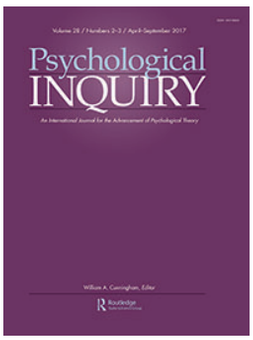

Routledge
Taylor & Francis Group

Psychological Inquiry

An International Journal for the Advancement of Psychological Theory

ISSN: 1047-840X (Print) 1532-7965 (Online) Journal homepage: https://www.tandfonline.com/loi/hpli20

Identity and Self-Control: Linking Identity-Value and Process Models of Self-Control

Daniel O'Leary, Andero Uusberg & James J. Gross

To cite this article: Daniel O'Leary, Andero Uusberg & James J. Gross (2017) Identity and Self-Control: Linking Identity-Value and Process Models of Self-Control, Psychological Inquiry, 28:2-3, 132-138, DOI: 10.1080/1047840X.2017.1337404

To link to this article: https://doi.org/10.1080/1047840X.2017.1337404

Published online: 18 Aug 2017.

Submit your article to this journal

Article views: 373

View related articles

View Crossmark data

Citing articles: 1 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=hpli20

PSYCHOLOGICAL INQUIRY
2017, VOL. 28, NOS. 2–3, 132–138
https://doi.org/10.1080/1047840X.2017.1337404

Routledge
Taylor & Francis Group

Check for updates

Identity and Self-Control: Linking Identity-Value and Process Models of Self-Control

Daniel O'Leary[a], Andero Uusberg[a,b], and James J. Gross[a]

[a]Department of Psychology, Stanford University, Stanford, California; [b]Institute of Psychology, University of Tartu, Tartu, Estonia

Self-control is crucial for achieving academic and occupational success, financial security, and mental and physical health (Moffitt et al., 2011; Moffitt, Poulton, & Caspi, 2013). Although self-control may be defined in many ways, we view self-control as the adjudication of a conflict between two action impulses, one driven by a goal that is of shorter-term value and one driven by a goal that is of more enduring value (Duckworth & Gross, 2014). Successful self-control entails resolving this conflict in favor of the more enduringly valued goal (see Figure 1).

Because self-control is thought to be more malleable than other important predictors of positive life outcomes, such as IQ and socioeconomic status, it has generated intense interest among scientists and policy-makers alike as a target for intervention (Duckworth & Seligman, 2005; Moffitt et al., 2011). To design effective interventions, however, researchers need a comprehensive yet parsimonious understanding of the psychological and neural mechanisms underlying self-control. One such model is the identity-value model (IVM; Berkman, Livingston, & Kahn, this issue).

The IVM offers a thoughtful conceptualization of self-control that draws on research in social and cognitive psychology and neuroscience to provide a framework both for understanding basic processes and for identifying interventions. For these reasons, we welcome the IVM and hope it will have a major impact on self-control research. In this commentary we first briefly review the IVM. We then describe the process model of self-control and indicate how the IVM can be contextualized within this broader framework. Finally, we show how integrating these approaches suggests promising new avenues for identity-based interventions.

The Identity-Value Model of Self-Control

The IVM holds that decisions are driven by the subjective value of the various items or actions that an individual could select in a given context. The subjective value for each choice option is computed as "a weighted sum of choice-relevant attribute values" and is represented in a common valuation currency (Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, in press). The alternative with the highest total subjective value determines behavior. The IVM further suggests that the brain calculates the combined subjective value of these weighted attributes in a dynamic fashion, meaning that the psychological and neural representation of value accumulates over time rather than all at once. This construal of valuation can be formalized using drift diffusion models (DDM), which have successfully accounted for key findings in the value-based decision-making literature (Johnson & Ratcliff, 2014; Krajbich & Rangel, 2011; Krajbich, Lu, Camerer, & Rangel, 2012; Ratcliff, Smith, Brown, & McKoon, 2016).

Two features of this value accumulation process are important here. First, value accumulation is noisy and probabilistic, fluctuating over time rather than following a direct path (Berkman et al., this issue; Johnson & Ratcliff, 2014). Second, key aspects of value accumulation can be characterized by two parameters—drift rate and decision boundary or threshold (Berkman et al., this issue; Johnson & Ratcliff, 2014). Drift rate represents the speed with which value accumulates for a particular choice option. Threshold can be thought of as the minimal value needed for a choice option to be selected. Support for this conception of value accumulation comes from neuroimaging findings that suggest the brain may indeed rely on processes approximated by the DDM when making various decisions (Smith & Ratcliff, 2004).

Self-Control and Value-Based Decision Making

This conceptualization of value-based decision making applies in many choice contexts where self-control is not required, such as when trying to decide which of two candy bars to purchase at a convenience store. However, Berkman et al. argue that decisions which require self-control—ones where short-term valuations conflict with long-term valuations—can be understood and modeled using the same framework (Berkman et al., this issue; Inzlicht, Berkman, & Elkins-Brown, 2016). In this view, self-control differs from other decisions simply in that the alternatives that compete for selection derive their value from different types of attributes.

To illustrate, consider an individual struck by midafternoon hunger pangs who decides to make a trip to a nearby convenience store for a snack. At the convenience store, he narrows the candidate snacks to chips and carrots. Some of the relevant features integrated into the overall subjective value for each choice option might be how tasty the food is and how healthy the food is. Each of these attributes is assigned a weight based on the relative importance of that attribute. Different people will have different weights for the same attribute (e.g., some people might not care about healthiness, whereas others might weigh this heavily). Weights may also vary as a function of internal or external context (e.g., how hungry the person is or what he sees other people eating). The

CONTACT Daniel O'Leary djolear@stanford.edu Department of Psychology, Stanford University, Jordan Hall, 450 Serra Mall, Stanford, CA 94305, USA.
© 2017 Taylor & Francis Group, LLC

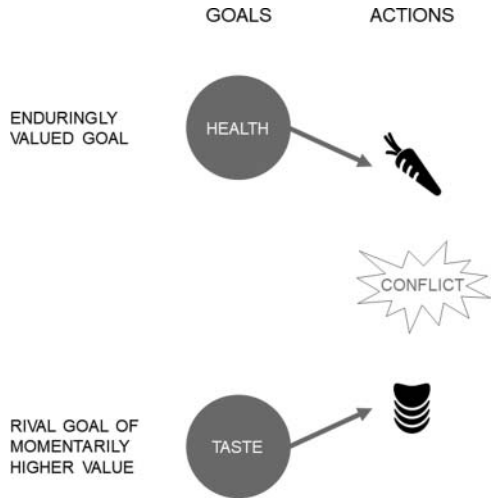

Figure 1. The need for self-control. *Note*. The need for self-control arises when two conflicting action impulses are activated, one driven by a goal that is of shorter term value and one driven by a goal that is of more enduring value. For instance, a person looking for an afternoon snack may experience a conflict between selecting carrots or potato chips. The action option of selecting carrots is driven by the goal to eat healthily. The action option of selecting the chips is driven by the goal to enjoy taste. Because the person can only purchase one snack, these action options come into conflict.

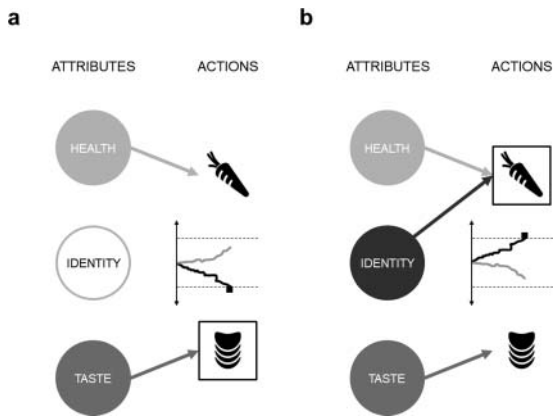

Figure 2. The identity-value model (IVM) of self-control. *Note*. According to the IVM, the decision as to which of two competing action options to execute (e.g., selecting carrots vs. selecting chips for a snack) is determined by a dynamic accumulation of the subjective value for each action option. Salient attributes such as health, identity, and taste are integrated into the overall subjective value for each option. *Panel a. Value accumulation leading to selecting chips*. A person is choosing between carrots and chips for a snack. Picking carrots is valued positively based on the health attribute of carrots. Picking chips is valued positively based on the taste attribute of chips. Identity is not a salient attribute in this decision and therefore does not influence value accumulation. In this case, taste has a higher weight than health (indicated by the shading of the circle). The values associated which each of the attributes are integrated in a weighted manner. Deciding between the action options involves dynamic accumulation of weighted values of each option until the value for one of the options, in this case picking the chips, reaches a threshold and triggers the associated action (see value accumulation traces and the square around chips). *Panel b. Value accumulation leading to selecting carrots*. In this scenario, a person is again choosing between carrots and chips. This time, however, identity has been made a salient and highly weighted attribute (indicated by the shading of the circle). It becomes an additional source of value for the action option of picking carrots. This changes the value accumulation process so that picking carrots reaches the threshold and triggers the associated action.

weight for each attribute associated with a particular choice is multiplied by how much of that attribute the choice contains (i.e., Weight on Tastiness × Magnitude of Tastiness). These weighted values are then integrated together into a total subjective value for each option, and the highest-value option is the one selected.

For the individual in our example, the chips are high in tastiness but low in healthiness. By contrast, the carrots are low in tastiness but high in healthiness. According to the IVM, the valuation of attributes that are relevant for short-term goals (e.g., taste) is often more automatic than the valuation of attributes relevant for longer-term goals (e.g., health). This means that in many situations, the option associated with short-term goals (chips) is more likely to be selected than the option associated with long-term goals (carrots; Figure 2, Panel a). In some situations, however, the option associated with longer term goals wins out over the option associated with short-term goals. According to the IVM, when we invoke "self-control," all we are doing is describing a decision-making process in which the option associated with longer term goals wins out. No new decision-making machinery is needed to explain such cases of self-control; in all cases, decision making relies on the same value-accumulation processes.

The Role of Identity in Self-Control

Berkman et al. (this issue) define identity as "a relatively stable mental representation of the self that includes, but is not limited to, cherished core values and beliefs, social identities, long-term goals, and important past experiences" (p. 79). In general, individuals are more likely to associate their identity with long-term goals (e.g., wanting to maintain a healthy weight) than short-term, hedonic concerns (e.g., wanting to taste something sweet), because identity is, by definition, a clustering of long-term goals and values. As a result, once relevant aspects of identity have been activated, an individual will give weight to identity as an attribute in the value integration process. To the extent that a choice option under consideration seems identity-relevant, it will accumulate subjective value associated with identity.

Thus, in the value accumulation process, identity-relevant choices are given an edge over alternatives that are identity-irrelevant. Berkman et al. (this issue) argue that increasing the salience of a choice's relevance to identity reliably increases the valuation of long-term goals over short-term impulses. Thinking of the person looking for a snack at a convenience store, it is likely that hedonic goals triggered in a bottom-up manner by cues in the environment will dominate his decision-making process. This person may notice both the chips and the carrots but, given that the principal attribute driving their value accumulation process is taste, might go straight for the chips (Figure 2, Panel a). However, if the identity-relevant goal to be healthy is made salient, their identity becomes an attribute that is weighted in the value accumulation process, which may tip the balance in favor of choosing the carrots (Figure 2, Panel b).

The Process Model of Self-Control

The IVM makes crucial contributions to the literature on self-control by arguing that self-control can be understood mechanistically, without reference to underspecified, homuncular processes, and by making it clear that identity is a crucial factor

that can influence the operation of self-control. However, the IVM does not specify the full range of mechanisms by which identity influences value accumulation. Moreover, the IVM is silent as to how identity's effects are similar to (or different from) other self-control processes. In this section, we outline the process model of self-control, a more general framework for describing self-control strategies that also explains the processing dynamics by which higher order goals, such as identity, are first activated and then influence the drift diffusion process. The process model of self-control draws inspiration from the process model of emotion regulation (Duckworth, Gendler, & Gross, 2016; Gross, 2015; O'Leary, Suri, & Gross, 2017) but considers all forms of self-control.

Self-Control and Goal Hierarchies

Most goals can be thought of both as desired end-states and as a means of obtaining other, more abstract goals. For instance, eating healthy food is both an end in and of itself and a potential means of obtaining higher order goals such as maintaining the identity of being a healthy person or dieting in order to live longer. Representations of goals are therefore often associated with one another in a hierarchical manner (2017; Duckworth & Gross, 2014). Lower levels of goal hierarchies are populated by goals that are relatively concrete, context specific, and rapidly attainable—to satisfy hunger, to enjoy taste, to eat healthily. Such goals are related to successively more abstract, context-independent, and long-term goals—such as to be a healthy person, to be active. These more abstract goals feed into identity-relevant goals at the highest level of the hierarchy, such as to be a good person (see Figure 3, Panel a).

From the vantage point of the process model of self-control, this hierarchical organization of goals is of central importance to self-control. The conflict between actions that is key to our construal of self-control can be formulated in hierarchical terms as a competition between goals that serve as a means of achieving more long-term and higher order goals in the hierarchy versus those serving more short-term, hedonic goals. Moreover, if a goal is more abstract, delayed, or removed from context (i.e., the higher it is in a hierarchy), it is likely that additional processes will be needed to transmit its value to an action option that would serve the goal (Berkman et al., this issue). From a system design perspective, this creates a need for a mechanism to compensate for the comparative disadvantage of higher order goals in value accumulation competitions. The process model of self-control suggests that this purpose is served by higher order feedback control processes that can modulate the weights or value outputs of attributes as they are integrated during the value accumulation process.

Self-Control and Valuation

A core building block of the process model of self-control is the notion of a "valuation system," a feedback loop (see Figure 3, Panel b) that captures shared features of multiple valuation systems distributed across the brain (Daw & O'Doherty, 2013; Rangel, Camerer, & Montague, 2008). Each goal in a goal hierarchy is served by its own valuation system, meaning that there

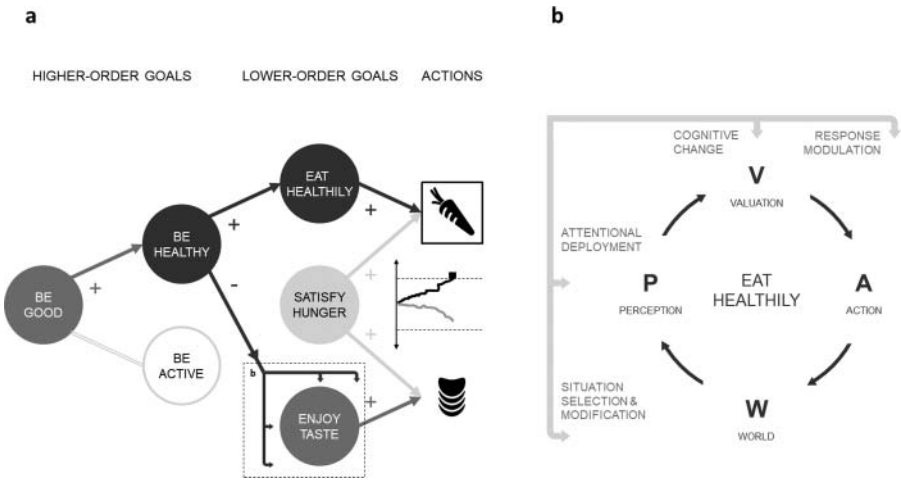

Figure 3. The process model of self-control. *Note*. According to the process model of self-control, goal hierarchies represent potentially active goals, each of which can be represented as a "valuation system." These valuation systems interact, and certain types of interactions correspond to what we call "self-control." *Panel a. Goal hierarchies*. Action selection through value accumulation is the final common pathway of a hierarchical pattern of goal activations. Goals are desired end states that are hierarchically related. For instance, to eat healthily can be both a valuable end state and a means for achieving more abstract, context-independent, and long-term end states such as to be a healthy person, which can in turn be a means of achieving one's goal of being a good person. Goals can influence the value accumulation that determines action in one of two ways. Lower order goals can be the attributes that provide value for a given action (see eat healthily, satisfy hunger, and enjoy taste, with different shadings corresponding to the weight of each attribute). Higher order goals can also influence value accumulation by biasing the activation of lower order goals (see be good and be healthy). *Panel b. Value generation and self-control strategies*. The process model further specifies how the value that becomes weighted and integrated within a value accumulation process is generated. Each goal activates a negative feedback loop where goal-relevant aspects and action options of the world (W) are perceived (P) and compared to the goal representation of a desired end state (V). Each action option is assigned a value based on the degree to which it is expected to reduce any discrepancy between the current state of the world and the goal state (A). For instance, the goal to eat healthily in a world of carrots and chips would assign higher value to carrots for their expected capacity to satisfy the goal. The four steps in value generation help to identify the ways in which value generation can be biased upwards or downwards. For instance, a person wishing to eat healthily can select worlds that are less likely to have tasty options (situation selection and situation modification), pay less attention to tasty options (attentional deployment), remind oneself of the costs of eating unhealthy, tasty foods (cognitive change), or force himself to avoid eating the chips whether he wants to or not (response modulation). Incorporating Panel b with Panel a illustrates how each goal in a hierarchy can generate weighted values

are often numerous, interacting valuation systems active simultaneously. The process model of self-control describes four aspects of a valuation system—world (W), perception (P), valuation (V), and action (A). In any given environment (or W), an individual is faced with a variety of possible choices or actions she could take. Each valuation system directs attention to a subset of these actions which are goal-relevant (P). It then evaluates (V) to what degree each choice would bring the individual closer to achieving the desired goal (i.e., how valuable each choice is). Finally, the valuation system generates an action impulse (A) to perform the option that is most likely to help the individual achieve her desired goal. Important to note, these valuation systems are organized cyclically such that this individual continues to iterate through these steps as she takes specific actions to work their way toward a particular goal.

To illustrate the operation of valuation systems in the context of a goal hierarchy, we return to the example of a hungry person in a convenience store making a decision as to which type of snack to eat. Although in reality there are many more layers to an individual's goal hierarchy, we depict three levels in this example (see Figure 3, Panel a). At the highest level of this hierarchy is the identity-relevant goal to be good. One level down are two associated goals—to be healthy and to be active—which are in turn associated to different degrees with lower order goals: to eat healthily, to satisfy hunger, and to enjoy tastiness. When the individual in our example enters the store, he has a single active goal, to satisfy his hunger. The W step of a valuation system that serves this goal includes the entire set of possible snacks that this individual could choose in their current environment. The P step occurs once this person has attended to a subset of the available choices in his environment that could satiate his hunger—chips and carrots, in this case. Both snacks have the potential to accomplish this goal, and so each motivates an associated action impulse. However, other goals influence this person's decisions about what to eat. The food-rich environment is likely to activate the hedonic goal to enjoy tastiness. The valuation system serving this goal would value chips higher than carrots, and, in many cases, the combination of hunger and taste valuation systems is thus likely to lead to the selection of the chips. However, in some cases, whether by internal motivation or by some external cue, the goal to eat healthily may be activated. If we imagine that this individual finds the chips tasty but not healthy, and the carrots healthy but not that tasty, then in this scenario the enjoy tastiness valuation cycle evaluates the chips as more likely to lead to the attainment of that goal, whereas the eat healthily valuation cycle does the same for carrots. This individual is now faced with decision conflict between a goal that is of shorter term, hedonic value and one that is of more enduring value and has the opportunity to deploy self-control.

A conflict between two goals can be a trigger for activation of higher level goals. The process model of self-control suggests that higher level goals can be viewed as higher order valuation systems that interact with lower order valuation systems. In our example, the higher order "be healthy" valuation system evaluates the eat healthily valuation cycle as being clearly more aligned with advancing its goal to be healthy than the "enjoy taste" valuation system. This leads to an action impulse that modifies the activity in the two subordinate valuation cycles, strengthening the eat healthily cycle and weakening the enjoy tastiness cycle. This, in turn, strengthens the action impulse to select the carrots, which, when then executed, results in self-control success. Important to note, although we have described the sequential activation of the two layers of this example goal hierarchy as arising from decision conflict in a particular choice context, this is not the only way to activate higher order goals. For instance, an individual could activate a goal to eat healthily or to be a good and healthy person either in a self-motivated fashion or through some external cue—prior to ever making a trip to the convenience store.

Self-Control Strategies

We view the activity in the lower order valuation cycles (eat healthily, satisfy hunger, enjoy taste) as an alternate representation of what happens in a drift diffusion framework. The attribute of an action option, such as tastiness, can be taken to refer a goal that is served by performing that action. The DDM construal of action options being valued based on their attributes can therefore be reformulated as a set of valuation systems evaluating the same action options with respect to different goals. Linking the two models opens up interesting possibilities. For instance, it offers a more mechanistic account of how the values integrated in a DDM process are generated. Moreover, the process model perspective suggests that each of the steps in a value generation cycle correspond to intervention points that are linked with particular families of self-control strategies (see Figure 3, Panel b). A particularly interesting implication of merging the DDM with the process model is the idea that each strategy identified in the process model should influence some aspect aspects of the drift diffusion process. Next, we review those strategies and outline ways in which they might operate in a DDM context.

At the W step, an individual can proactively decide whether to enter certain environments at all. For instance, in the chips versus carrots example, the person could decide to bring healthy snacks with him and forego the trip to the convenience store altogether. This family of strategies is called *situation selection*. Sometimes, however, an individual might be unable to avoid a situation but can still modify it in a way that decreases his chances of self-control failure. For instance, once inside the convenience store, a person could establish a plan to avoid the area where he knows the chips are located. This family of strategies is called *situation modification*. In the drift diffusion framework, *situation selection* and *modification* strategies are likely to influence the set of options the values of which compete with one another to drive behavior. In other words, one's environment and the available actions in that context determine the set of things for which an individual accumulates and compares values.

At the P step, an individual can deliberately direct his attention in ways that match his regulatory goals, such as looking away from the chips and toward the carrots. This category of tactics is called *attentional deployment*. The relevance of attentional deployment to DDM is made clear by the finding that the deployment of visual attention affects the rate of value accumulation for choices under consideration in a decision-making context (Konovalov & Krajbich, 2016; Krajbich, Armel, &

Rangel, 2010; Krajbich et al., 2012). Specifically, the more time that one spends looking at or fixating on a particular choice option, the faster value accumulates for that option, and the more likely a person is to choose that option (Krajbich et al., 2010). Important to note, the first three families of strategies represent some of the most robust methods available for self-control (Duckworth, White, Matteucci, Shearer, & Gross, 2016).

At the V step, an individual can make efforts to reconstrue the original significance or valuation of the option in question. In the case of the chips, rather than appraising them as tasty and filling, one might try to think of them as full of fat and cholesterol and potentially leading to weight gain and heart disease in the future. This family of tactics is called *cognitive change*. Cognitive change has been used successfully in value-based decision-making tasks that are often modeled with the drift diffusion framework. In at least one study, reframing strategies have been shown to alter activity in the ventral medial prefrontal cortex (Hutcherson, Plassmann, Gross, & Rangel, 2012), the brain region that most strongly correlates with self-reported subjective value (Levy & Glimcher, 2012). Other studies have shown that cognitive change strategies can alter activity in reward-related brain regions, suggesting that cognitive change is indeed altering valuation processes (Kober et al., 2010; Kober, Kross, Mischel, Hart, & Ochsner, 2010). We believe that whereas visual attention determines which choice options are valued, cognitive reframing determines the attributes that are included in the value integration process and the weights given to those attributes. From this perspective, the construal of a particular choice as identity-relevant can also operate as a type of cognitive change that includes identity in the value integration process and increases its weight.

Finally, at the A step, a person can take actions to increase or decrease the likelihood of completing a particular action. For instance, a person could attempt to suppress the urge to eat the chips once he has purchased them. This family of tactics is called *response modulation*. Little is known about response modulation in the context of value-based decision making. We propose that rather than changing the value accumulation process itself, response modulation tactics could potentially alter the decision threshold, or subsequent processes involved in performing the selected action. In other words, we imagine response modulation operating in a context where an individual has already accumulated a high level of value for a choice option and tries to resist the urge to act in the way that valuation dictates by moving the boundary that determines when an action is launched. As described elsewhere, strategies that intervene late in a valuation cycle are thought to be less likely to be effective than early stage efforts (Duckworth et al., 2016; Galla & Duckworth, 2015).

The Initiation of Self-Control

We have described a variety of strategies that can be used to engage in self-control at different points in the generation of an action impulse, but how does one decide whether to initiate one of these self-control strategies? Once initiated, how does one select among various possible forms of self-control? How does one know when to stop exercising self-control, or when to switch to a different strategy? The process model of self-control proposes four stages in the decision to apply self-control—identification of a need for self-control, selection of a self-control strategy, implementing the strategy in a series of mental or physical actions, and maintaining and monitoring the success of that implementation (see Figure 4).

In the first stage of this process, the *identification stage*, a person perceives decision conflict between multiple valuation systems, each promoting actions associated with competing goals. If the conflict is of sufficient magnitude, a self-control goal is activated to alter these lower order valuation systems. Activation of this goal then launches the *selection stage*, where a person represents families of potential strategies that could be used to alter first-level valuations at the different steps of the cycle (W, P, V, A, as just described). The most efficacious strategy, or the one with the highest likelihood of success and the lowest cost of deployment, is then selected. After deciding upon a particular strategy, the individual advances to *the implementation stage*, where he deploys the chosen strategy by choosing specific tactics and actions that are suitable for implementing the selected strategy in a particular context. After implementing a specific strategy, this process enters a *monitoring stage*, where the individual tracks how well he is doing at regulating the initial valuation toward the desired goal and continues to deploy whichever particular regulation strategy he chose. During this time, valuation cycles will continue to iterate, and in the course of monitoring progress toward achieving a self-control goal, a strategy other than the one initially selected may be seen as more efficacious or less costly than the original, implemented strategy. Thus, an individual can also switch to using a different strategy if he determines that a new strategy is more likely to lead to self-control success. An individual continues to traverse these stages until he succeeds in achieving the desired second-level valuation or until he gives up on this goal.

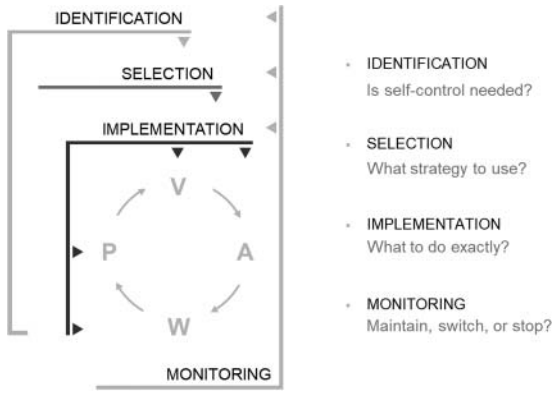

Figure 4. Initiating self-control. *Note*. According to the process model of self-control, one way the process of initiating self-control begins is when action impulses generated by different lower order valuation systems come into conflict (only one such system is depicted for clarity) and this conflict generates a need for self-control at the *identification stage*. Next, a suitable self-control strategy is chosen at the *selection stage*. Third, the *implementation stage* translates the selected strategy into a specific tactic that can be enacted in the present situation. Once the strategy has been implemented, the process begins anew. This cycle can go through multiple iterations, which are collectively viewed as a *monitoring stage*, concerned with

Identity-Relevant Self-Control Interventions

One key focus for future research is to devise ways to make salient the relevance of identity in environments where self-control might be necessary. Berkman et al. (this issue) highlight a variety of existing and potential interventions that are relevant to the model they propose, including ones that take advantage of research on self-affirmation, construal level theory, and self-fulfilling prophecies. One additional approach is to design interventions aimed at the process model stages that lead to the initiation of a self-control strategy—identification, selection, implementation, and monitoring. Interventions targeted at this level are thus designed to increase the likelihood that the processing dynamics described in the preceding section are brought online. Here, we offer some initial ideas of the type of interventions we envision.

In the *identification stage*, an individual recognizes conflict between two competing valuation systems, one of which suggests an action associated with a short-term, hedonic goal and the other of which is associated with a longer term goal such as eating healthily. At this stage, activation of a valued higher order goal associated with one's identity could be used to increase the chances of triggering this discrepancy so as to lead people to perceive a situation as one that requires the exercise of self-control. One could imagine signs or messages at the entrance to school and workplace cafeterias encouraging people to think of themselves as healthy eaters. Signs that suggest health goals at lower levels of construal have been employed to great effect, and so we presume that ones promoting higher order health goals would be equally effective (Suri & Gross, 2015). Similar messages could even be used in the context of restaurant dining as well, perhaps by labeling particular menus as designed for healthy eaters.

One input to the computation that determines the most effective family of strategies at the selection stage, or the best tactic at the implementation stage, is the estimated probability of success for the represented regulatory options. These estimates are likely to be influenced by general efficacy beliefs that constitute a core aspect of one's self-image (Bandura, 1977). For instance, a person may have a general belief that she is bad at overcoming impulses, a belief that may lead her to underestimate the chance that an attempt at self-control would yield desired results. Researchers could draw on techniques from cognitive behavioral therapy, which work in part by challenging negative beliefs about the self, to design interventions that teach individuals to challenge negative beliefs about their ability to exercise self-control (Beck, Emery, & Greenberg, 2005). In addition, intervention architects could draw on findings from the self-efficacy literature by helping individuals identify more manageable and proximal, rather than distal, self-control goals to accomplish as a way of building up their sense of self-efficacy at self-control, which in turn could help to boost probability estimates of strategy efficacy (Bandura & Schunk, 1981; Bandura & Simon, 1977). A different type of intervention aimed at this stage could work by generalizing high efficacy beliefs from one self-control context to another. For instance, an intervention could be devised that helps people identify and apply self-control behaviors they rely on in domains where they do not struggle (e.g., alcohol use) in the domains where they find self-control more challenging (e.g., healthy eating).

At the monitoring stage, people might more tenaciously sustain progress toward a self-control goal if that process is perceived as more identity-relevant. The ability to switch between different strategies is a key component of this stage, but it is conceivable that some people may construe the need to switch strategies as a form of personal failure that reflects negatively on their identity. For instance, some individuals may view toggling from implementing cognitive change or response modulation tactics to the deployment of situation selection tactics—such as refraining from purchasing tempting foods or alcohol—not so much as a way of exercising self-control, but rather as admitting that they are a weak-willed person. Correcting this framing by highlighting flexibility and foresight as valued aspects of identity might further enhance maintenance of self-control. One additional impediment during the monitoring stage is that too large of a gap between desired or expected progress toward self-control goals may demoralize people and derail attempts at self-control. Research on the benefits of setting proximal rather than distal goals could be used in interventions at this stage to remedy this problem (Bandura & Schunk, 1981; Bandura & Simon, 1977). One way to apply such findings would be to teach people both to set more manageable self-control milestones that they can accomplish on their way to achieving higher order self-control goals and to associate these more proximal goals with their identity. For example, an individual may have a higher order goal to lose 10 pounds, a goal she may closely identify with if she desires to be a healthy person. In this case, it might be useful for this person to frame eating green vegetables at dinner five times a week or only eating dessert on weekends as proximal self-control goals and to associate these goals with the identity of being a healthy eater. Similar reconstruals of the standards for what constitutes self-control success should reduce the gap between expected and perceived rate of progress.

Conclusion

The capacity to exercise self-control is vital to leading a healthy and happy life (Moffitt et al., 2011). Problems with self-control are endemic to modern society, and interventions are desperately needed to increase the use of effective forms of self-control. We believe that the IVM is a highly useful and mechanistically specific model that has the potential to usher in a new era of research on self-control both because it will help lead researchers toward a more computational understanding of the processes underlying self-control and because it may be a guide for more precise and effective intervention development. Our goal in this comment has been to link the IVM to the process model of self-control. In so doing, we proposed the process model of self-control as a framework for structuring the many ways one might launch an attempt at self-control and highlighted how the process model of self-control can be brought into contact with the drift-diffusion model of value-based decision making at the core of the IVM. Inspired by the IVM, we have focused in particular on how identity might be used to enhance self-control.

References

Bandura, A. (1977). Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. doi:10.1037/0033-295X.84.2.191

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*(3), 586–598. doi:10.1037/0022-3514.41.3.586

Bandura, A., & Simon, K. M. (1977). The role of proximal intentions in self-regulation of refractory behavior. *Cognitive Therapy and Research*, *1*, 177–193. doi:10.1007/BF01186792

Beck, A. T., Emery, G., & Greenberg, R. L. (2005). *Anxiety disorders and phobias: A cognitive perspective*. New York, NY: Basic Books.

Berkman, E. T., Hutcherson, C. A., Livingston, J. L., Kahn, L. E., & Inzlicht, M. (in press). Self-control as value-based choice. *Current Directions in Psychological Science*.

Daw, N. D., & O'Doherty, J. P. (2013). Multiple systems for value learning. In P. W. Glimcher & E. Fehr (Eds.), *Neuroeconomics: Decision making and the brain: Second edition* (pp. 393–410). New York, NY: Academic Press. doi:10.1016/B978-0-12-416008-8.00021-8

Duckworth, A. L., Gendler, T. S., & Gross, J. J. (2016). Situational strategies for self-control. *Perspectives on Psychological Science*, *11*(1), 35–55. doi:10.1177/1745691615623247

Duckworth, A. L., & Gross, J. J. (2014). Self-control and grit: Related but separable determinants of success. *Current Directions in Psychological Science*, *23*(5), 319–325. doi:10.1177/0963721414541462

Duckworth, A. L., & Seligman, M. E. P. (2005). IQ outdoes self-discipline in predicting academic performance of adolescents. *Psychological Science*, *16* (12), 939–944. doi:10.1111/j.1467-9280.2005.01641.x

Duckworth, A. L., White, R. E., Matteucci, A. J., Shearer, A., & Gross, J. J. (2016). A stitch in time: Strategic self-control in high school and college students. *Journal of Educational Psychology*, *108*(3), 329–341. doi:10.1037/edu0000062

Galla, B. M., & Duckworth, A. L. (2015). More than resisting temptation: Beneficial habits mediate the relationship between self-control and positive life outcomes. *Journal of Personality and Social Psychology*, *107* (12), 508–525. doi:10.1037/pspp0000026

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, *26*(1), 1–26. doi:10.1080/1047840X.2014.940781

Hutcherson, C. A., Plassmann, H., Gross, J. J., & Rangel, A. (2012). Cognitive regulation during decision making shifts behavioral control between ventromedial and dorsolateral prefrontal value systems. *Journal of Neuroscience*, *32*(39), 13543–13554. doi:10.1523/JNEUROSCI.6387-11.2012

Inzlicht, M., Berkman, E., & Elkins-Brown, N. (2016). The neuroscience of "ego depletion" or: How the brain can help us understand why self-control seems limited. In E. Harmon-Jones & M. Inzlicht (Eds.), *Social neuroscience: Biological approaches to social psychology* (pp. 101–123). New York, NY: Routledge.

Johnson, E. J., & Ratcliff, R. (2014). Computational and process models of decision making in psychology and behavioral economics. In P. W. Glimcher & E. Fehr (Eds.), *Neuroeconomics: Decision making and the brain: Second edition* (pp. 35–47). New York, NY: Academic Press. doi:10.1016/B978-0-12-416008-8.00003-6

Kober, H., Kross, E. F., Mischel, W., Hart, C. L., & Ochsner, K. N. (2010). Regulation of craving by cognitive strategies in cigarette smokers. *Drug and Alcohol Dependence*, *106*(1), 52–55. doi:10.1016/j.drugalcdep.2009.07.017

Kober, H., Mende-Siedlecki, P., Kross, E. F., Weber, J., Mischel, W., Hart, C. L., & Ochsner, K. N. (2010). Prefrontal-striatal pathway underlies cognitive regulation of craving. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(33), 14811–14816. doi:10.1073/pnas.1007779107

Konovalov, A., & Krajbich, I. (2016). Gaze data reveal distinct choice processes underlying model-based and model-free reinforcement learning. *Nature Communications*, *7*, 1–11. doi:10.1038/ncomms12438

Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience*, *13*(10), 1292–1298. doi:10.1038/nn.2635

Krajbich, I., Lu, D., Camerer, C., & Rangel, A. (2012). The attentional drift-diffusion model extends to simple purchasing decisions. *Frontiers in Psychology*, *3*(6), 1–18. doi:10.3389/fpsyg.2012.00193

Krajbich, I., & Rangel, A. (2011). Multialternative drift-diffusion model predicts the relationship between visual fixations and choice in value-based decisions. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(33), 13852–13857. doi:10.1073/pnas.1101328108

Levy, D. J., & Glimcher, P. W. (2012). The root of all value: A neural common currency for choice. *Current Opinion in Neurobiology*, *22*(6), 1027–1038. doi:10.1016/j.conb.2012.06.001

Moffitt, T., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., … Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(7), 2693–2698. doi:10.1073/pnas.1010076108

Moffitt, T., Poulton, R., & Caspi, A. (2013). Lifelong impact of early self-control. *American Scientist*, *101*(5), 352–359. doi:10.1511/2013.104.352

O'Leary, D., Suri, G., & Gross, J. J. (2017). Reducing behavioural risk factors for cancer: An affect regulation perspective. *Psychology & Health*. Advance online publication. doi:10.1080/08870446.2017.1314480

Rangel, A., Camerer, C., & Montague, P. R. (2008). A framework for studying the neurobiology of value-based decision making. *Nature Reviews Neuroscience*, *9*(7), 545–556. doi:10.1038/nrn2357

Ratcliff, R., Smith, P. L., Brown, S. D., & McKoon, G. (2016). Diffusion decision model: Current issues and history. *Trends in Cognitive Sciences*, *20*(4), 260–281. doi:10.1016/j.tics.2016.01.007

Smith, P. L., & Ratcliff, R. (2004). Psychology and neurobiology of simple decisions. *Trends in Neurosciences*, *27*(3), 161–168. doi:10.1016/j.tins.2004.01.006

Suri, G., & Gross, J. (2015). The role of attention in motivated behavior. *Journal of Experimental Psychology—General*, *144*(4), 864–872. doi:10.1037/xge0000088