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Beyond Description and Deficits: How Computational Psychiatry Can Enhance an Understanding of Decision-Making in Anorexia Nervosa

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Abstract

Purpose of Review—Despite decades of research, knowledge of the mechanisms maintaining anorexia nervosa (AN) remains incomplete and clearly effective treatments elusive. Novel theoretical frameworks are needed to advance mechanistic and treatment research for this disorder. Here, we argue the utility of engaging a novel lens that differs from existing perspectives in psychiatry. Specifically, we argue the necessity of expanding beyond two historically common perspectives: (1) the *descriptive perspective*: the tendency to define mechanisms on the basis of surface characteristics and (2) the *deficit perspective*: the tendency to search for mechanisms associated with *under*-functioning of decision-making abilities and related circuity, rather than problems of *over*-functioning, in psychiatric disorders.

Recent Findings—Computational psychiatry can provide a novel framework for understanding AN because this approach emphasizes the role of computational misalignments (rather than absolute deficits or excesses) between decision-making strategies and environmental demands as the key factors promoting psychiatric illnesses. Informed by this approach, we argue that AN can be understood as a disorder of excess goal pursuit, maintained by over-engagement, rather than disengagement, of executive functioning strategies and circuits. Emerging evidence suggests that this same computational imbalance may constitute an under-investigated phenotype presenting transdiagnostically across psychiatric disorders.

Summary—A variety of computational models can be used to further elucidate excess goal pursuit in AN. Most traditional psychiatric treatments do not target excess goal pursuit or

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associated neurocognitive mechanisms. Thus, targeting at the level of computational dysfunction may provide a new avenue for enhancing treatment for AN and related disorders.

Keywords

Computational psychiatry; Eating disorder; Anorexia nervosa; Goal pursuit; Executive functioning; Decision-making

Introduction

Anorexia nervosa (AN) is a poorly understood illness that is associated with a host of serious physiological and psychological outcomes [1, 2]. AN has one of the highest mortality rates of any psychiatric illness [3]. Despite a proliferation of mechanistic models [4•], treatment for AN is extremely limited [5] and has not improved in the last 50 years [6].

A major limitation to developing effective treatments for AN is an incomplete comprehension about the basic mechanisms underlying this disorder [7••]. Especially puzzling is how individuals with AN engage in such unrelenting pursuit of weight loss. Most individuals at some point attempt to alter their diet and/or activity levels to impact their weight [8]. In many cases, weight management attempts for individuals without an eating disorder involve healthy behaviors (e.g., opting for vegetables over less nutritive foods, increasing moderate exercise) [9]. Even when more extreme forms of dietary restriction (e.g., fasting) are used, most people do not sustain these behaviors long-term, apply them flexibly based on context (e.g., daily life vs. vacation), or abandon them once a weight goal is met [10]. In contrast, the drive towards weight loss in AN is rigid and repetitive, persisting well beyond severe negative consequences [7••]. Individuals with AN engage in weight control even after intensive treatment [11] and while recognizing the potential for negative outcomes, including death [12]. This inability to abandon weight loss goals may reflect an altered decision-making process in AN.

In this paper, we posit that AN may be conceptualized as a disorder of excess goal pursuit. Individuals with this disorder may extend too far a set of behaviors that are socially condoned and that can be adaptive in some contexts (e.g., exercise). We further propose that progress in understanding excess goal pursuit in AN may be enhanced by employing new frameworks for approaching mechanistic questions. Finally, we suggest that computational psychiatry encompasses a novel set of scientific tools that can be used to provide fresh perspectives on psychiatric mechanisms. Not only can this approach provide further insight into AN, but it may also help us better understand an under-studied subset of other psychiatric disorders in which potentially useful actions (e.g., work, saving money) are extended too far.

The Descriptive Perspective of Psychiatry

Currently, a number of broad theoretical frameworks have been employed to identify psychiatric mechanisms. One such framework is the descriptive perspective, which involves developing theories and treatments based on symptoms or diagnoses that are presumed to reflect underlying mechanisms on the basis of face validity [13•]. Descriptive models have often been helpful in developing a foundational understanding of psychiatric mechanisms, and have yielded several helpful treatments. To provide an example from the eating disorders field, in the traditional cognitive-behavioral model of eating disorders, a facet of body image concern (i.e., overvaluation of weight and shape) is considered to be the central mechanism and focus of treatment [14]. Overvaluation of weight and shape has face validity as a factor impacting eating disorder behaviors; individuals with eating disorders typically find weight-related stimuli more salient than unaffected individuals [15•]. Further, cognitive behavioral therapy (CBT) for eating disorders, which has been developed out of this descriptive model, has a wealth of evidence supporting its efficacy [16].

However, there are also potential limitations associated with this approach. Most critically, this process often depends upon clinical judgment to determine what might be perpetuating a disorder based on its outward presentation, which can lead to unintentional biases or oversights, and limit treatment options [17]. For instance, although many individuals with eating disorders report overvaluation of weight and shape, this experience is not endorsed by all people with eating disorders [18] and is often not predictive of eating disorder risk or maintenance [19]. This may explain limitations in the ability for CBT to yield positive outcomes for all individuals with eating disorders. Approximately 25% of eating disorder patients withdraw from CBT [20] and over half do not fully respond to treatment [21]. Further, many attempts to develop treatments for AN based on descriptive validity have been met with limited success. Although AN shares significant symptom overlap with bulimia nervosa (BN) and patients frequently transition between these diagnoses [22], treatments that work reasonably well for BN (e.g., CBT, fluoxetine) have not been as successful in treating AN [5, 23].

Thus, the descriptive approach may be limited in the ability to translate treatments from disorders that have outward similarities because in some cases they may be promoted through distinct mechanistic processes. Recognizing the limitations of the descriptive approach, other psychiatric subdisciplines have moved away from treatments targeting surface qualities. In addictive disorders, for example, research has advanced through focusing on targeting treatments based on distinct decision-making concerns (e.g., valuation impairments, impulsivity, and discounting of the future) rather than specific drug of choice (e.g., alcohol versus opioid addiction) [24•, 25–27]. However, it should be noted that the addictions field similarly struggles to identify treatments with long-lasting efficacy and there are not yet sufficient data to determine whether targeting such decision-making mechanisms may enhance treatment for these disorders [28].

The Deficit Perspective of Psychiatry

A related psychiatric viewpoint is the deficit perspective. Mental health research overwhelmingly focuses on identifying under-functioning in various cognitive abilities (i.e., deficits) as contributing to a disorder. Psychiatric disorders are associated with lower functioning across life domains [29–31]. In line with descriptive psychopathology models, there is a tendency to assume that poor life outcomes arise from poor cognitive abilities. It is clear that there is much validity in this perspective. At a population level, elevated executive functioning is associated with better mental health outcomes [32]. Further, many psychiatric disorders are characterized by deficiencies in a range of higher-level decision-making abilities necessary to pursue long-term goals (e.g., planning, delay and effort tolerance, impulse inhibition) [33•, 34, 35]. As just a few examples, deficits in higher order executive functions are reflected in habitual drug-taking despite negative consequences [36], persistent avoidance in safe contexts in post-traumatic stress disorder [37, 38], and rigid negative cognitions in depression [39]. Binge-eating disorder [BED] and BN frequently have been linked with impairments in the ability to inhibit impulses in order to access future rewards [33•, 40, 41]. Under-functioning of cognitive control circuitry, including fronto-parietal, frontostriatal, and cingulate-directed circuits, has been identified across many disorders, including BN and BED, potentially mediating these impairments [42–44]. Thus, compromised functioning in cognitive domains needed for goal pursuit underlies many psychiatric disorders.

However, this perspective may lead to blind spots in examining psychiatric mechanisms. Because there is a tendency to search for executive functioning deficits, it is less common to look for areas in which individuals with psychiatric disorders show *exaggerations or excesses* in decision-making abilities typically considered positive for pursuing long-term goals. It is possible that the decision-making abilities that are typically encouraged to promote mental health can be taken too far, to the point at which they begin to impede functioning. As we highlight below, there are several lines of evidence suggesting that this process may drive the hallmark symptomatology (e.g., extreme pursuit of weight loss) of AN.

Excesses in Decision-Making and Goal Pursuit in AN

Much evidence suggests that excess goal pursuit may reflect an overarching phenotype, rather than a disorder-specific process in AN. Extensive self-report data from personality measures have identified a heightened tendency towards persistence in AN [45]. In addition to over-pursuing weight loss, individuals with AN show elevated drive towards other typically encouraged activities, such as academics [46–49] and athletics [50, 51]. It remains unclear how individuals with such a severe psychiatric disorder can engage in behaviors that require such intensive cognitive and physical resources. It may be that executive functioning excesses promote heightened goal pursuit in AN across multiple domains.

The best-known example of an exaggeration of healthy decision-making in AN pertains to delay discounting. Delay discounting paradigms require individuals to choose between smaller amounts of money available earlier (smaller-sooner choices) and larger amounts of money available later (larger-later), with the assumption that selecting more larger-later selections (i.e., shallower discounting) reflects better self-control in inhibiting immediate impulses in service of long-term gain [52]. Across several studies (although not all [53, 54]), individuals with AN demonstrate shallower discounting rates, reflecting greater selection of larger-later rewards (and, thereby, greater self-control) compared to individuals without an eating disorder [55–57] or with BN or BED [58, 59].

There is also emerging evidence that effort tolerance may be heightened in AN. Effort, the intensification of physical or mental activity towards a goal, is typically considered aversive and avoided by most organisms [60••]. However, effort persistence is also necessary for achieving long-term goals (e.g., cognitive effort is needed for learning new skills). Therefore, effort endurance is typically considered to be desirable. Most psychiatric disorders are characterized by an over-discounting of mental and physical effort (i.e., a low tolerance to endure effort), at least for rewards that are unrelated to their disorder (e.g., money) [35, 61, 62]. However, one study found that eating pathology was associated with less mental effort avoidance [63]. This finding corresponds with extensive laboratory evidence demonstrating that individuals with AN and other restrictive eating pathology will engage in extreme motor effort to access disorder-relevant rewards, such as restrictive eating and exercise [64–69].

Some research has found similarly enhanced decision-making performance in AN on other facets of executive functioning, such as planning, goal persistence and attainment, and set-shifting [70–73]. Additionally, although the neuroimaging literature is highly mixed [15•], several studies have found evidence of over-engagement of cognitive control circuitry, such as the frontoparietal circuit, in AN during decision-making [74] and symptom provocation [75, 76]. These findings may reflect a disposition for individuals with AN to over-engage in executive functioning to sustain heightened goal pursuit, even while experiencing negative physical and psychiatric symptoms [1, 2].

Reconciling Contrary Evidence on Decision-Making in AN

In contrast to the above hypothesis, other research has found individuals with AN to show deficits in decision-making similar to those found in other psychiatric disorders. Meta-analyses have identified a moderate negative relationship between a range of executive functioning abilities and AN [77, 78]. There are several ways to account for these discrepancies. First, the profound effects of starvation upon cognitive functioning are likely responsible for many of the executive functioning deficits detected in AN. Older age and lower BMI are associated with poorer executive functioning in AN [77, 78], suggesting that prolonged or severe starvation may fundamentally alter decision-making. Several studies have identified fewer executive functioning deficits in adolescent versus adult AN and in weight-restored versus acutely underweight AN [56, 79–81]. Thus, decisional processes contributing to AN may vary according to illness stage and severity, with heightened goal pursuit characterizing earlier illness stages.

Other factors may influence these discrepancies within the literature. It may be that the expectation of deficits influences publication patterns or influences interpretation. The most recent meta-analysis of executive functioning in AN found evidence of publication bias [77], indicating that papers finding decision-making deficits in AN may be more likely to be published than those with null or discrepant results. Interpretation bias may also affect the framing of decision-making results in AN. Within the same meta-analysis [77], higher education was associated with poorer set-shifting (difficulty changing focus from one task to another). Thus, it is possible that the same quality could be perceived as a deficit (poor set-shifting) or enhancement (elevated goal focus) depending on the perspective. Indeed, one review found that the characteristics encouraged in “good athletes” (e.g., asceticism, pursuit of excellence) were the same as those perpetuating AN [51]. Further, not all decision-making abilities function similarly within an individual and across contexts. It is possible to demonstrate decision-making deficits in some situations and excesses in others. For instance, in AN set-shifting deficits have been commonly identified [82], but higher order executive functioning processes (e.g., problem-solving) appear intact or enhanced [77, 78]. A strategy also could be adaptive or maladaptive depending on the problem an individual is trying to solve (Table 1). The alternative lens offered by computational psychiatry offers promising tools for addressing these issues.

Computational Psychiatry Offers a Novel Framework for Identifying Mechanisms

Computational psychiatry, which integrates theory and methods from translational and computational neuroscience into psychiatric models, offers one promising new paradigm for enhancing mechanistic and intervention science for AN [83••]. The premise of the computational approach is that psychological symptoms arise from imbalanced or inappropriate mental calculations performed by neurally-separable decision systems, which may be shared or unique across diagnostic entities [84]. Contrasting descriptive models, computational models do not assume mechanistic function by outward presentation. Instead, computational psychiatry posits that different algorithmic processes can lead to the same cognitive or behavioral manifestation. A classic example of this principle from behavioral neuroscience relates to how rats trained to run from the south to the west arm of a plus maze might use two different computational processes to obtain food from the west arm [85]. One process involves deriving a cognitive map and identifying the food location on that map, allowing the rat to plan a path from the south to the west arm. The other process involves using the simple rubric of turning left from the starting location. Both processes yield the same outcome in this starting scenario, but different outcomes when the environment changes (i.e., when starting from the north arm). Importantly, each process has advantages and disadvantages and is best suited for different situations. Deliberative, map-based planning may be well-suited to goal-pursuit within a complex and changing environment, but is unable to respond quickly when rapid action is needed (e.g., if being chased by a predator).

These concepts can extend to understanding the type of computational problems that yield psychiatric symptoms. For instance, the low mood and anhedonia that characterize depression have been associated with several different computational dysfunctions [86], including poorer learning from rewards [87, 88], enhanced sensitivity to punishing experiences [87], inability to learn from interoceptive body signals [89], and effort aversion [86, 90]. Each of these computational breakdowns likely characterizes a subset of individuals with depression. Each unique process would warrant a distinct treatment aimed at the level of decisional dysfunction, as opposed to outward symptoms. For instance, depressive symptoms associated with interoceptive imprecision would be likely to improve with interoceptive exposure [91], while symptoms resulting from low effort tolerance would not.

Computational approaches also circumvent the potential oversights that can result from the deficit perspective. From the framework of computational psychiatry, each decision strategy is presumed to serve an important function; problems only occur when these strategies are engaged inappropriately (Table 1) [83••]. For instance, many research groups have investigated the balance of model-based and model-free learning in the maintenance of psychopathology [92•]. Model-based decision-making involves acting towards an imagined future based on an internal model of the environment and the simulated consequences of different actions [93]. This is a flexible and precise decision process, but it is typically time consuming. Model-free decision-making, on the other hand, entails learning specific, arbitrary action-chains to release in certain situations, informed by past consequences. Often, under-use of the model-based system or over-use of the model-free system has been identified as a suboptimal decision strategy contributing to psychopathology [90]. Many psychiatric disorders, including the full spectrum of eating disorders, demonstrate model-based learning impairments [94–96]. However, from a computational perspective, model-free learning is not inherently negative; healthy non-human animals and humans regularly effectively engage in this strategy in situations in which the consequences of certain actions are well established (i.e., stopping at a crosswalk maintains safety) and decisional efficiency is vital (i.e., cars are speeding down the road) [92•, 97]. Extending the same logic, heightened engagement of executive functioning could at times be harmful if this strategy is a functional mismatch with the environmental demands (e.g., over-attending to future consequences when meeting immediate needs is more critical).

Towards a Computational Account of Excess Goal Pursuit in AN

We propose that psychiatric disorders may arise from computational problems resulting in “too much” in addition to “too little” goal pursuit. Highlighted in Fig. 1, we suggest that both low and high pursuit of desirable goals, supported by algorithmic misalignment between the environmental requirements and decisional approach, can lead to negative psychiatric outcomes. This misalignment may occur in over-use of several different decision processes in AN, necessitating investigation into varied computational models of weight loss in this group.

Model-Based Versus Model-free Learning Models

Noted above, one of the most common models of goal pursuit distinguishes between model-based and model-free decision processes, typically measured using a two-stage Markov task [98•]. Long-term goal pursuit is typically considered to depend on model-based processes, since these decision patterns incorporate precise information about how to best reach desired outcomes [99, 100••]. Yet, AN has frequently been hypothesized as demonstrating model-based decision-making deficits [101••]. The neural correlates of model-free decision-making (i.e., dorsal striatum activity, dorsal striatal-dorsolateral prefrontal cortex connectivity) have been implicated in restrictive food choice [102–104]; however, while some research has found evidence for generalized deficits in model-based learning across AN [95], other research has not [105].

However, a recent study identified two different computational subgroups with AN [106], one of which was characterized by greater use of model-free decision-making and the other greater model-based decision-making, supported by distinct patterns of frontostriatal engagement. Another study utilizing self-report data found greater habit strength (a measure of the outcome of model-free learning) related to restrictive eating to be associated with longer duration of illness in AN [107]. Thus, it is possible that heightened model-based decision-making may contribute to excess goal pursuit in the earlier stages of AN, but that, over time, restrictive behavior may become “habitized” and transferred to the model-free system [7••]. More research is needed to investigate how these computational processes vary according to illness stage.

Foraging Models

Foraging paradigms offer another opportunity to assess decision-making processes that may lead to excess goal pursuit. These models, drawn originally from animal behavior in foraging for food rewards, allow researchers to determine how organisms decide to pursue or relinquish outcomes when other potential alternatives are available and time and resources are scarce [108]. Foraging paradigms require individuals to decide whether to accept a current reward or not without knowing the other rewards available, similar to decision-making in the real world (e.g., when someone selects a job or a partner, there are many other possibilities unknown to them). Thus, these models operationalize the current reward against a threshold representing the opportunity cost of selecting the current reward. Foraging models may be particularly useful for examining goal pursuit in AN, given the tendency of this group to overvalue future outcomes [33•], perhaps leading to suboptimal decisions when immediate needs (e.g., nourishment) are more critical. Our collaborative group has developed one such foraging paradigm that can be translated from rodents to humans [109•] and has found distinct behavioral patterns within animal models [97], which may provide insights to the decision process that allows individuals with AN to over-focus on future goals even when most individuals would attend to immediate desires.

Effort-Based Decision-Making Models

Computational models of effort-based decision-making have been derived to determine the degree to which the decision to expend cognitive or physical effort is impacted by perceptions of the relative value versus cost of effort [86, 110]. These models fit the elasticity of effort-based decision-making (i.e., how much response decreases with increasing effort cost [111]) by incorporating data on the magnitude of the reward that may be achieved from effort (e.g., amount of money) and the effort magnitude (e.g., amount of work needed to achieve the reward) alongside parameters that determine the steepness and shape of the effort discounting function. Although one study examined the association between mental effort-based decision-making and eating disorder symptoms [63], models of effort-based decision-making have not been applied specifically to AN [112]. Given the excess goal pursuit in this group, it would be expected that individuals with AN may under-discount effort. For instance, individuals with AN may exhibit lower sensitivity to effort costs and greater sensitivity to the value of the rewards that can be gained through effort. Alternatively, in AN, it is possible that effort has been conditioned to acquire secondary properties of reward itself [113]. In this case, AN participants would be expected to demonstrate less sensitivity to both effort costs and external rewards (because the effort itself would be the reward). Findings in line with this hypothesis have been identified in effort modeling for autism-spectrum disorders (ASD), which are also characterized by excess focus on a narrow set of goals [114]. Thus, further investigation of effort-based decision-making models in AN is warranted.

Extensions of Excess Goal Pursuit to Other Psychiatric Disorders

Over-engagement of what are normally considered adaptive decision-making processes may extend to other psychiatric concerns. There are other psychiatric disorders beyond AN that over-engage towards goals that are typically considered positive. Individuals with ASD and OCD often have elevated educational achievement relative to healthy individuals [46, 115]. Obsessive–compulsive personality disorder (OCPD), a condition of excessive concern with order and control, is associated with excess focus on a number of activities typically considered desirable, including work, saving money, and pursuit of moral good [116]. These same populations have also shown enhancements in certain decision-making abilities. Individuals with ASD and OCD demonstrate evidence of heightened effort tolerance [63, 114]. OCPD is associated with shallow delay discounting (i.e., heightened delay tolerance [33•]) and excess functional engagement of frontoparietal cognitive control circuitry [117]. In some models of anxiety, over-engagement of planning systems is considered a strategy for patients to reduce the distress associated with the unpredictability of the world [118].

Further, some individuals without one of the above diagnoses over-pursue other activities (e.g., work, exercise) to the exclusion of important life domains [119, 120]. These patterns are not currently classified as psychiatric disorders, but are associated with a range of psychiatric and physical ailments [119, 121]. As such, this model could also partially explain the elevated suicide rates in high functioning professions associated with heightened cognitive abilities (e.g., healthcare) [122]. Investigation into the computational processes maintaining AN may yield useful information about maintenance mechanisms promoting these other psychiatric concerns. Excess goal pursuit may also extend to subgroups within psychiatric disorders traditionally associated with decision-making deficits. For instance, some subsets of individuals with depression demonstrate shallow delay discounting [33•]. Thus, excess goal pursuit may represent an under-investigated subset of individuals with psychiatric disorders. Revealing the computational processes promoting AN will provide a first step to evaluating whether these other concerns are maintained through the same, or different, mechanistic processes.

Conclusion: Clinical Implications

If this excess goal pursuit hypothesis is correct, some portion of psychiatric problems may require novel treatment approaches. Individuals with excess goal pursuit may present for treatment of a secondary problem that may constitute an outcome of excess goal pursuit (e.g., depression, anxiety), rather than the core mechanism [123]. Informed by the deficit perspective, many common psychiatric interventions aim to enhance cognitive control circuitry and associated decision-making abilities to guide goal pursuit [124, 125]. However, in this psychiatric subset, it is possible that improving cognitive control could enhance the processes that led to symptom development. This could render these interventions less effective for this subset, or, in the worst-case scenario, could increase the potential for future mental health concerns (see Fig. 1, orange arrow). However, it should be emphasized that this proposition remains hypothetical; further research will be needed to both determine the populations impacted by excess goal pursuit, and the treatment implications for these individuals.

However, this process could explain why many treatments that work for disorders more commonly characterized by goal pursuit deficits (e.g., BN) have had limited success in AN [5, 23]: many existing treatments for AN may be targeted at an incorrect computational process. Some have hypothesized, for instance, that the highly structured, rule-bound settings in which individuals with AN are treated may ultimately perpetuate the rigid and perfectionist tendencies characteristic of this group [126•]. However, it is also worth noting that these highly structured treatment settings have also demonstrated the best efficacy for interrupting acute symptoms [127]. Addressing the computational processes promoting goal pursuit in AN can allow for adaptations of existing treatments or development of novel treatments that may be targeted more precisely to the underlying dysfunction.

Ultimately, treatment implications will depend upon the identified computational misalignments. However, in accordance with this approach, patients should be taught to identify when and how under- and over-use of certain decisional strategies lead to dysfunction, and alter their actions in a less extreme direction (Fig. 1, green arrows) rather than discouraging or encouraging use of a strategy altogether (e.g., always encouraging delaying gratification). In these ways, the novel field of computational psychiatry holds significant promise for developing more sensitive treatments for AN and related disorders designed to target the problems that arise when any decision strategy, whether classically considered good or bad, is extended too far.

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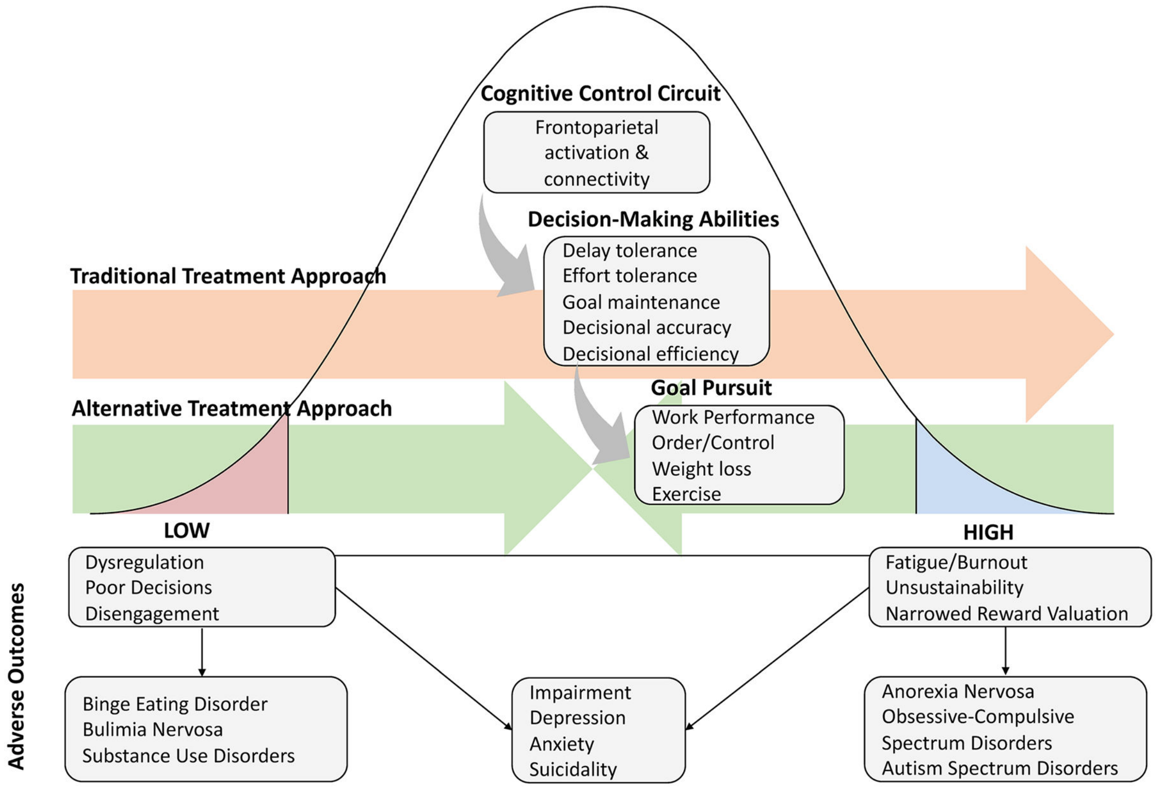

Fig. 1.

The goal pursuit paradox: too little and too much can lead to negative outcomes. Note: Orange line represents the typical psychiatric approach to addressing goal pursuit and decision-making, which typically aims to increase these qualities to support enhanced mental health. Green line represents an alternate approach emerging from computational psychiatry in which decision-making strategy and goal pursuit are modulated in the appropriate direction for optimal health, dependent upon the context demands

Table 1

Representative examples of the relative advantages and disadvantages of different decision-making strategies

Decision-making strategy	Advantages	Disadvantages
Model-based decision-making	Deliberative; precise; adaptable to changing environments	Slow; inefficient
Model-free decision-making	Rapid; efficient; useful for conserving resources when stimulus–response relations are well established	Insensitive to the broader reward structure of the world; imprecise; rigid
Delay discounting	Permits access to immediate rewards under scarcity; more sensitive to immediate reward value	Narrow-focused on current goals; discourages planning for future goals
Effort discounting	Conserves resources when reward-seeking is not vital; avoids aversive mental and physical sensations	Reduces ability to achieve goals requiring persistence; encourages inaction
Sunk costs	Encourages final actions towards a long-term goal, even under aversive conditions; less sensitive to momentary affective state	Over-weights the value of past actions over the future; Insensitive to diminishing returns
Rule-following	Simple rubric for goal-directed action; Permits rapid learning without direct experience of the consequences of certain actions	Rigid; success dependent upon the rule accuracy; vulnerable to over-generalization