursuit – by instigating revaluation and feeding into the costs of suppression – raises an important question: Are the fragility and the costliness of suppression undesirable properties? We argue they are not: These very properties allow for suppression to assume the role of flexibly balancing exploration against exploitation. Computational research has shown that boredom facilitates an intelligent system's ability to explore the environment (Gomez-Ramirez & Costa, 2017). This shift from the longstanding and exclusive focus on prediction error minimization is in line with empirical (Geana, Wilson, Daw, & Cohen, 2016) and theoretical research (Wolff & Martarelli, 2020) on the role of boredom in driving exploration. Willpower by resolve, which is a function that favors long-term effortless goal pursuit (e.g., Bieleke, Keller, & Gollwitzer, 2020), is not designed to adaptively account for boredom-induced impulses to explore. Instead, a more fragile mechanism like suppression is better suited to respond adequately to the dynamic changes in the costs and benefits of ongoing goal pursuit; it thereby provides degrees of freedom for flexibly balancing exploration against exploitation. This functional role of suppression as a fragile and costly mechanism might explain why evolution has favored imperfect self-control (Hayden, 2019).

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Increasing resolution in the mechanisms of resolve

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Abstract

Ainslie offers an encompassing and compelling account of willpower, although his big-picture view comes occasionally at the cost of low resolution. We comment on ambiguity in the metacognitive and prospective mechanisms of resolve implicated in recursive self-prediction. We hope to show both the necessity and promise of specifying testable cognitive mechanisms of willpower.

Although Ainslie frames resolve in terms of game-theoretic intertemporal bargaining, he leaves the cognitive and neural

instantiation of resolve at times underspecified. In part, this is because the empirical evidence is wanting – as he acknowledges – but it is also because, by design, game-theoretical accounts remain agnostic about underlying mechanisms. In a prisoner's dilemma, the rules of the game and its payoff matrix are similar whether the agents involved happen to be bacteria or bankers. Nonetheless, we think there are costs associated with low resolution in the proximate mechanisms of resolve, as well as promising routes forward if proposals concerning the nature of these mechanisms can be sharpened up. We attempt to demonstrate these points of constructive clarification in the context of the *metacognitive* and *prospective* mechanisms implicated in "recursive self-prediction" that Ainslie argues forms the basis of resolve.

As a starting point, we take it as a given that humans don't consistently think through their intertemporal trade-offs with the kind of game-theoretic bargaining logic that observers can attribute to them. Ainslie acknowledges that the intertemporal bargaining of resolve could indeed happen below the level of self-awareness, or without any explicit representation at all. In fact, he suggests that the recursive self-prediction underpinning resolve might operate through "explicit self-enforcing contracts," via "vague awareness," perhaps "displaced away from any explicit self-knowledge," or even as purely "implicit contracts." It is, therefore, unclear how much "self" we should expect to find in "self-prediction."

One cost of this low specificity in the metacognitive mechanisms of resolve is that it leaves Ainslie's model resistant to disconfirmation in the face of new evidence. For instance, any failures to find recursive self-prediction in the implementation of resolve could be explained away by shuttling the relevant level of explanation around inside the mind of the resolver. Suppose that, upon a careful experimental investigation, we find that participants report resolving to delay their gratification for a later payoff simply because they foresee the long-term benefits of doing so, absent any anticipation of their own future behavior. In such a case, the enforcement mechanism that maintains an intention against lapses could be the anticipated negative costs of the smaller, sooner reward option. For instance, to answer Ainslie's question, "Why not eat this piece of chocolate – it will barely show?" a non-self-predictive resolver might answer, "because I foresee even the small damage of a single piece as sufficiently costly, however tempting." Under Ainslie's view, could we not explain away this finding by arguing that the underlying logical structure of the participants' decision-making is nonetheless one of game-theoretical self-predictive bargaining, even if the participants themselves are not aware of it and would opt to explain their own decision-making differently?

The "prediction" portion of "self-prediction" is similarly somewhat ambiguous. Ainslie argues that because resolve is "a matter of framing and monitoring choices," it "might not be accompanied by measurable brain activity any more than *other semantic content is*" [our emphasis]. Elsewhere, though, Ainslie suggests instead that "scenarios created in episodic memory might also serve this function [of formulating and monitoring the intertemporal bargains that form resolve]."

These alternatives lead to various questions that could be productively reformulated as testable hypotheses. Does one need to actually imagine oneself failing in the future to adhere to a "no alcohol on weeknights" rule in order to implement the resolve to put down the Shiraz, as an episodic simulation account would entail? Is it enough to simply "know," in semantic terms, that one is more likely to fail in the future if one fails now? Situating resolve amidst existing frameworks of prospective cognition and deliberation could carve out a space for empirical steps forwards (see Bulley & Schacter, 2020; Szpunar, Spreng, & Schacter, 2014).

For instance, we might test the evidence accumulation process by which people generate whatever predictions are central to resolve. Ainslie describes the act of reneging on a rule as if it constitutes a piece of empirical evidence that people use to anticipate their own future behaviors. But how so? One possibility is that episodic memories of reneging serve as raw material in the constructive episodic simulation of one's behavior in facing future willpower challenges. Convergent lines of evidence support the proposal that episodic future simulation operates via the recombination of episodic details from memory (Schacter, Addis, & Buckner, 2007; Suddendorf & Corballis, 2007), with a common *core network* of brain activity supporting remembering the past and imagining the future (Benoit & Schacter, 2015). Accordingly, if Ainslie's "recursive self-prediction" is a constructive process that samples episodic memories to inform anticipated behaviors, we should hypothesize that resolve will be associated with activity in this core network, similar to when participants directly retrieve episodic memories of willpower failures.

Research on prospection may also help to accommodate the idea that both semantic and episodic processes are sufficient for resolve in different contexts. The development of "good habits" that Ainslie equates to the successful operation of resolve may involve shifting contributions along a gradient of semantic and episodic processes (Irish & Vatansever, 2020; Szpunar et al., 2014). For instance, episodic simulation might be required to get resolve "off the ground," but after repeated (successful) instances, resolve could be eventually implemented in entirely semantic terms (for a similar suggestion about external precommitment, see Bulley & Schacter, 2020). In this case, we should hypothesize that people with hippocampal damage who have deficits in the ability to imagine the future (Schacter, Addis, & Szpunar, 2017) would be less capable of *initiating* intertemporal resolve in Ainslie's terms – but perhaps less impaired when it comes to maintaining "good habits" once these have been established (see Bakkour et al., 2019; Kwan et al., 2012; Palombo, Keane, & Verfaellie, 2015).

In the foregoing, we have pointed out some costs associated with ambiguities in Ainslie's otherwise encompassing big-picture account of willpower. We have provided some examples where pinning down specific mechanisms leads to testable predictions, focusing on the nature of the metacognitive and prospective mechanisms involved in recursive self-prediction where increased clarity would be perhaps most instructive.

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When will's wont wants wanting

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Abstract

We use neural reinforcement learning concepts including Pavlovian versus instrumental control, liking versus wanting, model-based versus model-free control, online versus offline learning and planning, and internal versus external actions and control to reflect on putative conflicts between short-term temptations and long-term goals.

We are invited by this excellent target article (TA) to consider three critical questions: (1) why should there ever be conflict between short-term temptations and long-term goals; (2) what mechanisms in the brain overcome these temptations; and (3) why is the operation of some, but not others, of those mechanisms accompanied by a sense of effort? These are respectively ethological, psychological/neural, and metaphysical – and so demand answers of different characters. Here, we reflect on the TA using the terms and language of neural reinforcement learning (RL): Pavlovian versus instrumental control (Dayan, Niv, Seymour, & Daw, 2006; Dickinson, 1980; Mackintosh, 1983); liking versus wanting (Berridge, 2009); model-based (MB) versus model-free (MF) control (Daw, Niv, & Dayan, 2005); online versus offline learning and planning (Sutton, 1991; Mattar & Daw, 2018); and internal versus external actions and control (Dayan, 2012; Keramati, Smittenaar, Dolan, & Dayan, 2016; Pezzulo, Rigoli, & Chersi, 2013).

First, why should we and other animals suffer from temptations at all – why should there be even a possibility of misalignment between short- and long-term incentive structures? After all, patience *can* evolve quite naturally (Stevens & Stephens, 2008) – as in stalking hunters who presumably suppress immediate attacking urges in order to better their chances of ultimate success. In the context of thinking (and, in this case, acting) fast and slow (Kahneman, 2011), the TA hints that the former system repurposed a psychologically-common (hyperbolic) heuristic for valuation across delays that is simply not meet the challenge posed by the latter system of being sufficiently patient. Neural RL offers complementary Pavlovian and instrumental interpretations.

By Pavlovian influences we mean hard-wired or pre-specified actions such as direct approach and engagement with primary and even secondary reinforcers. One view of these influences – which largely align well with the visceral processes (Loewenstein, 1996) that are discussed, is that these are evolutionarily specified priors over actions or policies. The benefit of this sort of inductive bias is obviating the sample complexities of learning in stable environments (Dayan et al., 2006). Could it be that, on balance, the costs of lacking this pre-programming outweigh the benefits? The classic tasks assessing willpower focus on the benefits; a careful accounting of the costs would be interesting. Certainly, external pre-commitment (or suppression in the form of revaluation or attentional diversion) are ways of avoiding Pavlovian misbehaviour (Dayan et al., 2006).

By contrast, in instrumental conditioning, we and other animals learn to choose actions based on the contingent rewards they produce and punishments they avoid. Of course, here, the key question is what happens when these affective outcomes are in the future. A useful analogy comes from experiments into food reward that separate out the short-term hedonic (e.g., sweetness) and long-term (e.g., nutritive) qualities of the outcomes of actions (de Araujo, Schatzker, & Small, 2020). Animals are initially attracted by the hedonic appeal of outcomes, but ultimately (via information from the gut), their choices are dictated by what is closer to the true long-term value.

One possibility is that the hedonic system is again a sort of typically-useful prior, but now over likely long-term valuation rather than a policy/action – if, for instance, sweetness is sufficiently frequently aligned with long-term nutritive quality. Thus, the animal might be drawn, at least at first, into favouring what are actually poor choices from a long-term perspective. In RL terms, one speculation is that hedonics – as a form of *liking* (Berridge, 2009) – act as what is known as a shaping reward system (Ng, Harada, & Russell, 1999) – these are like hints for the instrumental system that speed learning when they are appropriate (but do not ultimately affect what is the optimal policy; rather only slowing the acquisition of this policy if they are misleading). Complementary to liking is *wanting* (Berridge, 2009), which would then be considered the true currency for choice. Thus, again, a conventionally useful, hard-wired, prior system can appear to give unwarranted favour to smaller-sooner outcomes that it then takes more or less learning to wash-out.

Second are the mechanisms that overcome temptations – when the temporal accounting of wanting over liking does not suffice. From an RL perspective, it is useful to think about MB and MF systems, and also externally- and internally-directed actions. MB (or goal-directed; Dickinson & Balleine, 2002) control operates by constructing, and performing forward planning in, an internal simulacrum of the environment; it can exactly capture, for instance, the resolve-associated observation that defection sooner implies defection later, thus reducing the chance of actually attaining long-term rewards. This sort of future planning

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has been associated with phenomena such as preplay in rodents (Pfeiffer & Foster, 2013; Wikenheiser & Redish, 2015) and, more speculatively, humans (Eldar, Lièvre, Dayan, & Dolan, 2020; Liu, Dolan, Kurth-Nelson, & Behrens, 2019) and, as noted in the TA, various parts of the default mode network.

By contrast, MF systems cache or store information about the actions performed in the past, and thereby come directly to favour those actions that were either associated with rewards or possibly just frequently exercised (Gershman, 2020). In the case that information about rewards is cached, mechanisms such as temporal difference learning (Sutton, 1988; Watkins, 1989) associated with the wanting mentioned above, ensure that these are appropriate in the long-run. These MF policies have been identified with *habits* (Daw et al., 2005; Dickinson & Balleine, 2002).

MB control is time-consuming (Pezzulo et al., 2013) and potentially taxing (see below); thus, there is a ready process of habit formation (Daw et al., 2005; Dickinson & Balleine, 2002), in which habits take over – becoming what we are wont to do – this is partly consonant with notions in the TA. What, though, of suppression – rendered here as internally-directed (e.g., devaluation, or indeed overriding Pavlovian control; Cavanagh, Eisenberg, Guitart-Masip, Huys, and Frank, 2013) or externally-directed (e.g., attention) mechanisms for changing the attraction of short-term temptations? In neural RL terms, these can be considered as (expensive; Shenhav et al., 2017) internal actions, that are controlled in the same way as external actions, along with other actions as the deployment of working memory (Dayan, 2012). Although the TA suggests that suppression is less stable than resolve (e.g., via a positive feedback process by which partial failures in distraction tend to spiral out of control and lead to full failure and defection on long-term goals); it should be noted that the internal actions necessary to complete the calculations for the MB realization of resolve are of a piece with those enforcing suppression, and so subject to some of the same problems. It's certainly not obvious that some forms of suppression will not also habitize.

Briefly, what of the effort associated with suppression and, I would argue, resolve, at least when MB calculations remain necessary? Here, we cheat to focus back on ethology. To the flavours of opportunity costs discussed (Boureau, Sokol-Hessner, & Daw, 2015; Kurzban, Duckworth, Kable, & Myers, 2013; Shenhav et al., 2017), we should add that of not being able to transfer knowledge from MB to MF systems (Mattar & Daw, 2018; Sutton, 1991), including the former's rendering its choices less effortful. That's what would make will become wont.

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The complex nature of willpower and conceptual mapping of its normative significance in research on stress, addiction, and dementia

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Abstract

Willpower (as suppression, resolve, and habit) has ramifications for autonomy and mental time-travel. Autonomy presupposes mature powers of volition and the capacity to anticipate future

events and consequences of one's actions. Ainslie's study is useful to clarify basic autonomy in addiction and dementia. Furthermore, we show how our study on coping with stress can be applied to suppression and resolve.

Ainslie's theoretical framework on willpower as *suppression*, *resolve*, and *habit* has important ramifications for the ethical and psychological literature on autonomy and mental time-travel. Emerging from Ainslie's study is the idea that subcomponents of willpower correlate with the temporality of autonomous decisions: *past* decisions can form habits, suppression deals with *present* distorting influences, whereas resolve is *future-oriented*, linked with mental time-travel and perseverance in goals.

Mental time-travel has implications for responding to and preparing for stressors. More stress is associated with poorer health and cognitive functioning, but most research has focused on what happens *after* stressors occur. Thus, the bulk of the stress literature emphasizes suppression, which indicates how current reactions to past stressors are handled. Recently, we put forth a conceptual framework that integrates the temporal space of anticipation *before* stressors occur (Neupert, Neubauer, Scott, Hyun, & Sliwinski, 2019), which emphasizes the future-oriented component of resolve.

Future-oriented thinking with respect to stress can take the form of proactive coping, stressor forecasting, and anticipatory coping. Proactive coping comprises efforts that prevent a stressor before it occurs and tend to be rather stable between individuals. We found that people who were high in proactive coping reported less negative affect in the face of stress (Polk, Smith, Zhang, & Neupert, 2020) and less COVID-19 stress (Pearman, Hughes, Smith, & Neupert, 2020).

Although proactive coping tends to be stable and associated with reduced stressor exposure, stressor forecasting is dynamic and involves predictions about domain-specific stressor occurrence in a defined upcoming time period. Using a daily diary design where people reported for consecutive days on their stressor forecasting across six stressor domains (e.g., work, home-related events, and so forth), we found that younger adults benefitted more than older adults in terms of better emotional responses to home-related events when they were able to predict the upcoming stressor (Neupert & Bellingtier, 2019).

In contrast to reactive coping that involves coping with an event that has already occurred (akin to suppression) and proactive coping that is supposed to prevent a future stressor from occurring (akin to resolve), anticipatory coping involves specific efforts to prepare for the stressful consequence of an upcoming event that is likely to happen. Similar to stressor forecasting, anticipatory coping is dynamic and domain-specific; the demands of the predicted upcoming stressor need to match the coping effort in order to be adaptive. Stagnant deliberation involves trying (but failing) to think about solutions to an upcoming stressor, but can be adaptive for certain people in certain situations: Older adults who reported increases in stagnant deliberation from one day to the next were able to maintain their emotional well-being in the face of home stressors (Neupert & Bellingtier, 2019).

In the context of habits/addictions, there are important differences between people (e.g., proactive coping) as well as dynamic and context-specific processes (e.g., stressor forecasting and anticipatory coping) that play a crucial role in resolve (forward-looking) and suppression (present-focused). Using a daily diary design with participants undergoing medication-assisted treatment for addiction, we found that increases in daily stressors were associated with increases in cravings to use illegal drugs as well as the likelihood of using illegal drugs (Neupert et al., 2017). Our results suggest a cyclical process; increase in previous-day illegal drug use was also associated with an increase in exposure to stressors the next day, especially for those who had sought treatment many times in the past.

Therefore, what are the normative implications of this work? Ethical discussions on autonomy and automaticity in decision making have long drawn attention to psychological literature (Bauer & Dubljević, 2019). There is an emerging consensus that automaticity may in fact enable autonomy (Dubljević, 2019). If, following Ainslie, we reconceptualize habits as crystallized automatic behaviors based on previous decisions and accumulation of expertise, then bad habits are no less autonomous (maladaptive coping) than good habits (adaptive coping). Similarly, if we assume that suppression is a necessary (but not sufficient) condition for autonomy, we have the conceptual mapping necessary to clarify limitations to autonomous decision making in people struggling with addiction and people living with dementia.

Addiction usually serves as a test-case for conceptions of autonomy (Dubljević, 2013), and our study discussed above contributes to this ethical debate. Autonomy as a *normative* concept presupposes *capacities* to form long-term intentions, develop plans, exert rationality, and mature powers of volition (i.e., self-control). Thus, in this view, controlling influences such as coercion (external) or compulsion (internal) do not automatically reduce autonomy but need to be assessed for their degree and justifiability. We have developed ideal-typical degrees of coercion and compulsion for clarifying loss of autonomy in addiction (Dubljević, 2013) and fronto-temporal dementia (Dubljević, 2020).

The clarification of subcomponents of willpower as suppression, resolve, and habit allows for a nuanced application of autonomy in additional cases (e.g., other dementias). The crucial point in applying autonomy to dementia cases is whether patients are able to use suppression to resist "mild compulsions," use resolve to maintain "long-term aims," and to "show commitment" to them by forming adaptive habits. In these terms, late-stage dementia patients are more akin to minors than to adults; they lack the resources they once had for self-control, and capacities for appreciating their critical interests in addition to maintaining and updating rational life-plans in view of changing circumstances. However, there is a wide-spread assumption that as soon as people are diagnosed with dementia, they are not capable of maintaining any level of autonomy, which leads to stigmatization (Dubljević, 2020). Part of the problem of maintaining day-to-day functioning is the response society has to dementia patients. Dementia causes memory issues and learning difficulties, which are exacerbated when patients are, unwillingly, placed in a completely new environment such as a nursing home. Typically, dementia is clinically specified in seven stages, each characterized by an anticipated pattern of symptoms (Reisberg, 1988). Ainslie's framework for willpower supports a stage-like approach to autonomy in dementia, facilitating ethical guidelines least likely to cause additional suffering.

In conclusion, Ainslie's study has reframed our work on addiction, stress, and dementia. It also offers novel ways of exploring autonomy.

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Beyond willpower

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Abstract

For all its popularity as a psychological construct, *willpower* is irremediably polysemous. A more helpful construct is *self-control*, defined as the self-regulation of conflicting impulses. We show how the process model of self-control provides a principled framework for examining how undesirable impulses may be weakened and desirable impulses may be strengthened.

In a field full of slippery constructs, *willpower* may be one of the most slippery. It has never been clear what *will* means, or whether it even exists, and its derivative – *willpower* – is perhaps even less precisely defined. Thus, as Ainslie notes, willpower has come to mean different things to different people. From here, Ainslie suggests that willpower is not unitary but instead takes two major forms, which he calls "resolve" and "suppression." He sees these distinctions as more or less self-evident, although he makes it clear that up to this point, his exclusive focus as a scholar has been on the former. He then suggests that although *willpower* sounds effortful, not all forms of willpower are equally effortful.

From our perspective, Ainslie is right to be concerned but has started in the wrong place and has not gone far enough. If one wishes to make the case for heterogeneity – and we share Ainslie's wish to do just that – we think a better starting point is *self-control*, which we define as the "self-initiated regulation of conflicting impulses in the service of enduringly valued goals" (Duckworth, Gendler, & Gross, 2016, p. 35). We prefer *self-control* as an object of scientific inquiry because, in our view, *willpower* is hopelessly polysemous and thus, for all its popularity, not amenable to cumulative science.

Our definition of *self-control* embraces Ainslie's conception of multiple, competing motives that must be regulated when they come into conflict. Working from this definition, we first sketch the process by which impulses of any kind are generated, and then use this sketch to consider how conflicts between mutually exclusive impulses can be adjudicated. We refer to our approach as the process model of self-control (Duckworth et al., 2016).

Figure 1 illustrates the recursive process by which impulses – whether they are good for us in the long run or not – are generated. To begin, an impulse arises when a particular situation in the world is attended to and then appraised in a way that is relevant to currently active goals. For instance, we may walk into the kitchen (situation), notice a box of donuts on the kitchen counter (attention), think how delicious they would taste (appraisal), and then feel an urge to open the box lid (response). Now, our situation has changed. We are in the kitchen with an open box of donuts, which leads us to notice the scent of cinnamon and sugar, and so on.

Having articulated the stages through which impulses are generated, we can now consider how competing impulses can be regulated. In Figure 2, we distinguish five points at which an impulse might be modified: situation selection (electing to be in one situation vs. another), situation modification (altering an existing situation), attentional deployment (redirecting one's attention), cognitive change (altering the way a situation is mentally represented), and response modulation (trying to directly adjust the strength of an impulse).

Self-control entails weakening the less-valued impulse, strengthening the more-valued impulse, or both. To illustrate, in Figure 3a, we lay out how the impulse to eat a donut might be weakened, and in Figure 3b, how the impulse to eat a banana instead might be strengthened. Self-control strategies need not be mutually exclusive – individuals often engage in polyregulation, deploying more than one strategy at once (Ford, Gross, & Gruber, 2019).

From our perspective, the process model of self-control offers several advantages over *willpower*: (1) it avoids the pitfalls associated with trying to clarify a construct as messy as willpower by focusing instead on the more sharply defined concept of self-control; (2) it links how impulses are generated to how they might be regulated, providing a conceptual framework for making principled distinctions among self-control strategies; (3) it allows for more useful distinctions than Ainslie does (note that what Ainslie calls "resolve" may be considered a special case of cognitive change, whereas his view of "suppression" may be considered a mix of attentional deployment and cognitive change); (4) it articulates a continuum of effort, with strategies deployed earlier (e.g., situation selection) generally more efficient than strategies deployed later (e.g., response modulation) within a cycle of impulse generation; (5) it can be extended to explain the benefits of planning, personal rules, and habits; and (6) it suggests that self-control is a special case of interacting valuation systems.

Finally, the process model offers one additional affordance. Although developed in the context of self-control, this scheme does not require the individual to initiate the regulation of

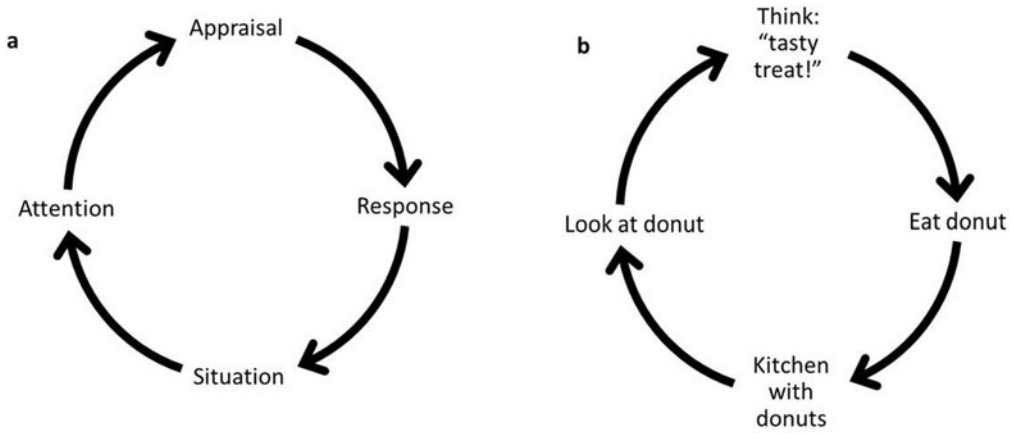

Figure 1. (Gross & Duckworth) Process model of self-control. *Note*. Impulses develop in an iterative cycle, beginning with the situation, then attention is directed to select features of the situation, then subjective appraisals are made of these situational features, leading to a response tendency that, when sufficiently strong, is enacted, thereby changing the situation anew. Figure reproduced with permission from Duckworth et al. (2016).

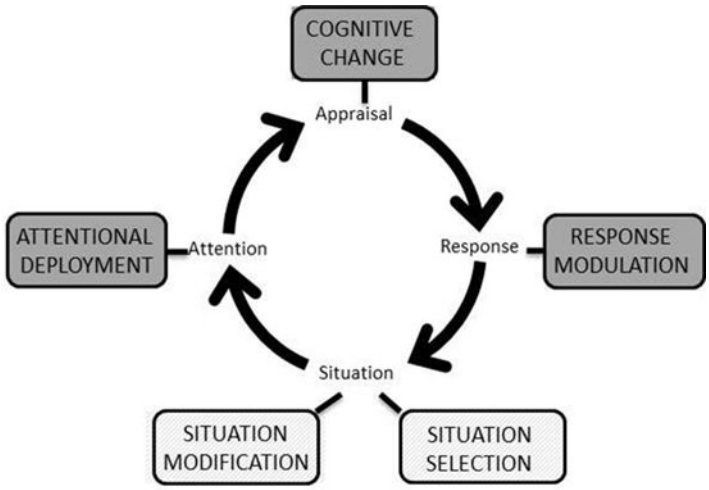

Figure 2. (Gross & Duckworth) Self-control strategies. *Note*. Self-control strategies target distinct stages in the generation of impulses. Situational self-control strategies (shown in the light, hatched boxes) precede cognitive strategies (shown in the dark, solid boxes). Figure reproduced with permission from Duckworth et al. (2016).

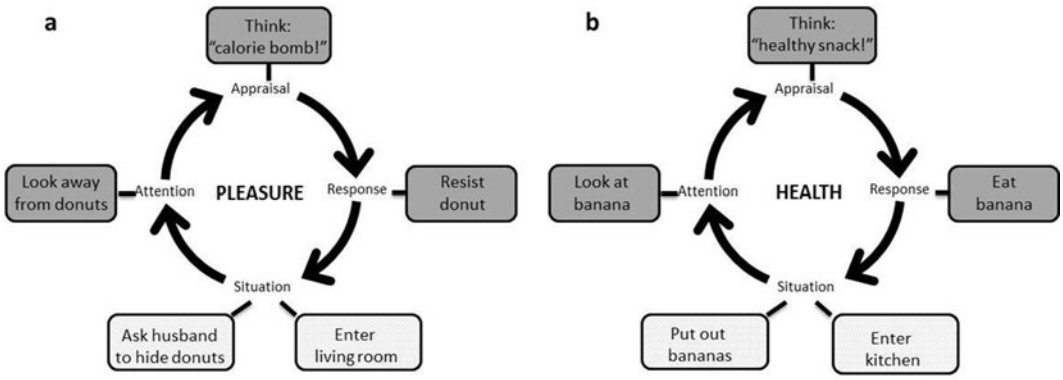

Figure 3. (Gross & Duckworth) Examples of self-control strategies. *Note*. Self-control strategies can (a) weaken a pleasure-oriented impulse or (b) strengthen a health-oriented impulse. Figure reproduced with permission from Duckworth et al. (2016).

impulses. This structure opens up the possibility of expanding beyond self-control (Angela regulates Angela's impulse in the service of Angela's long-term goal) to extrinsic regulation (James regulates Angela's impulse in the service of Angela's long-term goal, or the government regulates Angela's impulse in the service of Angela's long-term goal) (Duckworth & Gross, 2020; Duckworth, Milkman, & Laibson, 2018). In so doing, we can connect the psychological science of self-control to behavioral economics research on "nudges" and sociological perspectives on agency – deepening our appreciation of the multitude of contextual factors that influence whether what we do in the moment furthers or undermines our long-term well-being.

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Weighting on waiting: Willpower and attribute weighting models of decision making

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Abstract

Willpower is often conceptualized as incorporating effortful and momentary suppression of immediate but ultimately inferior rewards. Yet, growing evidence instead supports a process of attribute weighting, whereby normatively optimal choices arise from separable evaluation of different attributes (e.g., time and money). Strategic allocation of attention settles conflicts between competing choice-relevant attributes, which could be expanded to include self-referential predictions ("resolve").

A common feature of many models of willpower is effortful moment-by-moment inhibition of desire for immediately attractive but ultimately inferior rewards, a process linked to brain regions including dorsolateral prefrontal cortex (DLPFC) (e.g., McClure, Laibson, Loewenstein, & Cohen, 2004). Ainslie conceptualizes this *suppression* primarily in terms of inhibition of tempting impulses or attentional filtering of distracting stimuli, and contrasts it with more stable, lasting intentions based on self-prediction, which are termed *resolve*. Yet, growing evidence suggests that normative choices need not arise from the suppression of impulses toward tempting rewards. Instead, neuroscientific data and computational modeling approaches suggest that decision-makers can differentially weight relevant stimulus attributes of available options in order to arrive at optimal outcomes (Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, 2017; Rangel & Clithero, 2014).

Attribute weighting models have successfully explained decision behavior for a range of tasks, including dietary and intertemporal choice. In dietary choice, individuals select between options varying in taste and health attributes. Dietary self-control has been associated with changes in the relative weights associated with the perceived tastiness and healthiness of different food options, both behaviorally and at the neural level (Bhanji & Beer, 2012; Hare, Camerer, & Rangel, 2009; Harris, Hare, & Rangel, 2013; Tusche & Hutcherson, 2018). However, this attribute weighing process does not appear to require explicit suppression of taste representations for effective self-control. For example, Harris et al. (2013) used electroencephalography (EEG) to measure changes in neural signals associated with subjective value for participants during natural responding versus dietary self-control. Contrary to Ainslie's description of this study as demonstrating "suppression of reward center activity" during self-control (sect. 4), participants showed similar neural responses to taste attributes of the foods across both natural and self-control sessions. In contrast, neural activity associated with the perceived healthiness of the foods increased dramatically under the self-control conditions, consistent with a greater weighting of this attribute in this decision context (Harris et al., 2013), and in line with previous observations (Hare et al., 2009). Furthermore, studies that trace the decision process using mouse-tracking have shown that healthy dietary choices depend not only on the relative weights of taste and health attributes, but also the timing with which they are incorporated into the decision process (Lim, Penrod, Ha, Bruce, & Bruce, 2018; Maier, Raja Beharelle, Polania, Ruff, & Hare, 2020; Sullivan, Hutcherson, Harris, & Rangel, 2015). These different aspects of weighting strength and timing can be captured by a time-varying drift diffusion model (Maier et al., 2020).

Similarly, attribute weighting can better account for choice behavior in intertemporal choice paradigms, in which participants select among options varying in reward amount and time delay. Individual variation in intertemporal choice appears to reflect differential focus on reward amount versus time information, as well as when these attributes are incorporated into the decision process (Amasino, Sullivan, Kranton, & Huettel, 2019; Reeck, Wall, & Johnson, 2017). Specifically, more patient individuals focus on directly comparing between reward amounts, whereas comparatively impatient decision-makers integrate across amount and time information within options. Similarly, patient individuals incorporate amount information into the decision process earlier and have shorter response times (Amasino et al., 2019), effects that may seem paradoxical from an effortful suppression perspective. Experimental manipulations that promote a comparative, attribute-based strategy can also causally shift decision-making toward greater patience (Reeck et al., 2017). Although broadly congruent with the results from dietary choice tasks above, these data are also in line with the observation that manipulations such as displaying zero-pay events (Magen, Dweck, & Gross, 2008) can influence intertemporal choice by making the trade-off between time and money attributes more explicit (Lempert & Phelps, 2016).

Thus, the attribute weighting framework provides a powerful explanation for normative choice behavior across a variety of tasks. Moreover, by combining this approach with physiological data, researchers have shed light on the neural correlates of shifts in attribute weighting. In particular, converging evidence suggests that selective attention plays a key role in attribute weighting, both through eye-tracking of endogenous attentional shifts (e.g., Amasino et al., 2019) and exogenous cueing to specific attributes (Hare, Malmaud, & Rangel, 2011). Recent data suggest that attentional cueing can change both the strength and timing of attribute weighting (Maier et al., 2020), supporting an attentional mechanism for previously observed effects of attribute integration timing (Lim et al., 2018; Sullivan et al., 2015). Under conditions of

simple choice, this process is likely driven by salience and/or highest value (Busemeyer, Gluth, Rieskamp, & Turner, 2019; Krajbich, Armel, & Rangel, 2010; Rangel & Clithero, 2014). However, in decision contexts where there is a conflict between choice-relevant attributes (i.e., requiring willpower), attentional shifts to resolve this competition likely arise from activity in the DLPFC, which has known links to executive function and attentional selection (Kastner & Ungerleider, 2001; Miller & Cohen, 2001). Consistent with this idea, new analyses suggest that increased DLPFC activity is associated with choices that conflict with current objectives; for example, the DLPFC shows an increased response to *unhealthy* choices when participants are actively focusing on *health* (Hutcherson, Rangel, & Tusche, 2020).

Finally, attribute weighting can provide an alternative way to think about the issues raised by Ainslie's model of willpower. Existing models of attribute weighting seem analogous to suppression, reflecting an effortful momentary shift in the representation of stimulus properties such as healthiness or reward amount. However, attribute weighting could conceivably extend to the types of recursive self-predictions described by Ainslie as resolve. Self-referential processes such as prospection, imagination, and memory have already been implicated in patient intertemporal choice (Jenkins & Hsu, 2017; Lempert & Phelps, 2016; Lempert, Speer, Delgado, & Phelps, 2017). The finding that delay-of-gratification failures are more common when the arrival of a reward is uncertain (Kidd et al., 2013; McGuire & Kable, 2013) also points to the role of internal beliefs in maintaining resolve. Although these types of introspective processes have thus far received comparatively little attention in computational models of self-control, individual variation in attribute weighting strategies likely reflects larger differences in life experience, temperament, and personal beliefs. By adding self-referential processes to existing models of attribute weighting, future work may better characterize the computational and neural correlates of willpower.

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Aspiration fuels willpower: Evidence from the addiction literature

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Abstract

Ainslie identifies two possible motivational sources for resolve: "thinking categorically" and "intertemporal bargaining." Ainslie opts for intertemporal bargaining, adding that thinking categorically has no motivational power. The most researched

instance of willpower is remission from addiction. This literature shows that aspirations for a more desirable identity and comfortable lifestyle motivate remission. In other words, "thinking categorically" drives willpower.

An essential feature of the psychology of willpower is the determination to get something done. According to Ainslie, this factor has two possible sources: "to think categorically" and "intertemporal bargaining." He opts for intertemporal bargaining, adding that thinking categorically has no motivational punch – why do it? However, research on addiction encourages the claim that, to make sense of willpower, we need to include the capacity to "think categorically." This conclusion does not preclude Ainslie's approach, rather it calls for expanding it. But before, I present the case for "thinking categorically," some general observations and definitions are in order.

The empirical and conceptual foundation for the target paper is research on hyperbolic discount functions. Their mathematical properties make it possible for a smaller-sooner reward to temporarily have a higher value than a larger-later reward. This provides a handy account of preference reversals, impulsivity, and self-control. Moreover, hyperbolic discount curves describe the results of hundreds of experiments in which humans and nonhumans chose between smaller-sooner and larger later-rewards – often opting for the specious one. These findings are the basis for Ainslie's account of willpower.

Now the definitions: As in the target article, willpower is the capacity to reject a specious reward, resolve is the determination to get something done, and intertemporal bargaining is an internal process in which multiple selves, each attached to their preferred time horizon, jockey for precedence. For instance, imagine, one voice lobbying for a cookie now and exercise tomorrow and a competing voice extoling the benefits of exercise now and a cookie later. The referents for "thinking categorically" include a particular rate of consumption, say, six drinks an evening, the social and economic relations that accompany rates of consumption, say, going to the liquor store 5 days a week, and the identity that accompanies a lifestyle in which drinking plays a large role: "I'm an alcoholic."

The addiction research literature provides a strategic test of Ainslie's account of willpower. Remission is central to the addiction experience (e.g., Heyman, 2009), it is the most researched instance of willpower, and the target article mentions it more than two dozen times. But first, we need to review the delay discounting account of addiction.

From the viewpoint of hyperbolic discount curves, getting high on drugs is the smaller-sooner reward and sobriety is the larger-later reward. Accordingly, an addict is someone who prefers sobriety, but chooses getting high because the mathematics of hyperbolic delay curves make the smaller-sooner reward temporarily more valuable than the larger-later reward. Thus, addicts are those who again and again fall victim to specious rewards – never learning to correct their mistakes. In support of this account, experiments reveal that heroin addicts have steeper discount functions than non-heroin addicts (Kirby, Petry, & Bickel, 1999), and Harvard undergraduates who smoke regularly have steeper discount curves than Harvard undergraduates who smoke just on weekends or not at all (Heyman & Gibb, 2006). Nevertheless, crossing, hyperbolic discount curves (e.g., Figs. 1 and 2 of the target article) do not adequately model addiction or remission. Rather, we need to consider addiction as a rate of drug consumption, that the temptation to use drugs reflects visceral factors, and that the motivation to quit drugs (willpower) reflects the user's aspiration with regard to the sort of person they want to be and the lifestyle they hope to achieve. What follows is a sampling of the findings that lead to these conclusions.

(1) In order for drug use to take place frequently enough to meet the criteria for dependence, the user must plan ahead, engage in subterfuge, establish supply chains, and as conditions change, revise his or her plans. This may not take as much planning as maintaining a job or family, but maintaining an addiction is not, as in the discounting experiments, a series of independent trials between temporally offset rewards. Rather, "addiction" refers to a distribution of drug choices; the temporal order of the outcomes matters little (Herrnstein & Prelec, 1992; Heyman, 2009).

(2) People take drugs for the visceral and unique pleasures they provide. Consider the following reports on initial heroin experiences.

Raffaella is an 18 years old woman from London. She reflects on her first heroin experience as follows (Fletcher & Mayle, 1990): … the smack hit me … filling me up with a sensation that was like nothing I'd ever felt before.

Silver reporting on his first heroin experience, writes (*Erowid*, http://www.erowid.org; Heyman, 2009): "People always try to put into words the feeling smack brings you … that's just the problem … it doesn't … It was the most intense nothingness there ever was."

Umber who is 26 years old at the time of his interview reports (Hanson, 1985): "I found complete satisfaction … I felt exhilarated … It was cool … the ultimate high."

According to the language or these reports (e.g., "intense nothingness"), the heroin experience is a visceral category all its own. This is what tempts the user.

(3) In support of the above observations, ex-addicts explain their motivation for quitting (an instance of willpower) in terms of their lifestyle aspirations and how they would like to think of themselves. Consider the following examples.

Scott had been a daily heroin user for about 4 years (Biernacki, 1986). He no longer could afford his habit. In his words: "to deal I'd have to be available all the time at strange hours. I couldn't have people call me up at work to score … It finally became clear that this was the end. I was going to have to make a big change, of my whole life."

Wendy explains quitting heroin in the following terms (Jorquez, 1983). "What am I doing? God did not put me here on earth to be using heroin! … I began to have these powerful feelings for my parents to be proud of me again."

David Premack (who made significant contributions to behavioral, cognitive, and developmental psychology) was a two-pack a day smoker for about 20 years, but then quit – all at once (1970). The turning point was the recognition that he had left his kids standing in the rain in order to buy a pack of cigarettes. Spotting them in his rearview mirror, he writes, "with this glance came the realization that [I] was putting cigarettes ahead of [my] children … Humiliated and ashamed [I] turned around, picked up the kids and quit smoking."

In these stories, the issues are identity, values, and lifestyle – not which option shows up first. This makes perfect sense. Given a series of drug episodes, drug use comes both before and after periods of sobriety.

This analysis does not preclude contexts in which internal debates between multiple selves, each linked to a favored time

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horizon, motivate willpower. However, it does show that Ainslie is wrong to say that thinking categorically does not provide the motivation to resist temptations. Thus, a more complete account of willpower would include intertemporal bargaining and thinking categorically.

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Willpower without risk?

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Abstract

Ainslie does not formally incorporate risk and uncertainty in his framework for modelling impulses and willpower. To provide a complete account of the motivational bases of choice behaviour, Ainslie should extend his framework to incorporate risk attitudes *and* subjective beliefs.

Ainslie's review of willpower, and his delineation of resolve, suppression, and habit complements and extends a lifetime of work (Ainslie, 1974, 1975). His synthesis of disparate literatures is illuminating, but his neglect of risk preferences and subjective beliefs necessitates a reliance on hyperbolic discounting as the primary explanation for impulses and the attendant exercise of willpower. To provide a complete account of the motivational bases of choice, Ainslie should extend his framework to incorporate risk attitudes *and* subjective beliefs.

Risk preferences are primitives in economic theory because they define how agents respond to risk and uncertainty. Similarly, subjective beliefs about uncertain events, whether updated according to Bayes' rule or not, interact with risk preferences (and time preferences) in driving choice. In fact, subjective beliefs are the risk perceptions that *define* the risky choice objects one then applies risk preferences to evaluate. Atemporal risk aversion refers to aversion to variability of outcomes *at* a point in time, whereas intertemporal risk aversion refers to aversion to variability of outcomes *over* time. Ainslie's review is replete with references to "risk," "expectations," "contingencies," and "prospects." This raises the question: Why does risk not formally feature in his theoretical framework?

This neglect of risk is surprising given the economic literature that Ainslie cites. For example, Kőszegi and Rabin (2009) is explicitly a theory of reference-dependent consumption plans that incorporates risk attitudes, time preferences, and subjective beliefs. Furthermore, Gul and Pesendorfer (2001), Benhabib and Bisin (2004), Fudenberg and Levine (2006), and Loewenstein, O'Donoghue, and Bhatia (2015) all incorporate risk. Finally, Ainslie lauds Bénabou and Tirole (2004) for, "the most complete expression of the recursive self-prediction model in the terms of economics" but, again, they incorporate risk attitudes and subjective beliefs, Ainslie does not. Thankfully, Ainslie does not follow Rachlin, Logue, Gibbon, and Frankel (1986), Rachlin, Castrogiovanni, and Cross (1987), and Rachlin, Raineri, and Cross (1991) who argue that choice under risk can be tied to a temporal framework by interpreting the probability of a reward as the delay to, or rate of reinforcement of, reward; this approach is refuted by Hofmeyr (2020). The complete omission of a stochastic component leaves Ainslie's theory incomplete.

Consider the discussion of hyperbolic discounting and preference reversals. The shape of a hyperbolic discounting curve can incline an agent who prefers a larger, later (LL) reward over a smaller, sooner (SS) reward, when both are sufficiently delayed, to switch preference to the SS reward when its receipt is imminent. This is indeed a potential implication of hyperbolic discounting, but is there a simpler, primitive explanation for preference reversal?

SS and LL rewards differ in terms of their risk of receipt, with the LL reward presumably more risky than the SS reward, in the sense that it may not actually materialise or the agent might be dead before receipt. The continuous temporal risk of death from predators or natural causes, for example, starvation, is a constant theme in modelling risky foraging behaviour of species. When both rewards are sufficiently delayed, any difference in perceived riskiness is arguably small. Just prior to receipt of a SS reward though, any risks associated with delivery of that reward presumably decrease significantly, whereas the risks inherent in waiting for the LL reward likely change little. Thus, risk aversion alone could account for the choice of a smaller, imminently-available, essentially "riskless" reward over a larger, delayed, and, hence, more risky reward. Furthermore, presumably an agent's subjective perceptions about the size of the LL reward, the likelihood that it materialises, and whether they can wait for it, also influences choice. With a tangible, riskless, and imminently-available SS reward, one can explain why this may be chosen over a delayed, risky, and inherently-uncertain LL reward without invoking hyperbolic discounting as the mechanism.

In lab experiments, risks associated with delivery of SS and LL rewards can be minimised by emphasising credibility of payment, and through (clever) experimental design, such as the use of a

front-end delay to the SS reward so that the perceived risk of the SS and LL rewards is similar (Coller & Williams, 1999). One can also ground beliefs about reward magnitudes and days of receipt by simply informing subjects of these reward attributes. Thus, in the lab one could argue that it is possible to focus purely on time preferences without worrying about risk attitudes or subjective beliefs. But even this conclusion is premature because it is crucial to incorporate the curvature of the utility function when estimating time preferences to draw valid inferences about discounting behaviour (Andersen, Harrison, Lau, & Rutström, 2008; Harrison, Lau, & Rutström, 2010). Thus, even in lab settings, focussing purely on choices between SS and LL rewards is problematic.

In the world outside the lab, most choices involve risk and delayed rewards are inherently uncertain. For example, in any real exploration–exploitation trade-off, an agent must choose between harvesting an available resource with an unknown, but sampled, distribution of outcomes, and exploring, which entails deferring consumption, in the hope of finding a more profitable distribution of outcomes. Thus, risk, time, and beliefs are inextricably intertwined.

Ainslie's primary focus is not on impulses, but rather impulse *control* or willpower. He argues that by bundling a series of LL rewards agents can control impulses. But the implicit assumption underlying the summation of hyperbolically discounted rewards is that the intertemporal utility function is additively separable. As Richard (1975) shows, when additive-separability does not hold decision makers are either intertemporally risk seeking or intertemporally risk averse, which affects consumption decisions through time. Indeed, the vast majority of economic models of habit formation assume intertemporal risk-seeking behaviour. This generates intertemporal complementarities in consumption that can explain choices yielding immediate benefits but entailing long-term negative consequences. It is worthwhile investigating, therefore, how different intertemporal utility function assumptions affect Ainslie's interpretation of willpower.

In sum, Ainslie provides a masterful review of different but overlapping literatures, and a reconciliation of the misunderstood and often conflated notions of suppression, resolve, and habit. But one must insist that the theoretical framework be completed by incorporating the risk and uncertainty that are intrinsic to Ainslie's concept of willpower.

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More dynamical and more symbiotic: Cortico-striatal models of resolve, suppression, and routine habit

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Abstract

I extend Ainslie's core claims with three cortico-striatal models that respectively subserve the key constructs of resolve, suppression, and routine habit. I show that these models suggest a more dynamical and symbiotic relation among the constructs: there are more ways they interact to reinforce willpower, and the temporal dimension of the interactions can often determine the effectiveness of the reinforcement.

Ainslie provides a comprehensive account of willpower that integrates recent findings with his theory of recursive self-prediction. This commentary develops his account by incorporating three new developments from decision neuroscience, reinforcement learning, habit formation, and response inhibition. These integrate well into a framework I call *neurodemocracy* (Huang, 2017). These developments highlight that the key constructs interact in ways that are more symbiotic and dynamical than he recognizes.

The first development is the drift-diffusion model, according to which a decision mechanism accumulates decision variables until a threshold is met. His account, although compatible with this model, has not fully taken on board the dynamical nature it entails. This has significant implications if we take into account a second development: For any given decision, the decision variables are generated by a "society of controllers" (influenced by Minsky, 1986) of different sophistication, speed, and capacity. For example, a response can be evaluated by multiple model-based controllers using different algorithms as well as a variety

of model-free and Pavlovian controllers (Dayan & Berridge, 2014; Dolan & Dayan, 2013; Gershman, Daw, Rabinovich, Friston, & Varona, 2012; Ito & Doya, 2011). One reason that the dynamical nature of decision-making is crucial is that reliable evaluations can take more time to generate because of the nature of, say, model-based controllers. Hence, a lower decision threshold will result in decisions being overly influenced by faster, but potentially less reliable controllers. (Note that this point is orthogonal to that of hyperbolic delay discounting and visceral factors discussed by Ainslie.) The third development is that deliberation involves the basal ganglia, a sophisticated decision mechanism that handles complex and novel decisions better than cortical mechanisms. I will provide more details next as I explain the cortico-striatal models of the key constructs.

To begin with, recent findings suggest a model of routine habits as decision-making transferred from the basal ganglia to cortical mechanisms (Hélie, Ell, & Ashby, 2015). According to this model, novel decisions are made in the basal ganglia, which provide the reinforcement learning capacity that allows good decisions to be learned quickly. Through choosing the same response repetitively, the basal ganglia train the cortical mechanism through the slower Hebbian learning, which is sensitive to repetition but not to rewards. When the cortical connection is strengthened sufficiently (i.e., a strong stimulus–response connection is established), the decision-making is taken over by the cortex and becomes habitual. This new model explains better than the existing model why routine habit is stimulus-bound and insensitive to reward.

In addition, the framework of "a society of controllers" suggests that resolve (as well as routine habit and suppression) are implemented by multiple controllers simultaneously. Each controller adopts a strategy of varying explicitness and cognitive sophistication. This subserves the different conceptions of resolve discussed by Ainslie. Moreover, good habits feel less effortful because consistent resolve maintains a "resolve-context," in which SS (smaller, sooner reward) is evaluated increasingly less favorably and LL (larger, later reward) more favorably. This is because, among other reasons, at least some evaluations are performed by model-based controllers sensitive to the likelihood of obtaining a reward in a given context. Because LL is consistently selected (and obtained) in the resolve-context, but not SS, the evaluation for LL increases. This can also explain why failure of resolve (and failure of suppression or routine habit) can lead to more temptations: it increases the likelihood of obtaining SS and hence the evaluation of SS.

Finally, the cortico-striatal model of response inhibition points to two types of suppression (Wiecki & Frank, 2013). One involves the hyperdirect pathway of the basal ganglia, which increases the decision threshold as a result of receiving signals of response conflict from cortical controllers. It can prevent the formation of intention for SS when the accumulated decision variable for SS cannot reach the increased threshold. The other type of suppression involves the competition between the basal ganglia's direct pathway (which carries the positive decision variable, Go signal, for SS) and indirect pathway (which carries the negative, NoGo signal). Because a small NoGo signal can cancel out a larger Go signal in the basal ganglia, even a small increase in a NoGo signal for SS can potentially prevent the accumulated decision variables from reaching the decision threshold.

These models draw attention to how the dynamical interactions between different controllers implementing suppression, resolve, and routine habit reinforce each other. We can see this by looking at the relationship between routine habit and resolve. Successful resolve trains routine habit by choosing LL repetitively (this is true for suppression as well). When this routine habit becomes well-formed, LL is produced automatically under the resolve-context – we may see this routine habit as an integral part of a good habit. Routine habit also contributes to resolve. Resolve is a complex psychological construct composed of many component cognitive responses, some of which can become routine habits. The more its components become habitual, the more effective it becomes (the same point also applies to suppression).

The significance of the temporal dimension is also illuminated by examining the interaction between suppression and resolve: a faster suppression (especially, when some of its component responses become habitual) can provide a longer temporal window for resolve to work. Suppression, by preventing the formation of intention for SS, allows more time for Go signals for LL to be generated by resolve-implementing controllers, some of which are relatively capacity-limited and slow. When the accumulated decision variables for LL pass the threshold, LL is recommitted. At the same time, resolve also contributes to suppression. Some faster resolve-implementing controllers may generate initial NoGo signals for SS, which facilitate timely suppression through competition between direct and indirect pathways. Good habits (including the well-formed resolve-context maintained by consistent resolve) may also help cortical controllers generate faster signals of response conflict, contributing to timely suppression through hyperdirect pathway.

In what precedes, I have shown that an appreciation of recent study suggests that the temporal nature of the interactions between resolve, suppression, and routine habits determines the extent to which they reinforce each other more than Ainslie recognizes.

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Willpower is overrated

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Abstract

Any analysis of self-regulation that focuses solely on willpower in conflict-laden situations is insufficient. Research makes clear that the best way to reach one's goal is not to resist temptations but to avoid temptations before they arrive; it further suggests that willpower is fragile and not to be relied on; and that the best self-regulators engage in willpower remarkably seldom.

Ainslie analyzes the concept of willpower, which he defines as the process of foregoing small short-term rewards in favor of superior long-term rewards. Willpower, according to this view, entails cognitive conflict between two desires, typically with a passing temptation in conflict with some longstanding goal. Here, we submit that any analysis of goal-directed behavior that is restricted to such in-the-heat-of-the-moment cognitive conflict – no matter how fine-grained and valid – will inevitably miss an indispensable part of the self-regulatory process. Instead, we suggest that deeper insights can be gained by also focusing on the various psychological processes that occur well before facing a temptation. Our commentary thus focuses less on the details of Ainslie's proposal and more on what his proposal misses.

The disciplines of psychology, economics, and neuroscience presumably turned toward the scientific study of willpower because it appeared to predict a broad set of societally-important outcomes. Willpower, and the related concepts of self-control and self-regulation (Fujita, 2011; Inzlicht, Werner, Briskin, & Roberts, 2021), predict all manner of good outcomes, including academic achievement, health, wealth, even criminal offending (Moffitt et al., 2011). Famously, 4 year old children who had superior willpower, as assessed by how long they could resist eating a marshmallow, grew up to be adolescents with better academic, social, and health outcomes that persisted into adulthood (Casey et al., 2011; Mischel, Shoda, & Rodriguez, 1989; cf. Watts, Duncan, & Quan, 2018).

The implication of these sorts of prospective studies is clear: willpower is critical for the good life. Or, so it seemed.

The problem is that children who grow up to become well-adjusted adults might not achieve this feat only via willpower. In fact, the importance of willpower is unsettled. Other processes seem more critical. Research over the past decade makes clear that the best way to reach one's goals is not to fight temptations but to avoid them before they arrive. Research further suggests that willpower is fragile, and that the best self-regulators engage in willpower remarkably seldom.

The first clues that willpower may be overrated came from research examining people who appeared to be the best at meeting their goals. Such people have high trait self-control (Tangney, Baumeister, & Boone, 2004) or high levels of trait conscientiousness (Roberts, Lejuez, Krueger, Richards, & Hill, 2014). What came as a surprise to many at the time was that these people used willpower remarkably infrequently in their daily lives, markedly less than people with low self-control (Hofmann, Baumeister, Förster, & Vohs, 2012a). Instead, it appeared that their self-regulatory abilities were related to the routinization of goal-directed behaviors and the cultivation of good habits (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Galla & Duckworth, 2015). Why might this be?

People high in trait self-control experience fewer desires that conflict with their longstanding goals; they experience fewer temptations, fewer and less pronounced cognitive conflicts (Hofmann et al., 2012a; Schneider, Gillebaart, & Mattes, 2019). One reason for this is that effective self-regulators pursue goals because they truly feel like they *want-to* pursue them and not because they feel they *have-to* pursue them (Converse, Juarez, & Hennecke, 2019). That is, they come up with reasons to pursue their goals that feel autonomous and authentic and not reasons that feel like an imposition (Ryan & Deci, 2000). Such want-to goals seem resistant to temptation, attracting fewer disruptive thoughts and emotions (even implicit ones) that might detract a person from meeting their goals (Milyavskaya, Inzlicht, Hope, & Koestner, 2015).

Effective self-regulators avoid having to use willpower because they make plans that structure their lives to avoid temptation from arising. They are planful and future-oriented, drawing up comprehensive strategies that anticipate and deal with potential obstacles to bring their future goals about (Ludwig, Srivastava, Berkman, & Donnellan, 2018; Ludwig, Srivastava, & Berkman, 2019). They often recruit several simultaneous strategies to achieve their goals, many of which are considered proactive, occurring before a temptation is encountered (Hennecke, Czikmantori, & Brandstätter, 2019). For example, people high in trait conscientiousness have better romantic relationships, in part, because they avoid situations and actions that can lead to infidelity (Hill, Nickel, & Roberts, 2014).

By cultivating good habits, selecting personally meaningful goals, and avoiding temptation before it arises, effective self-regulators do not need to rely on willpower as often. And this is a good thing, as it is unclear whether willpower should be relied upon. Despite the controversy surrounding the empirical robustness of the concept of ego depletion (Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2019), fatigue, and its downstream consequences on attention, is real (Hockey, 2013). It has long been known that attentional control cannot be sustained indefinitely (Mackworth, 1948). The result of such limits is that people become less able or less willing to sustain their resolve after bouts of effortful work (Blain, Hollard, & Pessiglione, 2016; Lin, Saunders, Friese, Evans, & Inzlicht, 2020), although such effects might be considerably smaller than previously thought. And, it is not just fatigue that can impede willpower; stress, bad moods, and alcohol also weaken it (Heatherton & Wagner, 2011).

The benefits of willpower are in doubt in other ways. Although resisting temptations is more effective than not resisting, the empirical success of resistance varies considerably across studies conducted in real life. Some studies find that resistance is adequate (Hennecke et al., 2019; Hofmann, Schmeichel, & Baddeley, 2012b), whereas others find that it was successful in fewer than half the occasions it was attempted (Milyavskaya, Saunders, & Inzlicht, in press). What is worse, when looking beyond success or failure in one particular situation, at least one study suggests there is little connection between regularly

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engaging willpower and making progress on one's goals (Milyavskaya & Inzlicht, 2017). Despite promises that willpower is one of the keys to goal attainment, in the long-run, people who use it may not be better at meeting their goals than people who don't.

It is not yet clear if willpower is generally effective or not. What seems clear is that willpower is overrated. There are other, and arguably better, means to reach one's goals; and the people who reach their goals already know it.

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Is "willpower" a scientific concept? Suppressing temptation *contra* resolution in the face of adversity

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Abstract

The distinction that Ainslie draws among the triple-phenomena "suppression," "resolve," and "habit" is a great advance in decision making theory. But the conceptual machinery "willpower," and its underpinning distinction between small/soon (SS) rewards as opposed to large/later (LL) rewards, provides a faulty framework to understand the triple-phenomena.

This comment welcomes Ainslie's distinction between three phenomena, what he calls "suppression," "resolve," and "habit." He tries to provide a framework, namely, the term "willpower," to unite the three. However, "willpower" turns out to be a non-scientific concept. For a concept to be scientific, it must denote a form or an entity that has some internal coherence. Terms such as "storm," "organism," "organ," "firm," and "market" are scientific concepts insofar as the denoted forms or entities have internal coherence. There is no such internal coherence between "suppression," "resolve," and "habit" to the extent that warrants a common term, namely, "willpower," which can represent their presumed coherence.

Ainslie proposes "willpower" as a scientific concept on the supposition of a common function underpinning the three phenomena. The presumed willpower (1) maintains the *suppression* of impulses, temptations, and other distractions; (2) sustains the

courage to be *resolute* in the face of adversary, failure, and other challenges; and (3) regulates behavior into effective *habits*. This comment shall argue that the proposed "willpower" differs systematically in at least the "suppression" and "resolve" functions and, hence, the term is rather a catch-all phrase, that is, one denoting a different phenomenon. This comment does not discuss "habit" because it is not even close to the other two phenomena.

Ainslie makes his case by distinguishing between small/soon (SS) rewards as opposed to large/later (LL). He finds that the SS/LL distinction unifies the "suppression" and "resolve" phenomena. When the decision maker (DM) suppresses behavior in response to a temptation, the DM is choosing LL over SS rewards. Similarly, when the DM faces difficulties with courage and resolve, the DM seems to also be choosing LL over SS rewards. But such similarities are rather superficial, as this comment shall establish. On the contrary, Ainslie finds that what distinguishes "resolve" from "suppression" is a minor issue, namely, the role of effort. Although effort is not involved in "resolve," it is involved in "suppression." To be resolute in facing difficulties is not expensive in terms of pecuniary effort, although to adopt rules or commitments to stave off temptations is expensive in terms of pecuniary effort.

Let us agree with Ainslie that effort in the pecuniary sense is involved in "suppression," but not in "resolve." It is a welcome step in distinguishing cases of temptation from cases of tenacity and resolution that are needed in the fight against addiction. These two phenomena are often conflated (e.g., Khalil, 2008; Redish, Jensen, & Johnson, 2008).

However, if the two phenomena differ, namely, if pecuniary effort is not pertinent for "resolve" as in the case of "suppression," the machinery of SS/LL pecuniary rewards is not relevant for the analysis of "resolve." Indeed, the concepts of SS and LL rewards in the pecuniary sense do not enter into consideration in the first place – although they are relevant in "suppression." To see why, let us examine "resolve" closely. Resolve is the resilient attitude in the face of pandemics, natural disasters, poor reception of one's novel, negative reviewers' responses to one's scientific paper, career failures, addiction to drugs/sex/videogames, and so on. As such, "resolve" cannot be an optimal decision in the standard rational choice sense – as the case when one adopts second-best optimal rules or commitments in "suppression" in the face of temptations (Khalil, 2015, 2017). In the case of "resolve," staying the course and tenacity, as opposed to giving up in the face of difficulties, is not a rational act in the standard sense. There is no well-defined bundle of pecuniary rewards that the DM has to maximize in the first place. Either the DM has stamina, faith, or the belief in one's destiny – or not. And such a decision is rather existential and even transcendental. It is outside the realm of rational choice insofar as such a choice is between pecuniary rewards (see Khalil, 1997).

But if "resolve" involves concepts outside the halls of pecuniary SS and LL rewards, tenacity and steadfastness in the face of difficulties cannot be grounded on the SS/LL pecuniary rewards – that is, the pecuniary rewards that inform the adoption of the rules and commitments in "suppression" in the face of temptations. It is misleading to analyze "suppression" and "resolve" with the same conceptual tools, namely, pecuniary SS/LL rewards. It is erroneous to suppose the same "willpower" that informs the DM in staving off temptations in "suppression" is the same operative that infuses the DM to persist in the pursuit of an acting career, an academic profession, or any goal of distinction.

The term "willpower" might be a convenient shorthand that one may use occasionally to characterize "suppression" and "resolve." But the term "willpower" cannot be a scientific concept, that is, a concept that captures the different inner coherence of "resolve" and "suppression."

The distinction between "resolve" and "suppression" is pivotal for many other studies and investigations. To mention one, "resolve" is infused with aspiration for a career path or a desire for distinction in one's profession, whereas such aspiration or desire might be a critical pillar of happiness (Khalil, 2019, 2020). It might be the case that the machinery of the SS/LL pecuniary rewards is limited; it cannot explore the nuanced nexus between pecuniary wellbeing, on one hand, and aspiration that infuses "resolve" that is critical for happiness, on the other.

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Willpower is a form of, but not synonymous with, self-control

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Abstract

We build on Ainslie's discussion of willpower by highlighting another common misconception in the literature: the conflation of self-control and willpower. In our commentary, we identify this issue and discuss the importance of recognizing willpower not as synonymous with self-control, but rather as a subset of self-control. We describe a set of upstream strategies as more effective alternatives to willpower.

Ainslie identifies and seeks to rectify an important assumption about the construct of willpower. The goal of this commentary is to extend this clarification in two ways. First, we point out that much of the relevant literature on willpower has conflated willpower with self-control, leading to a lack of clarity around how best to identify ways to help people overcome self-control problems.

Second, we point out an important and often overlooked distinction between upstream and downstream self-control strategies and discuss the ways in which this distinction helps further Ainslie's distinction and research on self-control more generally.

Behavioral science research has often referred to "willpower" as synonymous with "self-control" (Duckworth & Kern, 2011; Inzlicht, Schmeichel, & Macrae, 2014; Lian, Yam, Ferris, & Brown, 2017; Metcalfe & Mischel, 1999). Although one could argue this conflation is merely semantic, we propose that it also obscures a theoretically important distinction. Willpower is the internal "brute-force" approach to a self-regulation problem (Duckworth, Milkman, & Laibson, 2018), namely resisting temptation in the moment (which can be described by Ainslie's two functions of "resolve" and "suppression"). If "willpower" is used interchangeably with "self-control," then one could wrongfully conclude that all self-control activities are a form of willpower.

This, however, is not the case (for a thorough review, see Duckworth et al., 2018). As Ainslie himself claims: "means of forestalling changes of preference in advance (for instance, Duckworth et al., 2016) are straightforward, and are not usually counted as forms of willpower." But are they a form of self-control? We argue that they are. In particular, the Duckworth et al. (2016) paper Ainslie references includes the five categories proposed in the process model of emotion regulation (situation selection, situation modification, attentional deployment, cognitive change, and response modulation; Gross, 1998). Two of these categories are identified as situational self-control strategies that must take place in advance of facing a temptation directly. We refer to these advanced actions (situation selection and situation modification) as "upstream" activities because they take place well before one encounters a temptation and can ultimately change the likelihood of encountering the temptation at all. We identify the remaining three categories (attentional deployment, cognitive change, and response modulation) as "downstream" activities, as they occur later, when one is already face-to-face with the temptation. Willpower (and Ainslie's two subcategorizations of willpower) would clearly fall under the category of "downstream" self-control actions.

This has implications for how we study, design, and promote interventions aimed at increasing self-control. In particular, one of the primary reasons we feel the need to emphasize that willpower is not the only strategy to combat self-control problems is because empirical research has demonstrated that willpower is, in fact, one of the least effective ways to do so (see Fujita, Orvell, & Kross, 2020). Instead, upstream situational strategies that help people achieve their goals while circumventing the "need for willpower" altogether are typically more fruitful (Duckworth, Gendler, & Gross, 2016; Ent, Baumeister, & Tice, 2015). These include strategies such as defaulting people into workplace retirement savings plans (Madrian & Shea, 2001), reformulating processed foods to have less salt (Regan et al., 2017), and externally-imposing deadlines that prevent people from procrastinating (Ariely & Wertenbroch, 2002). As a case in point, people who score high on the psychological trait of "self-control" are not any better at resisting temptation or deploying willpower; they have simply created situations where they are less likely to experience temptation (and thus do not need to resist it very often) (Adriaanse, Kroese, Gillebaart, & De Ridder, 2014; Galla & Duckworth, 2015; Hofmann, Baumeister, Förster, & Vohs, 2012).

Beyond being an important distinction for understanding the most effective ways of dealing with self-control problems, we believe that the conflation of willpower with self-control may also affect lay beliefs about how to overcome such problems. Despite their effectiveness for achieving self-control, people often fail to employ situational or upstream strategies for themselves (Ashraf, Karlan, & Yin, 2006; Giné, Karlan, & Zinman, 2010; Marotta & Acquisti, 2017; Moser, Schoenebeck, & Resnick, 2019; Royer, Stehr, & Sydnor, 2015) and others (Blount & Larrick, 2000; Daniels & Zlatev, 2019; Zlatev, Daniels, Kim, & Neale, 2017). Distinguishing willpower from upstream strategies enables us to ask whether people instead prefer to resolve self-control problems using willpower and, if so, why this is the case. We believe that these are important questions that future research should attempt to answer.

In all, the distinctions between willpower and self-control and between upstream and downstream strategies add further context to the important clarification Ainslie offers in his target article.

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Suppression, resolve, and habit in everyday financial behaviour

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Abstract

Everyday financial behaviour involves inter-temporal choices, between saving, spending, and debt. Consumers do not always take these decisions to their best advantage. Ainslie's analysis of the means to willpower as suppression, resolve, and habit is potentially applicable to understanding and improving the decisions that consumers make. Some relevant research on these topics exists, and it is briefly reviewed here.

Ainslie draws a valuable distinction between three means by which people can avoid making choices that are attractive in the short term, but disadvantageous in the long term: suppression, resolve, and habit. I want to consider whether this distinction can be helpful in understanding the inter-temporal choices that arise in everyday economic life, and in supporting people to make more advantageous decisions in those situations.

Depending on their current financial situation, consumers in a modern economy are faced with three inter-temporal choices, all of which typically occur repetitively or even continuously. If we receive money, we have to decide whether to spend it or to save it for later expenditure. If we hold savings, we have to decide whether to maintain them for our future benefit, or to spend from them. And if we have little money, we have to decide whether to put up with some degree of deprivation of goods or services, or to go into debt. Logically, these three decisions should be mutually exclusive, but in reality most people are involved in two or even all three of them at any time: an unwillingness to run down savings may even be a cause of going into debt (Sussman & O'Brien, 2016).

Although many of the experiments underlying Ainslie's discussion of willpower have been carried out using money incentives, applications involving real everyday financial decisions are rarer: applications have more often involved addictions of various kinds. Most addictions have an economic component, in the cost of obtaining the substance or activity that is craved, and some are more directly economic, as is the case for compulsive buying. But everyday financial behaviours are different: they affect almost everyone, and they tend to lack the visceral intensity of addictions. One well known application of inter-temporal choice theory to ordinary financial behaviour is the use of a commitment response to enhance saving, in the "save more tomorrow" strategy of Thaler and Benartzi (2004). But this is an exceptional case. Can more be done, and in particular, can the analysis in the target article leads to more ways of helping consumers make better decisions?

Although "willpower" is a valuable concept analytically, it can have unhelpful moralistic overtones. For most people with serious debts, it is not lack of willpower, but lack of money, that has caused their situation, and reduction of the social problems caused by debt can only come about through economic and social policies designed to alleviate poverty (Lea, 2021). The same is true of the widespread failure of young employees to make adequate pension provision, which is better explained by the low wages and insecure employment that characterize the "gig economy" than by fecklessness. It is critical that we do not seek to explain away social problems, resulting from political choices, by pathologizing individuals (Walker, Burton, Akhurst, & Degirmencioglu, 2015). Nor should we mistake the shortened time horizons that are an inevitable and rational consequence of poverty (Shah, Mullainathan, & Shafir, 2012) for a lack of willpower. Nonetheless, the processes that are thought of as strengthening willpower can all be considered as means towards better inter-temporal choices.

Suppression through avoiding arousing appetite and diverting attention can play a part in avoiding spending that is not in our better long-term interests. Regulating the display of "tempting" products such as tobacco and confectionary in shop displays is a common strategy to reduce their consumption (Ejlerskov et al., 2018; Paynter & Edwards, 2009), although that is more in the interests of public health than of helping people manage their budgets. On both traditional media and the internet, consumers frequently choose to block advertisements (Speck & Elliott, 1997; Tudoran, 2019), although again that tends not to be in the interest of budgeting, but related to general attitudes and beliefs about advertising and its role in society.

What about resolve? Finances often feature in New Year resolutions: in one study, a third of such resolutions concerned saving or repayment of debt, in a roughly 2:1 ratio (Woolley & Fishbach, 2017). Planning is a key component of successful money management in difficult conditions (French & McKillop, 2016). Also, the behaviours and mental processes that Ainslie describes as "resolve" are very similar to those that have been considered under the heading of attitudes to debt. Adolescents with no experience of debt tend to be highly hostile to it – but if, as is commonly the fate of students nowadays, they are forced to take out loans, their intolerance of debt is much reduced, and this effect takes a long time to wear off (George, Hansen, & Routzahn, 2018; Lea, Webley, & Bellamy, 2001). This is closely akin to the process Ainslie describes in which a lapse from a personal rule can undermine future adherence to it.

Habit is the area where we have most evidence for a role of willpower-related processes in everyday financial behaviour. It has long been known that much of both spending and saving is habitual (Katona, 1975). Bank marketing, and consumer advice agencies, routinely urge consumers to "get into the savings habit," and propose tips and tricks that will enable us to do it. Academic research on the acquisition of savings habit is thin on

the ground, however. In one study, indeed, saving money proved to be one of the hardest of good habits to acquire (Van der Weiden, Benjamins, Gillebaart, Ybema, & de Ridder, 2020). But, once acquired, savings habits certainly make a difference; for example, acquiring even a small savings account early in one's independent financial life predicts higher savings and lower debts years later (Friedline & Song, 2013).

Ainslie's earliest study on hyperbolic discounting in intertemporal choice (Ainslie, 1974, 1975), has played a key role in establishing the need for a psychological and behavioural approach to economic behaviour. It has been less influential in the study of everyday finances. The brief review I have given here suggests that the analysis in the present target article could be of significant value in this applied field.

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Pleas for patience from the cumulative future self

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Abstract

Current selves wield all the power in intertemporal tradeoffs. Although one set of future selves will make similar tradeoffs in the future, another self – who we term the cumulative future self – falls on the receiving end of those dictated decisions. How current selves commune with the cumulative future self determines whether the former heed pleas, from the latter, for patience.

Will Durant quipped, "we are what we repeatedly do," and Ainslie contends that people, armed with this ammunition, deploy it to nag themselves into prudence. In facing a choice between pleasure now and future rewards, people extrapolate the decision as diagnostic of how their preferences will play on loop *ad infinitum*. They draw this inference to marshal their resolve, with one self-control failure tantamount to indefinite self-control failure. That people must infer – rather than simply foresee – their choices down the road connotes that the self making those choices remains, to the current self, a mystery. No wonder, then, that Ainslie describes choice over time as, "an intertemporal variant of repeated prisoner's dilemma" (sect. 3.2.1., para. 3).

This conceptualization specifies one particular set of future selves: the unpredictable choosers who, Groundhog Day fashion, will debate again and again whether to take smaller payoffs sooner or larger payoffs later when their turns come. Each chooser considers what to choose because each has the power to choose. Each decision presupposes another set of future selves: those who either receive that preordained larger payoff later or suffer in its absence. Either way, these future selves bear the consequences of the prior choices made by their past selves. Summing across these individuals results in a wholly powerless *cumulative future self*. Where agentic selves might jockey across time in a repeated prisoner's dilemma, the cumulative future self can only hope to curry favor in what amounts to, for her or him, an intertemporal dictator game.

At the mercy of choices made by past selves, the cumulative future self does not tend to fare well. People spend, smoke, snack, and (unprotectedly) sex their future into trouble because the person they will one day become seems more like someone else altogether (Bartels & Urminsky, 2011; Frederick, 2003; Hershfield & Bartels, 2018; Parfit, 1971; Pronin, 2008). Defined by slippery features that beget less generosity from the current self, pleas for patience from the cumulative future self work best by closing the gap between selves.

Cumulative future selves might warrant poor treatment because they lack a sense of vividness. Therefore, why not put a

face to the name, even if they're both your own? Showing people an age-rendered visage of themselves compels them to take better care, via their behavior right now, of that person (Hershfield et al., 2011). Swapping pictures for words can have just as strong an effect (Bryan & Hershfield, 2012; Chishima & Wilson, 2020) because both enhance emotional connections over time (Bartels & Rips, 2010; Ersner-Hershfield, Garton, Ballard, Samanez-Larkin, & Knutson, 2009).

Uncertainty makes the future self feel not just socially remote but also as belonging to a future age (see Maglio & Kwok, 2016), as these different constructs conspire to push things farther and farther away (Maglio, 2020a, 2020b; Maglio, Trope, & Liberman, 2013a). Although the intertemporal tradeoffs that impact cumulative future selves transpire over objective time (e.g., $20 today vs. $40 next week), people mentally convert from absolute time to a relative sense of closeness or distance in thinking across time (Hu & Maglio, 2018), including the making of choices between smaller payoffs sooner and larger payoffs later (Maglio, Trope, & Liberman, 2013b; Malkoc & Zauberman, 2019; Xu, González-Vallejo, & Vincent, 2020; Zauberman, Kim, Malkoc, & Bettman, 2009).

Changing how people subjectively see time, then, might change how they see – and act toward – their future selves (Evans & Wilson, 2014; Peetz, Wilson, & Strahan, 2009). This need not apply only to the time separating now from one particular future choice, or now from one specific version of the future self, but to the broader progression of time. Based on this possibility, we recently manipulated the sense of how long the present lasts and found that expediting the felt onset of the future – casting the present as short and the future as imminent – caused people to opt for more far-sighted alternatives (Hershfield & Maglio, 2020).

Habits, Ainslie proposes, are outcomes and not mechanisms, suggesting that, "good habits require intertemporal bargains" (sect. 3.3.2., para. 3) with future selves in the position of agentic choosers. A different future self – a cumulative future self – falls on the receiving end of those dictated decisions, subject to the decrees made by many prior-self overlords. Different interventions, including but by no means limited to those summarized herein, can change how people think about the self progressing through time and, in turn, whether current selves sacrifice on behalf of the cumulative future self. Evidence attesting to the merit of these interventions to strengthen self-control, although, almost exclusively takes the form of one-off choices between immediate and delayed rewards. Might these assessments leave hiding in plain sight not just a fleeting shot in the arm, but the spontaneous emergence of something that looks a lot like a good habit? Ainslie's model at least suggests that single-shot allocations themselves serve as test cases resulting from a resolve-based stiffening of willpower. It remains to be seen whether singularly, or perhaps even repeatedly, intervening on behalf of the cumulative future self can transform single-shot behaviors into habitual changes in action writ large. Favorable reappraisal of the cumulative future self may thus fast-track the formulation of good habits for the benefit of all selves over time.

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Resolve is always effortful

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Abstract

Ainslie argues there are two main kinds of willpower: *suppression*, which is necessarily effortful, and *resolve*, which is not. We agree with the distinction but argue that all resolve is

effortful. Alleged cases of effortless resolve are indeed cases of what Ainslie calls habits, namely stable results of prior uses of resolve.

Willpower or internal self-control is the psychological function that resists present temptations (by contrast with forestalling future temptations, which is not considered a variety of willpower). Temptations arise when the agent is confronted with a choice between a smaller reward that is closer in time, and a larger reward that is temporally more distant. The agent will act according to the option which is the most rewarding. Temptations arise because the closer the sooner-smaller alternative gets, the more rewarding it appears.

There are, Ainslie maintains, two methods for resisting temptations: one can confront the temptation head on by inhibiting other options or keeping one's attention away from them (*suppression*); alternatively, one can reinforce the intention by interpreting the current choice as a more general test case for some desired pattern of behavior (*resolve*). Ainslie argues furthermore that *suppression is necessarily effortful*, whereas *resolve may be effortless*. He identifies effort with the operational costs of implementing a willpower tactic. According to him, resolve involves operational costs only when temptations generate risks associated with giving in. By contrast, resolve involves no operational cost – and is, therefore, effortless – when agents are confident that they will not give in to temptations, as in the case of flight attendants who feel no urge to smoke while in flight.

Although we agree with the suppression/resolve distinction we maintain that there is no such thing as effortless resolve. The view that exertion of willpower is always effortful is largely accepted in the literature (see, however, Fujita, 2011). Why does Ainslie think that in the case of resolve, that orthodoxy has to be rejected?

Ainslie's reason is this: there are documented cases in which agents are entirely confident that they will not give in to temptation, so that no effort is needed to resist the temptation. Reporting Dar, Stronguin, Marouani, Krupsky, and Frenk studies (2005), Ainslie writes: "Orthodox Jews who never smoke on the Sabbath and flight attendants who never smoke during flights have no urge to smoke during those times, while still having strong urges at other times." These, he maintains, are cases of effortless resolve.

We do agree that such cases are effortless, but we reject that they are cases of resolve and more generally cases of willpower. Willpower is defined as the resistance to present temptation; but such cases are explicitly described as cases where there is *no urge*. In the absence of temptation or risk to give in, there is no need to employ any willpower tactics. It would, in fact, be irrational to enter into complex intertemporal bargaining if not under the pressure of temptation.

Perhaps, "no urge" is an overstatement here; perhaps, the idea is that urges in such cases are very low. But the point remains: either the urge is too low to justify the implementation of a self-control method, in which case there is no effort, but no resolve either. Or the urge constitutes a "marginally permissible temptation," in which case we need to employ resolve, which, as a willpower tactic is going to be (marginally) effortful.

Thus, on closer scrutiny, the cases put forward by Ainslie provide no reason to admit effortful resolve. Moreover, there is a strong reason to admit that resolve is effortful:

P1 Resolve entails a process of cognitive abstraction.
P2 Cognitive abstraction processes always have operational costs.
P3 Having operational cost entails being effortful.
C Resolve is effortful.

P1 follows from Ainslie's definition of resolve as interpreting a particular decision context as an instance of more general pattern or rule. That requires cognitive abstraction. P3 follows from Ainslie's definition of effort. P2 seems highly plausible – it is hard to see how cognitive abstraction could be implemented at no cognitive cost at all. Hence, the view that resolve may be effortless is incompatible with the view that cognitive abstraction is costly, a view that appears to stand on firm ground.

If correct, alleged cases of effortless resolve are indeed cases in which *resolve* is absent. More generally, they are not cases of willpower. But if so, what are they?

After having discussed suppression and resolve, Ainslie moves on to *habits*, which according to him are not methods of self-control but results thereof. We suggest that alleged cases of effortless resolve are in fact cases of habits.

More specifically, we propose that such cases are either cases of good habits or cases of routine habits. Good habits are more fragile than routines. Having a reason not to go running today comes with a rush of pleasure and endangers the habit that one has effortfully managed to create. Therefore, good habits are tightly dependent on resolve: When temptation kicks in, resolve has to come to the rescue to preserve them. Ainslie concludes that good habits are therefore "forms of willpower." But this does not follow – to depend on something does not entail being a species of it. If true, alleged case of effortless resolve might be cases of good habit without being cases of resolve or willpower more generally.

The alleged cases of effortless resolve mentioned by Ainslie are perhaps even better seen as cases of routine habits, which, Ainslie rightly insists, are not forms of willpower. In routine habits, the temptation that was regularly resisted in the good habit ends up disappearing. Routine habits no longer need the protection of resolve for they are no longer challenged. Tellingly, Ainslie also mentions the case of a person who never thinks of smoking during a flight as an example of routine habit. However, because resolve is a mechanism and routine habit is a result, the same example cannot be at once an instance of resolve and an instance of routine habit.

Instead of subsuming such cases under the dubious category of effortless resolve, Ainslie's position would be stronger if they were subsumed under the category of – good or routine – habits.

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Self-control from a multiple goal perspective of mixed reward options

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Abstract

We introduce a distinct type of choice that has yet to be addressed by self-control research: Choosing between activities that offer *both* delayed *and* immediate rewards. We describe when and why such mixed-reward choices pose challenges to self-control, and suggest that self-control in mixed-reward choices may be supported (rather than undermined) by delay discounting.

Like most self-control research, the target article by Ainslie conceptualizes self-control (or willpower) as the process of foregoing smaller sooner rewards in favor of larger later rewards. Prioritizing delayed over immediate reward activities can be challenging, and we do not dispute the importance of understanding how people negotiate such choices. Yet, we suggest that a more complete picture of self-control challenges involves a different type of choice people frequently face: choosing among activities that offer *both* delayed and immediate rewards.

Most goal-directed activities offer not just one but multiple distinct rewards (for a comprehensive account, see Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, 2017). In this commentary, we focus on a specific subset of such multi-attribute activities, namely activities that offer a combination of delayed *and* immediate rewards. Goal pursuits are often selected for delayed outcomes, that is, for the prospect of reaping rewards that materialize at a later point in time (e.g., Mischel, Shoda, & Rodriguez, 1989). Yet, many goal pursuits also offer immediate rewards that lie in the goal-directed activities themselves or in small interim targets (e.g., Rheinberg, 1989; Woolley & Fishbach, 2016). For example, the activities of "community work" and "studying" may be primarily motivated by the prospect of achieving delayed rewards (e.g., for community work: contributing to societal good; for studying: good grades). However, engaging in these activities also offers immediate rewards (e.g., for community work: the enjoyment of engaging with people; for studying: the enjoyment of learning about interesting topics). We refer to activities that offer both types of rewards, immediate and delayed ones, as *mixed-reward* activities.

Assuming that many goal-directed activities are best described as mixed reward activities, we suggest that people frequently face a distinct type of choice: choosing among multiple mixed-reward options. More specifically, we suggest that mixed-reward choices are ubiquitous in multiple goal pursuit contexts. People usually strive for multiple long-term goals in their everyday lives (e.g., multiple work, leisure, and family goals; Freund, Knecht, & Wiese, 2014). Balancing the demands of these goals can be challenging, as the amount of resources available for any goal pursuit (e.g., time) is finite. Choosing to act on *one goal* (e.g., studying) thus often comes at the expense of not being able to act on *another goal* (e.g., community work). Accordingly, whenever two (or more) mixed reward goal pursuits compete for the same finite resource, people are faced with the task of prioritizing among mixed-reward options.

To promote and sustain success in multiple mixed-reward long-term goals, people have to negotiate on a regular basis *when* to work on *which* goal, and for *how long*. Yet, despite their importance, mixed-reward choices are yet to be addressed by self-control research. Navigating mixed-reward choice options can be challenging because the use of *suppression* and *resolve*, as conceptualized by Ainslie (this volume), may be particularly effortful.

Suppression: When attempting to prioritize one mixed-reward activity over another mixed-reward activity, the alternative option may act as strong temptation, as it offers both immediate and delayed rewards. This can render *suppression* (i.e., blocking or interfering with a positive revaluation of alternative options) particularly effortful. For example, choosing to spend the afternoon at the library studying is difficult on a beautiful summer day, when the alternative of doing community garden work would offer not only higher immediate rewards (e.g., engaging with people and enjoying the weather) but would also allow for promoting the associated delayed reward of contributing to societal good. In short, temptation posed by alternative options that are temporarily preferred for their immediate rewards is further bolstered by the prospect of also promoting valued delayed rewards.

Resolve: Navigating mixed-reward decisions by means of *resolve* (i.e., avoiding perceived risks to larger incentives) can also be challenging, as these choices may be particularly susceptible to perceptions of what Ainslie termed "credible exceptions to one's rule." Changing one's plans from studying at the library to community garden work can be framed as a credible exception rather than as lapse, because doing community work, albeit not compatible with the academic goal rule, is consistent with the community goal rule. In other words, choices between two mixed reward options can be perceived in terms of two rules, each of which can be used to argue the other, thereby creating "permissible temptations" (i.e., choosing a mixed-reward option based on immediate rather than delayed rewards seems like a justifiable decision).

Finally, we propose that successful (or effortless) resolve of mixed reward choice dilemmas may be promoted by *capitalizing on* – rather than *interfering with* – delay discounting. To reduce resource-based conflicts between goals (Riediger & Freund, 2004), people may decide to temporarily behaviorally disengage from some goal pursuits and shelve them with the intention to reengage in the future (Mayer & Freund, 2020). In shelving otherwise conflicting goals, people can reduce the availability of and exposure to permissible intergoal temptations. This approach is similar to strategies that support decision-making through the restructuring of one's decision-making environment (e.g., Hoch & Loewenstein, 1991; Thaler & Shefrin, 1981): By means of postponing goals, people restrict their set of actively pursued goals, effectively reducing the complexity of their inter-goal decision-making environment. Critically, people can also capitalize on delay discounting: As both the (formerly) immediate and (now even further) delayed rewards of shelved goals can be (further) discounted, they should be less likely to interfere with intentions to act on active goals. In this sense, effortless self-control may be best understood as *avoiding* rather than *suppressing* or *resolving* temptation and may actually *benefit* rather than *suffer* from delay discounting.

Taken together, taking a multiple goal perspective, we argue that research on self-control needs to consider the specific

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challenges and processes involved in choosing among two (or more) mixed-reward activities.

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Stress and imagining future selves: resolve in the hot/cool framework

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Abstract

Although Ainslie dismisses the hot/cool framework as pertaining only to suppression, it actually also has interesting implications for resolve. Resolve focally involves access to our future selves. This access is a cool system function linked to episodic memory. Thus, factors negatively affecting the cool system, such as stress, are predicted to impact two seemingly unrelated capabilities: willpower and episodic memory.

In "Willpower with and without effort," Ainslie characterizes the mechanisms underlying willpower (as distinct from mere habit) as being suppression and resolve. He consigns the hot/cool framework of willpower and of memory (Metcalfe & Jacobs, 1996, 1998, 2000; Metcalfe & Mischel, 1999) to a class of "visceral" theories of willpower that pertain only to reward perception and its suppression. Although not denying that the hot–cool balance can affect reward characterization and suppression, we argue, here, that it also makes important predictions concerning the other component, namely, resolve.

Explicit or episodic memory depends on the cool system. As detailed below, this system is responsible for mental projection into one's future, as well as for remembering one's past. Thinking about the future is necessary for an individual to "recursively self-predict" – the cognitive process that Ainslie argues is at the core of resolve. It follows that if cool system functioning were selectively impaired by stress (or for other reasons), an individual's ability to engage in recursive self-prediction, and with it their resolve, would also be impaired, with adverse results for willpower.

Resolve, within the Ainslian framework, involves perceiving a particular instance or violation as being a test-case of a larger category. Smoking a single cigarette is more than an inconsequential isolated act; it is seen as typifying an undesirable although specific behavior that jeopardizes one's future health. One resolves to do something, such as resist cigarettes, to benefit one's future self (who is imagined, in this case, to be healthy). Although not explicit in Ainslie's framework, his notion of recursive self-prediction implies the construct of a future self. The proposal that people use an internally generated image of their future selves to activate present behavior has a distinguished history in psychology going back to the study of Markus and Nurius (1986) and elaborated extensively by others (e.g., Hershfield, 2019; Oettingen & Mayer, 2002; Oettingen, Sevincer, & Gollwitzer, 2018; Urminsky, 2017). Many studies show that the mental recruitment of future selves predicts effective self-regulation (Frazier & Hooker, 2006; Frazier, Schwartz, & Metcalfe, 2021; Hooker, 1992; Leondari, Syngollitou, & Kiosseoglou, 1998; Oyserman, Destin, & Novin, 2015; Oyserman & Markus, 1990). These "future selves" are characterized as mental representations of who we are – our own identities – projected into the future. They are an embodiment, on the positive side, of the person we aspire to become (Higgins, Roney, Crowe, & Hymes, 1994; Stokes, 2019). On the negative side, they comprise a graphic portrayal of the alternative dismal fate to which we might succumb. Accessing such future selves readily is necessary for resolve-based willpower, which Ainslie argues is underpinned by ongoing monitoring of progress toward this goal. We evaluate if smoking the cigarette represents behavior that gets us closer to the healthy future self or to the dismal fate, and make a decision to act accordingly.

Many take temporal discounting – an adult variant of Mischel's (2014) "delay of gratification" paradigm – to be the prototype paradigm of willpower. The role of the future self in this paradigm is obvious. In the temporal discounting paradigm, an individual is asked to abjure immediate but small rewards for the present self in favor of larger rewards for an imagined future self. If the individual cannot conjure up a future self then presumably those hypothetical future rewards are meaningless. There is no reason to resist immediate impulse. Willpower and the resolve that underpins it collapse. The extent to which the individual clearly imagines and identifies with the future self, then, appears to be crucial for the value accorded to those future rewards. Within the hot/cool framework, stress disrupts the ability to imagine a future self.

In the hot/cool framework, explicit or episodic memory is a cool system function, whereas conditioning and taxonomic and implicit learning are hot system functions. There is considerable evidence, from the amnesia literature, that cool explicit memory is dissociable from hot forms of memory. This selective cool-system-related explicit memory impairment seems, at first

blush, to be unrelated to future thought or to willpower. Studies of amnesics, however, show that the explicit memory system and people's ability to think about the future are deeply linked (Tulving, 1985, 2002). For instance, psychologists have studied amnesic patients, such as KC, who was purportedly unable to recall any particular instances of events from his life. Interestingly, KC, and other such amnesics, also experience enormous difficulty in thinking about the future (e.g., Schacter et al., 2012). Furthermore, there is considerable evidence from neuroimaging that the same neural systems underlie both remembering events from one's own past and generating projections of oneself in the future (Okuda et al., 2003). Mental self-time travel pertains to both past and the future.

There is also growing evidence that stress, especially at high levels, selectively impairs the cool system, while possibly even enhancing function of the hot system (Jacobs, Brown, & Nadel, 2017). For example, Eich and Metcalfe (2009), tested marathon runners who had just completed a 26.2 mile race (as compared to unstressed marathoners tested days earlier). They found selective stress-related impairment of explicit memory. Similarly, when New York City firefighters were tested for their memory of events experienced in dangerous fires, Metcalfe, Brezler, McNamara, Maletta, and Vuorre (2019) found that the degree of explicit memory impairment depended on the stressfulness of the fire. The "cool" system, then, is impaired under stress.

The hot/cool framework indicates that when stress selectively impairs the cool system it is not only explicit memory that is impaired, but also future projection. When people are experiencing high levels of stress, they are less able to contemplate their own future selves. As a result, their resolve, mediated by Ainslie's recursive self-prediction mechanism, dissolves. Stress-related dysfunction of the cool system, then, directly affects resolve-mediated willpower. The vulnerability of resolve to factors that negatively affects the cool system provides a testable explanation for why people under extreme stress exhibit two otherwise seemingly unrelated symptoms: impaired episodic memory and impaired willpower.

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Present-state dependency in valuation of the future

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Abstract

Ainslie's target article provides a map of distinct mechanisms relevant to self-control, potentially providing needed precision to the field. He also breaks new ground in characterizing the symbiotic relationship between suppression and resolve. In this commentary, I argue that one behaviorism-based feature of his framework, *present-state independence*, is unjustified and unnecessary for the broader claims of the theory.

Most smokers want to quit, if not today, soon (Babb, 2017). Most students I poll think they spend too much time on social media. And I expect most academics think they put off long-term projects more than they ought to. We often miss out on that second marshmallow. But, if the point of comparison is not optimality but instead other species, we are extraordinarily effective at pursuing long-term interest. How do we do this? Ainslie has been refining what is the most complete functional

account of this for nearly a half-century. Here, he advances the work by, above all, articulating the symbiotic relationship between the effortful control of attention ("suppression") and the intra-personal bargaining phenomena necessary for durable resistance of temptation ("resolve"). This advance in the theory should be an invitation to experimental psychologists who can integrate methodologies previously more narrowly directed at suppression.

There is, however, a behaviorist's commitment Ainslie holds that strikes me as unjustified and unnecessary because his essential insights do not depend on it. And I think it may contribute to the neglect of the broader theory by some in behavioral sciences grounded in biology (relative to its embrace by economists and philosophers). According to Ainslie, the *present value* of any anticipated future reward is its *value at the moment it will be experienced, discounted for delay*. The present state of the organism should not matter. For example, consider two opioid dependent individuals who both are interested in quitting, and who both have the option of making a phone call for delivery of heroin in 1 hour. One is experiencing intense withdrawal. The other is comfortable, but knows she will be experiencing intense withdrawal in an hour (perhaps because of an unavoidable scheduled injection of the opioid antagonist naloxone). Given Ainslie's approach, the divergent present states (withdrawal vs. comfort) should not impact motivation to make that call – they should be equivalent. An implication of this "present-state independence" assumption is that the shape of the discount function is the only motivational basis for systematic inconsistency. If there were an intervention that could make discounting exponential, problems of self-control would vanish.

It seems likely that present state influences valuation sufficiently to constitute a separate source of self-control challenge. It is helpful to step back and consider inconsistency in the context of living organisms generally. Inconsistency is fundamental to complex life. This is obviously true at the timescale of biological development. Babies are no more mini adults than caterpillars are mini butterflies. The problems babies need to solve are different than those adults need to solve, and their bodies and brains are designed accordingly. At shorter timescales, emotions are also transformations. Heart rate increases when the environment signals threat – presumably trading-off future energy stores for greater immediate capacity. Activities that are enjoyable when secure (e.g., an interesting conversation) lose appeal when one is frightened. Emotions transform the organism to better solve the problems of the present, making them inconsistent over time. And although strong emotions make inconsistency easy to see, the issue is more general. Complex organisms are fluid in countless ways, adaptively shifting internal functioning, and behavioral tendencies from one moment to the next. Inconsistency is fundamental and not limited to special cases of strong emotions. And yet because humans pursue plans and maintain social relationships that require dependability, inconsistency poses a serious challenge.

Of course, Ainslie is well-aware of state changes that impact value, but he holds they do so only to the extent they are anticipated at the time a reward will be realized. If I am not hungry when I am preparing for my hike, but I anticipate I will be when miles into a trail, food holds present-value grounded in my future anticipated state. And so I take the time to pack my lunch. People have foresight, and the present-value of packing food is influenced by its anticipated value later in the day. However, the fact that changes in appetite are anticipated does not imply the process is unfailing or optimal. Indeed in many cases we likely lack the capacities that would be necessary for unbiased good approximations of future state-based value. We regularly make decisions on timescales large enough to rule out reinforcement history as a mechanism for shaping orderly (present-state independent) preference. Indeed, we value rewards at delays so great there is no reliable way to anticipate their value when realized (e.g., saving for retirement that might be decades away). When deciding about contingencies that span years, the mental imagery (whether spontaneous or manipulated) is influential (Hu et al., 2017; Peters & Büchel, 2010). And imagery of the future suffers corruption from the present (Wilson & Gilbert, 2003). Even when imagining state changes relatively near in time, forecasts can be poor if the predictable state change is significant, leading people to undue confidence that their resolutions will hold (Sayette, Loewenstein, Griffin, & Black, 2008).

If state-based inconsistency were extreme and global, it would create inconsistent behavior impervious to Ainslie's resolve. Mr. Hyde does not share enough with Dr. Jekyll to have any bargaining basis for sticking with resolutions Dr. Jekyll made. But people experience themselves as continuous. If state changes are a source of inconsistency (in addition to hyperbolic discounting) the mechanisms Ainslie characterizes would apply with little modification. Suppose, as seems possible, being in a present-state of withdrawal makes even next week's heroin more valued. If so, it does not follow that the increase has made the value greater than the value of abstinence next week. And if it has not, a conceived connection between present choice and the larger category (the individual's interest in cessation) provide the necessary ingredients for Ainslie's resolve.

Relaxing the assumption of present-state independence is a more dramatic departure from Rational Choice Theory than is hyperbolic discounting. Whether doing so provides enough additional explanatory power to justify the added complexity is an empirical question.

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Self-control (or willpower) seeks to bias the resolution of motivational conflicts toward an individual's long-term interests

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Abstract

We define self-control as an individual's efforts to bias the outcome of present or anticipated motivational conflicts in order to increase the likelihood that subsequent behavior serves perceived long-term interests. We suggest suppression and resolve are not "mechanisms" that underlie self-control, but rather are classes of strategies that influence motivations in order to increase the likelihood of successful self-control outcomes.

Assuming that willpower – or self-control, more commonly – is being modeled "as a phenomenon within the competitive marketplace of reward," Ainslie asserts that *suppression* and *resolve* are the two primary types of mechanisms available to construct such models; accordingly, he dedicates the better part of his article to cataloging existing theories and findings according to their apparent alignment with suppression or resolve. The bipartite schema that emerges from these efforts is well organized and impressively documented – indeed, at the very least, Ainslie has done much to assemble and sort through many prominent pieces of this puzzle; however, he appears to stop short of outlining a systematic theory that integrates the assorted phenomena he has detailed. In this commentary, we aim to take this study a step further by outlining a motivational account of self-control that unifies suppression and resolve, classifying both as strategies for manipulating one's motivation levels in order to bias behavioral outcomes in favor of one's perceived long-term interests.

Ainslie defines willpower as the process by which a tempting impulse to pursue an attainable reward is resisted in order to facilitate the pursuit of a delayed outcome that is associated with greater long-term value. This definition features what we consider to be the critical components of every context in which self-control is employed: (1) a motivational dilemma regarding which of two exclusive outcomes to pursue, wherein one is more immediately gratifying whereas the other features a delayed, but larger reward; and (2) an intentional effort to influence the resolution of this conflict in favor of pursuing the delayed outcome. We suggest that self-control (or willpower) may be defined more generally in terms of (2), as an individual's efforts to influence their own decision-making processes in order to bias the outcome of present or anticipated motivational conflicts such that subsequent behavior is more likely to serve the individual's perceived long-term interests. From this perspective, suppression and resolve are not "mechanisms" that underlie self-control, but are more aptly considered to be classes of cognitive/behavioral strategies that (when employed) increase the likelihood of successful self-control outcomes – either by impeding the pursuit of short-term goals (suppression), or facilitating the pursuit of long-term goals (resolve).

Given the inherent motivational conflict between immediate versus delayed rewards in self-control contexts, neuroscientific models of intertemporal decision making (e.g., choosing between a smaller/sooner and a larger/later reward) may be a source of insight here. A study by van den Bos and McClure (2013) suggests that two distinct brain networks are involved in estimating the respective values of delayed versus immediate outcomes: roughly, delayed rewards appear to be evaluated by a cortical network (associated with executive control), whereas immediate rewards are estimated by a network of dopaminergic circuits that connect cortical and subcortical regions (associated with impulsivity); their model based on this framework predicts intertemporal decision making by comparing relative activation levels in these two networks (with predictive performance on par with traditional hyperbolic discounting models). That intertemporal choice can be predicted in this way supports the assumption that greater relative network activation is indicative of a greater estimated value – and thus higher motivation – associated with pursuing an immediate or delayed outcome.

This competing-networks framework meshes well with the perspective of self-control that is outlined by Berkman, Hutcherson, Livingston, Kahn, and Inzlicht (2017); they suggest self-control should be viewed as a value-based choice, in which the estimated values of competing actions are compared and the action with the highest estimate is selected. By situating self-control within this context of competing networks, suppression can be recast as any cognitive or behavioral strategy that reduces relative activation in the dopaminergic network (e.g., a deliberately-averted gaze, which prevents the increase of network activity that otherwise would have resulted from staring longingly at chocolate); similarly, resolve may be recast as a class of strategies that lead to increases of relative activation levels in the cortical network. However, although terms such as suppression and resolve appear to fit nicely with the underlying neural processes outlined above (impeding or facilitating the motivation to pursue short- or long-term goals, respectively), it is not clear that some self-control behaviors are strictly one type or the other – for example, deliberately traveling to do work at the library may simultaneously limit a student's motivation to play video games as well as increase their motivation to study. Regardless, with the above foundation as a starting point, untethered from strict conceptual adherence to suppression and resolve, Ainslie's *recursive self-prediction* can be seen as one of many possible resolve-like strategies (rather than the singular "process … that underpins resolve"); even procrastination – if not a particularly efficient or self-actualizing form of self-control – may be viewed in terms of a resolve-like strategy, as it effectively serves to increase the motivation to (eventually) begin pursuing some odious task (as the passage of time steadily increases the cost that would be incurred by further delay).

Here, we recommend defining self-control as an individual's efforts to bias the outcome of present or anticipated motivational conflicts in order to increase the likelihood that subsequent behavior serves the individual's perceived long-term interests. This view considers self-control in terms of its motivational influence on behavioral outcomes via known neurological processes, a framing which largely avoids jargon at its base. Although it is highly desirable to have discourse on important phenomena in an interdisciplinary context such as this, one disadvantage can be that each field has already stumbled upon its own unique vocabulary; coming from disparate starting-points can cause confusion and may hamper the development of consilience. Rather than reworking existing concepts from one field or subfield in terms of related concepts from another – for example, recasting construal-level self-control strategies (e.g., Fujita & Carnevale, 2012) in terms of recursive self-prediction – it is preferable to have a relatively-neutral theoretical foundation that may be used to translate such connections into a common language that is interpretable by members of all fields.

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Is resolve mainly about resisting hyperbolic discounting?

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Abstract

Ainslie insightfully refines the concept of willpower by emphasizing low-effort applications of resolve. However, he gives undue weight to intertemporal discounting as the problem that willpower is needed to overcome. Nonhumans typically don't encounter choices that differ only in the time of consumption. Humans learn to transform uncertainty into problems they can solve using culturally evolved mechanisms for quantifying risk.

Ainslie's essay displays again his matchless artistry in refining our conceptual resources for describing ambivalent choice behavior. Human willpower, as he argues, is more complex than metaphors drawn from energetic exertion can capture. In its most reliable applications, it requires little effort at its moments of use. I once had to deliberately battle with myself to avoid a third glass of wine before bed each night. Now it's two and done with no conscious attention. My will rules absolutely and serenely. This is resolve, paying a steady dividend stream from an investment made long ago. I get a side payment: each sip of wine tastes better when there's no ambivalence about its goodness.

Other animals don't seem to get to enjoy such triumphs. As Ainslie points out, a dog is visibly uncomfortable while waiting to be allowed to eat a biscuit, apparently losing an opportunity to enjoy the anticipation. The dog's willpower seems limited to active suppression of the urge to disobey her owner, and active suppression is unpleasant. Ainslie argues that the dog's foregone consumption utility stems from a lack of foresight. Human achievement of this capacity, he rightly says, is among the primary bases of the species' ecological dominance.

This is deeply insightful and persuasive. What is less so is Ainslie's explanation of it almost entirely in terms of hypothesized neural implementation of hyperbolic intertemporal discounting of reward value, to which the dog is said to be prisoner but which the human often manages to work around. Ainslie appeals to neuroimaging evidence for this hypothesis. But the evidence in question comes heavily pre-interpreted. For example, Kable and Glimcher (2007) *assume* that the measurements of BOLD differences they graph hyperbolically represent intertemporal discounting. That's fair enough in context: it's the maintained hypothesis of a rival model they collected their data to test and then criticize. But the signals might just as easily be related to preparation for reward harvesting rather than to utility differences associated with expected *time* of consumption.

Rats, pigeons, chimps, and bees do seem to discount future rewards hyperbolically *if* we assume that their choices are over time-indexed rewards. But these behavioral patterns can equally be modeled as responses to uncertainty more generally. Here is food the bee can harvest under circumstances where she's detecting no signs of danger. Who knows when she'll next be so lucky? The patch over the hill might be a richer source, which she could exploit only if she's patient and doesn't fill her pollen sacks right here. But the probability of a predatory wasp being *there* is higher than the probability of a wasp *here*, simply because she doesn't see one now.

Humans arguably have technologies that most animals lack for turning uncertainty into (roughly) quantified risk. The technologies in question are probably culturally evolved, rather than based on novel adaptations that could be measured in functional neural architecture. Humans divide labor and distribute roles based on explicit rules and normative principles that they encode in shared stories, or, lately and more reliably, in written regulations and numerical algorithms. Then, as Ainslie has emphasized for years, they can apply this governance by regulations to themselves. A person can explicitly insert herself into the virtual role of a boss or influential peer, and give herself orders. As Ainslie has also stressed insightfully, she can even construct a virtual tyrant over herself, against whom she looks for loopholes and might stage a disruptive revolt.

Of course animals, including humans, must pay attention to time. A songbird in a high latitude can in summer wait to venture out to forage until all owls have surely retired, but risks starving if she is equally patient for sunrise in mid-winter. But it isn't clear that she should, or does, represent this by computing an intertemporal discount function. She tolerates higher risk of predation in January than in July because burning energy while hiding in the bush is also risky. The mere prospect of time ahead is a source of risk, because intervals always include *events*, and event probabilities get harder to estimate as their interactions over time accumulate and must be multiplied.

Ainslie may be encouraged to take future time preference as a primitive instead of one of many arguments in a risk function because his favored metaphor for behavioral control at the scale of the whole organism is a marketplace. He understands interests in different consumption prospects as bidding against one another in a common currency. Then the only evident factor that could possibly make two seed pellets now preferable to four seed pellets in 2 hours is the difference between now and later. Humans *deliberately* create choices like this for themselves, because doing so turns uncertainty into risk and allows us to apply powerful tools we've collectively developed, mathematics

and statistics. This is how humans pull off most of their highly distinctive feats: by actively transforming decision problems into terms for which their social environments provide solution rules. Most animals in the wild – although elephants, dolphins, corvids, and parrots might be exceptions – simply don't encounter option sets that differ only or mainly in time of consumption. In the lab, we can try to force them to reckon with such problems, but it's difficult to fully succeed. The mouse who stays close to the wall of her cage evidently isn't getting the message that her predation risk is zero. And, in any event, she can't imagine a more authoritative mouse telling her to let rationality override her fear.

The internal marketplace metaphor certainly has its uses. A brain doing a job must allow itself to be distracted by new opportunities, but not too easily. And this requires that alternative objects of attention be comparatively valued in real time. Expected consumption time of rewards is a recurrently important variable, and one that we *know* is estimated by dopamine signals. But real markets, unless they involve only very simple informational dynamics, are highly volatile and inefficient unless they are well regulated. Resolve as Ainslie characterizes it requires good government.

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Socializing willpower: Resolve from the outside in

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Abstract

Ainslie's account of willpower is conspicuously individualistic. Because other people, social influence, and culture appear only peripherally, it risks overlooking what may be resolve's deeply social roots. We identify a general "outside-in" explanatory strategy suggested by a range of recent research into human cognitive evolution, and suggest how it might illuminate the origins and more social aspects of resolve.

Contemporary research on human evolution traces the ecological success of our species to sophisticated capacities for cooperation and culture (Richerson & Boyd, 2005; Henrich, 2015) and a suite of underlying psychological mechanisms selected to increase the efficacy with which humans interact with and learn from each other (Chudek & Henrich, 2011; Laland, 2017; Mathew & Perreault, 2015; Sterelny, 2012). This indicates that many distinctive forms of human cognition are fundamentally *social* (Kelly & Hoburg, 2017).

Such capacities may be social even when they pretheoretically appear otherwise. For example, Mercier and Sperber (2011, 2017) argue against an orthodox view according to which reasoning initially evolved to enable individuals to deliberate and make better decisions, and only afterward acquired social functions for, for example, facilitating interpersonal interactions and collective negotiations. Their "argumentative theory" offers an alternative picture, according to which reasoning is *primarily* social, and the mechanisms that underpin it initially evolved to perform the public functions of persuading others and assessing their attempts to persuade. Only once they emerged and established their social-oriented functions were those psychological mechanisms able to be turned back on the self, allowing reason to acquire the more private dimension that accompanied its new, interior, individual-oriented functions. Their theory also compels a shift from an individual to a socially-oriented evaluative perspective that reveals the mechanisms that guide reasoning as often performing their original public functions *well*, rather than merely being riddled with maladaptive biases causing them to do private reasoning poorly. Following Sterelny (2018), we will call this an instance of *outside-in explanation*.

Outside-in explanation is, if not widespread, becoming more common. Carruthers (2009, 2011) argues that our capacity to know the contents of our own minds is, perhaps counterintuitively, parasitic on mechanisms that originally evolved to know the minds of others. Introspection is a derivative, private usage of mindreading machinery that is primarily other-oriented, then reflexively turned back on oneself. McAdams and colleagues (McAdams, 2018; McAdams & McLean, 2013; McLean, Pasupathi, & Pals, 2007) develop a similarly outside-in explanation of narrative identity. It sees an individual's creation and maintenance of their own narrative identity as a by-product of social mechanisms for mindreading, language, and storytelling. Others argue that features of human cognition like confirmation bias (Peters, 2020) and overimitation (Hoehl et al., 2019) that look like design flaws from the perspective of individual rationality are actually adaptations selected to perform important social functions. Under headings such as "relational" and "dialogical," philosophers from a range of backgrounds continue exploring outside-in-type explanations of gender (Haslanger, 2000; Witt, 2011), personal identity (Carr, 2021; Lindemann, 2014), and the collaborative character of human agency (Doris, 2015) and autonomy (Stoljar, 2015).

Is resolve, as Ainslie depicts it, amenable to outside-in explanation? The prospects are promising (cf. Shea et al., 2014). Many of Ainslie's key ideas and theoretical resources – perspective taking, bargaining, prisoner's dilemmas, credibility, excuses – are most at home in discussions of sociality. Even mental time travel, foresight, and the general expansion of the time horizons to which human minds are sensitive has been linked to selection pressures generated by the demands of increasing social complexity (Donald, 1991, 2006; Suddendorf & Corballis, 2007).

Assuming this connection is not accidental, what might a more specific outside-in explanation of resolve look like? Here is one possible trajectory. The human species arrives and thrives on the strength of hypertrophied capacities for cooperation and culture, central to which are enhanced mechanisms for reputation tracking (Santos, Rankin, & Wedekind, 2011), social prediction (Frith & Frith, 2006), and normative forms of conformity and enforcement (Kelly & Setman, 2020; Wu, Balliet, Peperkoorn, Romano, & Lange, 2019). These initially outward-oriented social mechanisms – some of which may *themselves* have culturally evolved and been socially acquired (Heyes, 2018) – are reoriented

inward and turned back onto oneself, repurposed to help solve personal intertemporal dilemmas. When an individual learns the trick, they become capable of the self-directed and self-regulating (cf. McGeer & Pettit, 2002) form of prediction and enforcement Ainslie calls resolve.

Ainslie notes the affinity with oath taking (21), another manifestly social practice. Resolve and its (hypothesized) transition from outer to inner might be further illuminated by considering its similarities to *avowal* (cf. Kelly, forthcoming). This suggestion sees the dynamics of resolve as a mostly private, internalized mimicking of dynamics whose original form is found in public acts of endorsement. An individual can publicly affirm a norm they have adopted, or announce to others an intention to behave in a certain way, as a means to help themselves abide by it. With such acts of social signaling, they attempt (whether or not they explicitly understand what they are doing in these terms (21)) to realign others' expectations of them and thereby summon a special kind of social influence onto themselves. More specifically, they create new *reputational stakes* that are tied to the credibility and status they have among people whose good opinion they value or need.

Public avowal can thus reorganize incentives, much like resolve does on Ainslie's account. With avowal, however, an individual attempts to manage their own behavior by actually changing something external to their own mind, namely the kind of person *others* see them as, and the expectations others have of how they will act. In succeeding to change those expectations, they change their actual incentives, thereby exerting a socially-directed form of ecological control over their own behavior (Clark, 2007; Holroyd & Kelly, 2016). With resolve, a person changes not the external social world but their own internal perspective, broadening the incentives taken into consideration and bundling them in ways that change how they bear on an immediate choice via how that choice bears on their ability to continue *seeing themself* as the kind of person they want to be. More of the process is internal, but the strategy and elements are suggestively similar.

Remaining steadfast and resolute, especially in the face of temptation, is often an intensely personal, internal struggle. Nevertheless, we think it plausible that the inner resources one draws on, both to make resolutions and to abide by them, have an external, social provenance.

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Putting the pieces together: Self-control as a complex interaction of psychological processes

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Abstract

Ainslie's account of willpower addresses many important mechanisms (e.g., habit, visceral activation, and implementation intention). We argue that a model of willpower should be grounded in general psychological principles and with a primary focus on their interplay. We discuss the reflective-impulsive model that covers willpower and impulsiveness as special constellations of processes that govern various forms of cognition and behavior.

Proposing a conceptual model that accounts for the dynamics of willpower and impulses, the author invokes "resolution" and "suppression" as central means and attempts to provide a deeper understanding of basic behavioral conflicts by integrating elements from both psychology and behavioral economics. In this endeavor, the author lists some mechanisms (e.g., habit, visceral activation, and implementation intention) as part of an economically oriented approach that emphasizes a bargaining between SS (smaller, sooner) and LL (larger, later) outcomes. Although we agree on the importance of the described mechanisms and phenomena, we here argue that a better understanding of willpower requires to be firmly grounded in theories about the psychological underpinnings.

Such efforts have been made by dual process theories (Sherman, Gawronski, & Trope, 2014) in psychology that describe the interplay of different psychological mechanisms in the generation of judgment and behavior. Crucially, in such models, temptation and self-regulation are special constellations of processes that govern all sorts of cognition and behavior. One such attempt is the reflective-impulsive model (RIM; Deutsch & Strack, 2020; Strack & Deutsch, 2004). The RIM contributes to the current discussion as it (a) conceptualizes behavior to be generated by the interplay of two groups of psychological processes (i.e., systems of processes), and (b) explains many phenomena laid out in the target article as a function of this interplay.

The impulsive system (IS) influences behaviors through the activation of associative clusters that have previously been created by spatial or temporal coactivation. In addition, emotional experiences change the activation of emotion-specific or more general (i.e., approach/avoidance) associative clusters, thereby rendering compatible behaviors more likely. The IS is always active, operates effortlessly, and is thus the primary instance at which information is processed. The reflective system (RS), in contrast, is made up of a cluster of processes that operate on top of the IS. It functions by syllogistic principles and complements the operation of its impulsive counterpart by goal pursuit and strategic action plans. The RS is more resource dependent than the IS, such that some situations compromise the operation of the RS more than that of the IS.

Given that low control resources tend to interfere with the RS, tasks need to meet a certain threshold of intensity and attention to surpass the IS and enter the RS for further processing. Applying this to the resolve-suppression model reveals that whether a resolve process occurs is likely to be tied to individuals' perceived stakes associated with a given task, as well as potential extraneous factors (e.g., distractions) affecting the cognitive capacity available to the individual.

Although the two systems support one another if their behavioral implications are compatible, conflicts may arise if the RS generates action plans that are incompatible with the behavioral tendencies triggered by the IS (e.g., sight of food activates eating schema whereas the RS is executing a decision to stop eating). These are the conflicts described in the target paper. But instead of proposing mechanisms that are specific for this situation, the RIM invokes universal principles used to explain behavioral execution under normal circumstances.

One is the degree to which the RS lacks the resources to operate and counteract incompatible influences from the IS. This is the case if distractions, exhaustions, or sedating substances affect processing. In contrast, the IS is strengthened by strongly linked associative patterns and intense emotions. Importantly, the interaction between the two systems predicts that the mere negation ("Just say no!") of an impulsive behavior may generate undesired effects by activating specific affirmative cues that may cause the opposite behavior to occur. As a consequence, the RIM implies that guiding behavior through activating desired options is more efficient than guiding it through negating or suppressing undesired options.

Moreover, the RIM touches upon another relevant aspect presented in the target article, namely, the time dimension in the conflict between action plans generated in the RS and behavioral tendencies elicited by the IS. Because the RS is independent from immediate perceptual input, it can assume a time perspective and bridge temporal gaps and thus increase the impact of future outcomes relative to immediate rewards. This becomes relevant when contextual changes require a modification of the long-term decision-making strategy. In this context, initial changes in choice patterns are likely to necessitate processing in the RS to enable a long-term sustainable habit through resolve processes as predicted in the resolve-suppression model. Although this seems promising, it presupposes that sufficient control resources are available in a given moment and context.

Most important, the RIM allows deriving predictions for self-regulatory situations (Hofmann, Friese, & Strack, 2009) that are based on the dynamics of the interaction between the two systems. The innovative contribution of the RIM becomes particularly obvious when dealing with the impulsive determination of behavior and considering the extraneous and dispositional factors allocating the process preceding a behavior to one of these systems. This is relevant, when the behavioral tendencies predicted by these two models are not compatible, as is the case in the situations presented in the target article.

These parameters also afford interventions that may imply important improvements of people's health and well-being (Deutsch & Strack, 2020). One example is the treatment of alcoholic patients for whom strengthening their resolutions to stay

away from alcoholic beverages is not sufficient to effectively treat their addiction. Partly based on the implications of the RIM, patients' impulsive approach tendencies toward such drinks have been successfully retrained as part of clinical therapy (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011).

In summary, we argue that a conceptual approach based on the regular interplay of reflective and impulsive mechanisms will provide an integrative and coherent framework of human behavior in which conflicts between opposing behavioral tendencies can be accounted for. Moreover, such an approach affords empirical tests and applied interventions that speak to its usefulness.

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Self-organization of power at will

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Abstract

We challenge and extend Ainslie's top-down view of willpower as a dual function, resolve and suppression. Instead, we propose an alternative self-organizational view of the motivational system as a network of urges, incentives, drives, and so on that interact dynamically. With such a view, resolve, suppression, and other functions emerge under certain environmental and social conditions for certain personality profiles.

George Ainslie embraces the traditional view that willpower is the psychological function that resists temptations, such as impulses and addictions. This view relies on a confrontation between positive and negative behaviors or actions, with willpower dragging the individual away from negative behaviors. Thus, willpower is viewed as persistence and focusing of attention to beneficial behaviors against distraction from harmful behaviors. But semantics left aside and regarding involved mechanisms, there is nothing structural or syntactic that makes persistence to positive behaviors different from persistence to negative ones. Even more disturbing appears the fact that, unlike momentary impulse, addiction is a form of persistence as well. Additionally, we can imagine many otherwise noble and, in principle, benign behaviors that we can call addictions, if we dare: addiction to reading, to playing music, to socializing, and so on. Willpower is, therefore, at its root an instantiation of the generic ability of an individual to persist despite opposites, as is addiction. The timeline of the presence of opposites is in reality irrelevant, whether momentary (e.g., distraction), periodic (e.g., interference), constant (e.g., a static external environment), or irregular or anything else.

Within this broader dialectic perspective, a large set of possible actions and behaviors may interact, compete, and give rise in a bottom-up manner to a range of emergent phenomena such as routines, intermittent behaviors, oscillatory or hesitant patterns, persistent habits, and so on. This is then the basis of complex self-organization because each behavioral candidate struggles for excellence, often to the detriment of others. Self-organization is well-established at the neurocomputational level (Cisek & Kalaska, 2010; Doya, 2008; Kelso, 1995; Prescott, Bryson, & Seth, 2007) but here we abstract it at the subsymbolic level (Hurley, 2007) (and even a dual system counts; Berridge, 2009), loosely in a neo-behaviorist ecological view (Ross, Sharp, Vuchinich, & Spurrett, 2008). We also use the term behavioral candidate as an umbrella term to regroup all motivational and/or emotional components that participate in behavioral expression and development. Where do these candidates come from? Some may be innate and intrinsic, such as some urges, incentives, and desires. Some others may be socially or culturally imitated, taught, or learnt, such as ambitions and morals. Finally, there are contingencies of all sorts. A richer environment presents to the individual more candidates and thus more chances for internalization or for conflict, selecting or rejecting in passing some of the intrinsic or social motivations and shaping the relevant rewards. It is no surprise that more willpower is necessary in our modern urban environment that is both overcrowded with stimuli and extremely as well as irreversibly fast-changing.

Back to the traditional view. Willpower is tacitly situated at a higher level than the temptations that need to be controlled. This is right and fortunate and no different than in the self-organizational view. In reality, the distributed interaction between behaviors, desires, drives, and the like depends on a set of organizational parameters, such as rates (e.g., rates of desire decay), thresholds (e.g., switching thresholds between preferences), and delays (e.g., abandonment period for unsuccessful habits). These parameters are largely independent of the behavioral components involved but not unrelated with one another. Rather they show systematicities and internal consistency. This is what corresponds to a character or personality profile that constrains and channels activity without fully predicting future behavior. For example, consistently short reaction delays to a larger range of stimuli are often correlated with anxiety and are not pathological *per se*. Despite carrying an initial exploratory advantage in times of social stress when innovations are necessary, such an individual is expected to need more willpower to resist distractions in regular times, unlike a calm and diffident conformist.

Moreover, it is imaginable that some intrinsic or developed urges are not about doing anything in the real world but are indeed about spying, interfering with and controlling other internal desires, therefore meta-urges. For example, one may take personal intrinsic pride, thus a form of reward, in modulating expression of anger and even anger itself. Any behavioral

component in the system may have multiple such internal dependencies and influences, sometimes amplifying one another, sometimes canceling out each other. It is reasonable to assume that all of the above personality dimensions are continuously shaped in the joint external/internal environment and co-adapt and develop accordingly. Pertinent questions about such behavioral development are predominantly whether a higher-order urge can develop *de novo* and whether an abstract urge can develop from concrete ones (it is less demanding to be able to suppress something than to be able to suppress anything). We can be fairly confident in answering positively to both questions because these phenomena pertain to various forms of learning (instrumental, generalization, and so on). This also answers positively another emerging question, whether higher-level monitoring and controlling urges can be learnt through adequate stimulation. Positive functions such as suppression and resolve are possible within this configuration, but they are not the only ones. For example, behavioral replacement in a rich or merely different environment is also a possibility. This can be gesturally homomorphic, such as vaping instead of smoking, or arbitrary behavioral replacement, such as painting instead of smoking. Negative phenomena are also possible, such as obsession when no replacement or suppression works.

Depending on the nexus of personal, social, cultural, and contextual factors present at the time, the behavioral trajectory may naturally veer toward or away from positive or negative attractors, that is, with minimal effort. Substantial and probably conscious effort might be necessary to revert to the other direction, whichever this is. It is perfectly possible to abandon effortlessly a malignant habit, for example, thanks to the appearance of a significant other, and to have a hard time sticking to a desired creative behavior, for example, because of social constraints. The conscious nature of some of these activities is reflected in the perceived effort it takes to engage in them, itself also an outcome of self-organization.

What appear ultimately as powers or weaknesses are emergent phenomena in a self-organized motivational/emotional system that feeds itself on the wealth and the contingencies of complex internal and external interactions and that is in constant motion. Our battles are lifelong.

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Evolving resolve

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Abstract

The broad spectrum revolution brought greater dependence on skill and knowledge, and more demanding, often social, choices. We adopt Sterelny's account of how cooperative foraging paid the costs associated with longer dependency, and transformed the problem of skill learning. Scaffolded learning can facilitate cognitive control including suppression, whereas scaffolded exchange and trade, including inter-temporal exchange, can help develop resolve.

The Neolithic Revolution (the transition from hunter-gatherer lifestyle to agriculture) was preceded by the "Broad Spectrum Revolution" in the Upper Palaeolithic (Flannery, 1969). This saw increasing reliance on a wider variety of food sources, including ones requiring skilled processing and more sophisticated technology (Stiner, 2001). Broad spectrum hunting and gathering required skills and knowledge that no lone individual could have accumulated from scratch, and which varied quickly enough to outpace genetic selection.

We adopt Sterelny's (2012) argument that expansion in hominin expertise and reliance on technology was driven by feedback loops linking co-operative foraging, learning, and transformation of the environment. Learning broad-spectrum foraging is time-consuming and expensive, but cooperative foraging provides enough surplus to support itself. Culturally transmitted skill learning is facilitated by a transformation of the learning environment, in addition – eventually – to master–apprentice relationships. This framework can be put to work addressing the evolution of suppression and resolve, complementing Ainslie's suggestions in the target article.

Ainslie correctly notes that the evolution of the influence of future expectations on current preference is itself a resource for sophisticated tool use and other distinctive hominin practices. Advanced tool making, tool use, food preservation and storage, exploitation of food requiring processing, and group hunting require foresight and often demand extended current effort with high costs and delayed returns. Acquiring the skills for broad spectrum life takes time, perhaps many years, before an individual generates a surplus (King, 1991). Hominin life, that is, depends on extended and repeated intergenerational transfer of support and skill.

Execution of a skill like stone knapping depends on socially acquired cognitive control models (Christensen, Sutton, & McIlwain, 2016; Hiscock, 2014; Shipton, 2010). These involve hierarchically and temporally organized goals, and their application demands attention management. Sterelny (2012) argues that small motivational changes, including increased tolerance for unrelated young watching and imitating, and increased interest in adult activities by the young, can improve the fidelity of trial and error learning. Without tolerance, interest in adults is

punished. With it, it is rewarded. He also stresses how the acquisition of expertise can be supported by the learning environment. For example, learning tool making is facilitated by having the stages from material selection performed openly, with samples from the stages of manufacture available for inspection, play, and imitation.

Maintaining focus on task goals and sub-goals in the face of distractions and incomplete recall demands what Ainslie calls suppression. This challenge is reduced when the environment provides scaffolding in the form of models and reminders of goals, sequencing, and methods. Supervision helps even more. Years of experience might be needed before achieving relative independence from those props. Developing individual skill at suppression, that is, needn't be an unaided individual achievement. Co-operative foraging can both scaffold learning it, and pay for the time it takes.

Increasing intra-group specialization, a wider variety of foraging targets and a larger portfolio of tools and technology brings increasing reliance on exchange across more and varying modalities organized over much longer time-scales for hominins than other animals. Tools and other artefacts, shares of hunts and processed vegetables, child-care, protection, and much more had to be allocated and sometimes exchanged. Those who made exchanges that were too inconsistent with their longer run interests would have done badly.

Economists since Smith (1776) have favoured the idea that money arose to address inefficiencies in barter-based systems of simultaneous exchange, making delayed repayment possible. This myth is rejected by all available evidence. In societies without token money barter is either absent, restricted, or occurs between non-relatives and whole groups, and exchange, including gift, involving credit and later repayment is ubiquitous within groups (Chapman, 1980; Graeber, 2011). Much later, token money appears to have transformed practices of valuation and exchange, but this won't illuminate Palaeolithic agency.

Features of later societies provide clues. Morgan (1851) explained how surplus in Iroquois nations was stored in longhouses, and distribution handled by councils of women. Meggitt (1971) detailed a conventional hierarchy of gift-types specifying acceptable reciprocation (a stone axe could discharge a debt of a pork side, but not a whole pig), and Lévi-Strauss (1969) how rules among the Tsonga specified the division of a whole ox among a group of relatives receiving one (front leg to elder brother, hind leg to younger, and so forth). Kahn (1986) documents an inter-temporal mechanism among the Wamira: A gift of a female pig obliged repayment with that very pig's female offspring, and required shouting at the time of transfer to specify whether debt was being created or settled. Loud complaining about disappointing reciprocation is widely documented (e.g., Marlowe, 2010). Between-group barter often involved conventions, such as that one cow was worth 50 baskets of rice among the Naga of India (Einzig, 1949). Such socially stabilized practices simplify exchanges by constraining the options and crowd-sourcing the burden of tracking obligations, including delayed ones.

Exchanging and sharing in the open would also provide opportunities for learning, and allow for stabilizing input from others, including reminders of delayed consequences. Apprentice learning, when it took off, likely involved supervision in exchange along with execution and assessment of quality. Even without supervision proper, seniors ridiculing or approving a nascent exchange could provide learning signals and scaffold consistency. Gossip, when available, could distribute recognition of the easily exploitable or notably astute. Repeated and open inter-temporal bargaining and cooperation among group members can thus increase consistency and scaffold precursors to resolve. Similar to stone-knapping which develops in a cognitive niche including successful practitioners and their products, resolve can begin socially in a shared consumption scheduling niche. Here too, the surplus generated by mature members is crucial. No hominin could acquire the skill for cooperative foraging without the surplus and learning environment generated by a group succeeding at it. The skill of temporally organized choice called resolve is arguably no different.

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Author's Response

Reply to commentaries to willpower with and without effort

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Abstract

Twenty-six commentators from several disciplines have written on the assumption that choice is determined by comparative

valuation in a common denominator of reward, the "competitive marketplace." There was no apparent disagreement that prospective rewards are discounted hyperbolically, although some found that the resulting predictions could come just as well from other models, including the interpretation of delay as risk and analysis in terms of hot versus cold valuation systems. Several novel ideas emerged.

R1. Self as a marketplace

No commentator seems to have a problem with my basic assumption, that (all) choice is determined by comparative valuation in a common denominator of reward, which I refer to as the competitive marketplace. There is similarly no apparent disagreement that prospective rewards are discounted hyperbolically, although some find that the resulting predictions can come just as well from other models – **Hofmeyr**, **Nordli & Hirt**, and **Ross** – if not better – **Heyman**. Proposals to modify "traditional hyperbolic discounting models" (Nordli & Hirt) include subjects' cumulative valuation by drift diffusion (in the target article, sects. 2.1, 3.1.1, but also in **Huang** and **Harris**); incorporation of or even replacement by valuation of risk (Ross, Hofmeyr); and modification – or overriding – of delay discounting by the arousal of appetite/emotion (**Monterosso**, **Metcalfe & Jacobs**, Nordli & Hirt, **Strack, Deutsch, and Abraham** [**Strack et al.**], and probably Heyman).

Huang proposes a marketplace model, or "society of controllers," although he does not say how the controllers are determined. His controllers sound like my *interests*, which are learned processes named for the rewards on which they were based. He similarly proposes that they form a population, and compete for acceptance in a drift diffusion model where their expected rewards build to a threshold. **Tzafestas** similarly uses a bottom-up "self-organizational" model in which "higher-order" and abstract "urges can develop *de novo*." Her approach is compatible with drift diffusion, but she does not mention it. I don't understand why she interprets my model as top-down – long-term interests exert power to the extent that they bid early enough or are combined enough to prevail in a competitive marketplace. **Harris** simply incorporates drift diffusion, which I agree is a straightforward addition to our knowledge of choice.

R2. Risk

The uncertainty of expected outcomes puts another variable in the marketplace (**Ross, Hofmeyr**), but this does not necessarily change the delay factor. Ross is partially right that I take time preference as a primitive, in that a monotonic effect of delay on preference is widely measured in both humans and nonhumans, and fades in human subjects only in situations that invite reflection, if not resolve. He stops short of saying that delay discounting is actually one form of risk assessment, but seems to argue that it can't be isolated experimentally. But repeated animal trials with differential delays of seconds show hyperbolic delay discounting, as do human self-reports about sure hypothetical rewards – which match their preferences for actual rewards (Johnson & Bickel, 2002). Hofmeyr, at one point, rejects equating risk with delay, but again seems to argue that the dimension of delay can't be factored out, even in the laboratory, because a curved utility function blunts the ostensible size of a larger reward. But that would not produce preference reversal, which he argues would take place when the earlier of two risky rewards came closer. His narrative example introduces hyperbolic, or at least hyper-concave, discounting of risk by the back door. The same assumption is necessary for Ross' assertion that animals' apparent delay discounting "can equally be modeled as responses to uncertainty." I am puzzled, especially because both Ross and Hofmeyr are co-authors of a recent experimental report in which risk is differentiated from delay (Harrison, Hofmeyr, Ross, & Swarthout, 2018). That delay discounting evolved as a proxy for risk assessment is a plausible just-so story, but so is the hypothesis that delay discounting is necessary to prevent information overload, and the Weber–Fechner law provided a workable mechanism off the shelf (Gibbon, 1977).

Humans modify valuation of risk as well as of delay from presumably inborn elementary (primitive) calculations. We sometimes work around this endowment for hedonic purposes, for instance in savoring. In the most interesting examples, people sometimes come to value risk positively as a means of refreshing appetite, which we often can't acknowledge lest we undermine resolve (Ainslie, 2003, 2013a; see my response to **Bieleke & Wolff**).

R3. Arousal

Monterosso points out that delayed options must be evaluated from the viewpoint of various successive present moments, making resolve vulnerable to "state-based inconsistency –" the arousal of appetites or emotions. Although we remember rewards with the appetite for them factored in, as when we pack a lunch for a hike – Even satiated rats will learn a maze when hunger is turned on at the food cup by hypothalamic stimulation (Mendelsohn & Chorover, 1965) – current appetite is well known to make the prospect of a reward more effective. What is now being discovered is that an aroused appetite can increase the temptation for apparently unrelated rewards as well, for instance sexual arousal increasing impatience for money (Van den Bergh, Dewitte, & Warlop, 2008). That is, arousal may affect a general valuation level, a tide that raises all boats.

Some psychiatric conditions seriously change the value of delayed options in general. Deeply depressed patients sometimes say that they believe they will get better but can't *imagine* that happening, and so are not deterred from suicide. Conversely, someone while manic may find many imminent prospects so rewarding that no delayed contingency can compete with them. The extreme case is **Monterosso**'s Jeckyll and Hyde, rare real-life examples of whom exist (Putnam, 1989). I have seen a patient show great anxiety before she switched to a dissociated alter ego, but without being able to describe the prospect. Her intertemporal bargain may have been to accede in turn-taking by two complete, incompatible sets of motives, just as habitually inhibited binge drinkers sometimes dissociate to let "the alcohol do the talking."

The apparent specialization of brain regions in generating visceral and non-visceral motives has led many writers to advocate a bicameral decision-making process, where fast/model-free/Pavlovian/hot/impulsive systems make decisions that conflict with those of slow/model-based/instrumental/cool/reflective systems. It is easy to overstate both the internal coherence and the functional independence of these two "systems."

Model-free or Pavlovian processes are past sequences of cues and actions that have been cached as units in memory. Although they arise irrepressibly (as demonstrated in the famous Stroop task), they also serve as macros to speed choice under familiar conditions. The brain networks that have been identified as serving model-based and model-free choice have now been found to interact intimately in real time (Dixon & Christoff, 2014; Dolan &

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Dayan, 2013). **Dayan** describes pragmatic collaboration of the two modes (more in Keramati et al., 2016, that he cites). These "internal actions" are called upon in the same way as external actions, that is, in the marketplace of reward (an example of **Bermúdez**'s choice among tactics). Where they do not reach a response threshold immediately, they will be part of the person's vicarious trial and error (*preplay* in Dayan's terms; see Schacter et al., 2017, cited by **Bulley & Schacter**; Redish, 2016) just as new plans are. Importantly, there is no reason that a person's use of model-free thinking should affect arousal of appetite or emotion *per se*. Model-free thinking is fast but not necessarily hot.

R4. Hot systems

Unlike model-free valuation, visceral factors intrinsically affect intertemporal bargaining. Three commentaries propose that they are the basis even of separate choice-making systems.

Hot thinking refers to the increased value of smaller, sooner (SS) rewards because of aroused appetite/emotion. Although this increase may make an SS reward more likely to overcome resolve, as **Metcalfe & Jacobs** point out, it does not "dissolve" resolve as they assert. They would have only the unaroused, cool "system" making – and presumably enforcing – resolutions, but the marathon runners and firefighters they cite are undoubtedly relying on resolve specifically to keep performing despite fatigue and danger. This could be said to be the main function of resolve – to push routines forward in the face of urges to abandon them. Processes that tie up cognitive capacity undoubtedly reduce the precision of intertemporal bargaining, as suggested by the Eich and Metcalfe (2009) and Metcalfe et al. (2019) reports they cite, but do not disable it.

Strack et al. speak of the reflective system generating "action plans that are incompatible with the behavioral tendencies triggered by the impulsive system," but these authors also suggest some more upstream interaction, as the reflective system "rides on top of" the impulsive. Similarly, **Nordli & Hirt** adopt the model of two competing brain systems, subcortical and cortical, that are separately sensitive to immediate and delayed rewards. However, although it is sometimes possible to identify input from particular brain areas in arousal of appetite/emotion, this influence does not necessarily constitute a separate valuation system. The exact shape of delay discounting remains controversial (Wulff & van den Bos, 2018): The dual discounting model of Van den Bos and McClure (cited) is contradicted by direct functional magnetic resonance imaging (fMRI) measurement of valuation, which shows no division between value-tracking of immediate and delayed rewards (Kable & Glimcher, 2007). However, if a separate hot system exists, its influence must still be exerted through the common marketplace. The controversy about dualism is ultimately just over how far downstream in the choice process different rewards are compared.

It seems inevitable that interests with different payoff delays repeatedly get grouped as two different kinds, beginning with Plato's wild versus well-behaved chariot horses – sinful versus good, passionate versus reasonable, impulsive versus reflective (for instance **Strack et al.**), hot versus cool (for instance, **Metcalfe & Jacobs**), subcortical versus cortical (for instance, **Nordli & Hirt**). Some motivational mechanisms do serve longer term interests better than others do. However, the defining characteristic of each of these factors is its intertemporal bargaining position, and hence its strategies (in Nordli & Hirt's term). In any pairing, the longer term interest tries to forestall the shorter term interest, and the shorter term interest tries to evade this constraint. Importantly, an interest may be long term with respect to another interest, but short term with respect to still another. I've previously used the example of an ill-advised practical joke which, as an impulse, must fight off wiser choices, but must in turn act as a controller of urges so as not to spring the joke prematurely (among other examples in Ainslie, 2009). **Heyman** points out that addictions are best seen as belonging to a middle category, impulsive with regard to a person's lifestyle aspirations, but supporting rational planning to protect the addiction. Of course for a time an addict may simply prefer "the most intense nothingness there ever was," but having turned against it in her long-term view she may still accept failure to quit for quite a while, lest she suffer from futile attempts (see target article, sect. 3.2.1). In a more everyday example, most smokers say they want to quit, but accept the bad habit after wasting repeated efforts to do so. My point here is that such middling kinds of behavior do not dance back and forth between inhabiting hot and cool, or fast and slow, "systems." Rather, the agent's strategy simply alternates between running with the fox and hunting with the hounds. It is between these stances that the true dichotomy lies.

Heyman also mentions my favorite example of an addictive "habit" changing instantly on the basis of different framing (Premack, 1970). This kind of example shows that membership in a category is the key to good versus bad "habits." Heyman seems to think I doubt this, but what I say in the target article is that the motivation provided by belonging to a category has to be defended by seeing individual choices as test cases.

R5. Methods of impulse control

Gross and Duckworth's *self-control* is less specific than *willpower*, as they mean it to encompass all "self-initiated regulation" of impulses. Their "situation selection" and "situation modification" are upstream actions, as **Kristal & Zlatev** point out, whereas I have been talking about only downstream actions, the hard case: "the process of overcoming a seemingly superior, currently available SS reward," simultaneously with the impulse (sect. 3). Even distinguishing *internal self-control* would not do, because this includes mental precommitting tactics such as manipulation of attention and preparation of emotion (Ainslie, 2001, pp. 76–78). The latter two tactics are also part of the suppression that occurs simultaneously with an impulse, but only in that case is the motivation for them puzzling: I have argued that impulses are defined by being temporarily *more* valued than alternatives that pay off in the longer term, and the problem for the long-term alternatives – and for motivational theory – is how to avoid ceding control to them. In the case of suppression, **Huang**'s proposal of a hyperdirect striatal-cortical pathway that prolongs the opportunity for suppression may be relevant.

Nordli & Hirt give examples where "it is not clear that some self-control behaviors are strictly one type or the other." They and **Bermúdez** raise the question of how a person chooses a method of self-control. There are certainly choices to be made, but underneath them is a baseline of management that does not depend on deliberate action. Suppression is probably *always* operating to some extent. It starts with the ordinary process of maintaining intentions – of fetching objects and solving puzzles and making a sandwich – and becomes remarkable only when temptations raise obstacles to an intention without (yet) overturning it. Suppression may then grow to be an absorbing activity and show up in prefrontal cortical activity. As **Huang** points out, it can be directed by resolve. It does not apparently become more

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effective with practice (Xu et al., 2014). However, **Harris**'s work suggests that sequentially paying attention to particular reward attributes may be a learnable form of suppression, and even of an eyes-on-the-prize *converse* of suppression.

Resolve does require some self-awareness, but there is probably no adult who does not sometimes ask – or sense – the question, "if not now, when," or "am I going to go on doing this?" without stopping to frame a resolution. However, there is considerable scope for learning to make resolve both more effective and more efficient – more effective by increasing the perceived contingency of valued outcomes on a current choice, more efficient in avoiding resolutions that are either overly restrictive or unlikely to succeed.

Maglio & Hershfield are right that intertemporal bargaining can't be a classical iterative prisoner's dilemma, because a future self can't literally retaliate against past incarnations. They suggest a dictator game, but depicting the responder as a monolithic "cumulative future self" obscures the dynamic process, imagination of which guides the present chooser. In my proof-of-concept game, a roomful of people successively chose a dollar just for oneself or ten cents added to everyone's individual total, making the cooperative, 10 cent choice adaptive if and only if the player expected similar moves by future players (Ainslie, 2001, p. 93). The fact that the players were separate people rather than prospective selves separated by discounted delays did not change the logic of the contingencies they faced.

R6. Resolve versus suppression and precommitment

The self-help profession has been critical of the venerable *willpower* because many clients have been demoralized by fruitless attempts at "internal brute force" (**Kristal & Zlatev**) or **Harris**'s "effortful moment-to-moment inhibition," but these are not its most effective form, as I have argued. The form of willpower that has been found "least effective" (Kristal & Zlatev) is the kind so often experimented with, suppression, as in the Fujita et al., article they cite ("effortful inhibition"). Similarly, **Inzlicht & Friese** say that the high "trait conscientiousness" people who are "the best at meeting their goals" have done so not by willpower but by "routinization of goal-directed behaviors and cultivation of good habits," which, I have just argued, is the outcome of successful resolve.

Lea surveys applications of resolve in real-world financial decisions, and **Acquaro & Sosis** in recovery from alcoholism. **Khalil** insists that "the term 'willpower' cannot be a scientific concept, that is, a concept that captures the different inner coherence of 'resolve' and 'suppression'" – and, incidentally, that "resolve" denotes only higher aspirations, but he does not suggest better terms.

This is not to deny the importance of preparing in advance to face impulses (**Gross & Duckworth**, **Kristal & Zlatev**, **Inzlicht & Friese**) or the stressors that predispose to impulses (**Dubljević & Neupert**). However, impulses mostly arise from the ordinary pleasures of life – to have an extra helping, to take a break from work, to take sex play a bit further. Just starting to think about them is pleasurable. The choice to give such impulses a wider berth is not a neutral cognition but entails a loss of this pleasure. Entertainment of a risky appetite or emotion is what the Catholic church calls a venial sin, and when its avoidance isn't early enough to be accomplished by mere intention it will also require resolve. By the same token, skill at resolve lets you steer closer to danger. For instance, limited sex play is an exercise in resolve that depends on discernment of bright lines, cues that demarcate flirting and seduction, safe and unsafe sex, and teenagers' famous bases, as in "only got to first base."

Whether boredom is a distinct emotional state, as **Bieleke & Wolff** propose, or just an awareness of being stuck in an unrewarding activity, is apt to be a matter of some debate. Either way, they point out that its frequent occurrence during long-term goal pursuit highlights the "exclusive focus on prediction error minimization" in reward learning theory – and utility theory generally – that fails to recognize the role of appetite in maintaining reward effectiveness. This is an important point for welfare planners. I have argued elsewhere that much seeming inefficiency in the modern world comes from *indirection*, the maintenance of unnecessarily challenging goals in order to refresh appetite (Ainslie, 2013b).

The choice among mixed goal options as discussed by **Mayer & Freund** is probably the usual case, because long-term resolve will be frequently threatened by boredom, and it needs to budget subsidiary goals or harmless pastimes to stay dominant. Future prospects must compete with current comfort, and at a substantial discount. The sort of deal the authors suggest may well be effective, as long as its budgetary numbers hold up – The choice to defer a goal may be rewarding in the short term as it reduces pressure on resources, but might also be seen as a failed test case.

Practice at resolve inevitably entails failures, where you learn its limits, its routes to recovery, and how to hedge it with rationalizations and evade it by inattention to its tests. For impulses that are too strong and/or dangerous to allow failures, for instance in recovery from alcoholism, intertemporal bargaining is still called for, as in **Acquaro & Sosis**'s "playing the tape through." But the stake that this exercise demonstrates is Alcoholics Anonymous' "helplessness" against alcohol, that is, sobriety that is wholly vulnerable to any drink, with none of resolve's usual arbitrage permitted (see "atomic bargaining" in Ainslie, 2001, pp. 113–116). Of course, advance preparation still helps – Alcoholics Anonymous' avoidance of "persons, places, and things."

Khalil interprets how I distinguish suppression and resolve as a matter of effort. I do not present it as a defining feature, only a measure of operational cost, which may be as high in a contested resolution as in sustained suppression. **Massin & Gauchot** say resolve is always effortful, but they maintain that "cognitive abstraction processes always have operational costs," even though in terms of either processing time or unpleasant experience these are often trivial. These authors also say we must stop referring to the defense of a resolution as resolve once it is successful, but this point of usage could be argued either way.

R7. Construction of the future

Besides the arousal of appetite/emotion, **Monterosso** points out that the other complication in figuring out the motivation for resolve is the complex basis of belief in the future. Philosopher Robert Nozick once asked why someone should care about her future selves. The answer is easy in the realm of seconds to minutes, and perhaps even hours and days – the prospect of differential reward urges us. It is probably impossible not to notice when we're about to fall into a cold lake, or even that we're facing a big exam tomorrow. More distant prospects still compete in the marketplace of reward, but their values are more subject to interpretation.

The key issue for intertemporal bargaining is what forms the stake in test cases. The most important stakes are apt to be enduring states rather than repeated LL events – freedom from the

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prospect of lung cancer, or a claim to good character – the contingency that Bodner and Prelec imagine in their game-theoretic analysis of self-prediction (2003), and that **Heyman** sees as the ultimately effective motivation in recovery from addiction. A history of successful resolve may itself come to form a major stake – confidence in your ability to keep resolutions. But the experience of empathy may also be worth examining as a repository of expected value.

Growing exploration of mental time travel, correlated with activity in the default network and other areas of the brain, suggest moderators of prospective value but do not promise to tell the whole story. **Bulley & Schacter** point out that such "episodic simulation" is probably unnecessary for "prospective cognition and deliberation." Resolve can be enforced simply by the observation that "defection sooner implies defection later" that shows up in model-based *preplay* (**Dayan**). The overuse of resolve seen in compulsiveness is a whole other topic (Ainslie, 2001, pp. 143–160), but it provides an example uncorrelated with future simulation: The rigid self-control seen in obsessive-compulsive personality disorder (OCPD) and closely correlated, autism spectrum disorder (Gadelkarim et al., 2019) occurs despite reduced episodic simulation (Crane et al., 2013), but its motivation has not been characterized.

Maglio & Hershfield explore how "the self making [future] choices remains, to the current self, a mystery." Hershfield and collaborators have elsewhere reviewed the various ways that a current self has been proposed to experience future prospects (for instance, in Hershfield & Bartels, 2018, cited), and have noted the similarity between empathy with future selves and empathy with other people which is also found in brain imaging patterns. This is evidence for the old suggestion that we model our future selves in much the way we model other people (Hazlitt, 1805/1969; Simon, 1995). The LL stake may be embodied in an imagined future self or a felt relationship with another person, real or imaginary, that will be spoiled by a defection. For instance, if you pray to Saint X for help in resisting an impulse, then give in, she may become less willing to help in the future (Ainslie, 1975).

The further we look into the future, the less our expectations will run up against our rules for realism. Increasingly, we will be writing fiction that occasions reward endogenously, constrained by what makes fiction effective, less to be believed than believed *in*. But my argument for this also another topic (Ainslie, 2017). I will just note here that although we construct the far future imaginatively, there is evidence that we still discount its value in hyperbolic curves, albeit not curves that span the time continuously (Ainslie, 2017, p. 150).

R8. Relationship of intertemporal with interpersonal bargaining

The possibility that intertemporal bargaining evolved from the interpersonal sort is intriguing (**Setman & Kelly**, **Veit & Spurrett**). Certainly the two are related, and probably inform each other. Again, the simple observation that "defection sooner implies defection later" can occur without it, as **Dayan** says. Explicit pictures of a future self that is constructed of episodic memories undoubtedly add to larger, later (LL) stakes, but they are not necessary for valuing delayed rewards.

I keep my analysis within the individual person not to belittle the overwhelming importance of social mechanisms, but to make sure we keep in mind that their physical occurrence must be in individual brains. Intertemporal and interpersonal forms of bargaining can each operate without reference to the other – respectively Robinson Crusoe rationing his seed grain, and primitive tribes leaving out goods for serial, contactless barter. However, I have suggested one area where the intertemporal kind may have informed the interpersonal: Philosophers puzzle over how people who believe in strict determinism can assign moral responsibility, but we may be just broadening our natural perception of self-blame in cases of failed resolve to interpret analogous interpersonal situations (Ainslie, 2011). This is the converse – and perhaps complement – of philosopher Peter Strawson's argument that individual's sense of responsibility comes from her experience in a moral community (1974). **Setman & Kelly** propose that direction of evolution – internal bargaining copying social – which is certainly plausible.

R9. Brain imaging

I would like to think that increasing resolution in imaging of the vast core network will let us follow the conduct of resolve in real time (**Bulley & Schacter**). However, because resolve as I have proposed it consists of belief in a contingency (of future reward on a current choice), it is hard to picture the experimental design that would create a differential amount of brain activity directly. I made a suggestion in the target article: The best hope is probably to track resolve by a reduced use of suppression, as evidenced by a reduction in dorsolateral frontal cortex activity.

R10. Reply conclusions

Commentators brought out several important issues with willpower. First of all, the term itself looks condemned to be tarred with the implication of "internal brute force," so it may be necessary for clarity to speak about intertemporal bargaining in so many words, or simply as resolve. Limitations of its LL stakes will be a rich field for research: State-based inconsistency can come both from the arousal of appetite or emotion and, in the extreme, from the dissociation of ego states, but probably not from dissociation of fast versus slow or hot versus cool motivational processes. Even less known is what constrains imagination of the future in creating LL stakes.

Several speculations are worth following up: The recent finding that bidding for action is not a single event but diffused among reward components suggests opportunities for temporarily less favored options to compete by instituting suppression, for instance by a hyperdirect striatal-cortical pathway that raises the decision threshold in the presence of conflict (**Huang**). **Harris** brings up a learnable route to more effective suppression: to sequentially focus attention on different reward attributes. **Bieleke & Wolff** raise the likelihood that reward effectiveness depends on more than prediction error minimization, which I would relate to the cultivation of appetite. Evolutionary questions include, biologically, the possible shaping effect of risk on delay discounting (**Ross**, **Hofmeyr**), and culturally, the possible learning of intertemporal bargaining from the interpersonal (**Setman & Kelly**, **Veit & Spurrett**).

This was a wide-ranging discussion of reward, which I found highly rewarding.

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