Journal of Bioeconomics (2020) 22:137–154
https://doi.org/10.1007/s10818-020-09303-7

EDITORIAL

Ordinaries

Surviving desire: the causes and cures of self-control issues

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Published online: 29 September 2020

Abstract
Self-control is central to human success. Neoclassical economics posits a cohesive, rational brain that always picks the best outcome. Behavioral economics documents self-control problems and suggests 'nudges.' Evolutionary biology explains the source of self-control struggles. Based on an evolutionary understanding, we present a comprehensive taxonomy of self-control strategies.

Ordinary: "With no special or distinctive features; normal. Not interesting or exceptional; commonplace."

-Oxford English dictionary.

1 Introduction

Perhaps the most quoted part of *Mean Genes* is Jay's solution to airline food. The problem is that airline meals usually include an unhealthful dessert item such as a brownie that many of us would rather not eat. However, because the brownie is likely to sit on our tray table for an hour or more before being swept away by flight attendants, all too often the brownie gets eaten (Burnham and Phelan 2000).

Jay's solution is to use the mayonnaise that comes with the meal and smear it on the brownie as soon as possible. The brownie becomes disgusting to Jay and his will power battle is over.

Self-control battles are part of human nature, discussed by Plato as follows, "And might a man be thirsty, and yet unwilling to drink? Yes, he said, it constantly happens. And in such a case what is one to say? Would you not say that there was something in the soul bidding a man to drink, and something else forbidding him, which is other and stronger than the principle which bids him?" (Plato 360 BCE, Jowett 1888 translation).

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Table 1 Self-control battles exist in two forms (based on Burnham 2016)

		Feels	
		Good	Bad
Consequences	Good		Colonoscopy, flossing, saving money, college, vaccines
	Bad	Crack cocaine, Big Mac, TV, motorcycle, pizza, trans fats, cigarettes	

The essential aspect of the battle for control is internal mental conflict. Paraphrasing Plato, "something bidding a person to commit an act and something else forbidding." These conflicts exist in two forms. There are behaviors such as eating the brownie that feel good, but that we want to resist. And there are behaviors such as physical exercise that we feel are valuable, but that we have a hard time completing (see Table 1).

There are philosophical issues underlying the notion of self-control. What does it mean to want something and to not want it at the same time? Who is the individual in this situation? Why should we favor the part of us that wants to be nice, physically fit, and polite, over the hedonistic part that wants to binge, consume, and indulge in other pleasures?

In this article, we take it as a given that people do face self-control issues and that it would be useful to have a better framework to understand and exert self-control.

This article explores self-control within the mission of this series (Burnham and Phelan 2019):

> The Ordinaries column will interpret economic behavior from the perspective of evolutionary biology. From this view of life, the anomalies of behavioral economics will disappear into a coherent biological framework that incorporates elements of neoclassical maximization.

2 Self-control in economics without biology

Neoclassical economics is based on 'revealed preference.' Likes and dislikes ('preferences') are best delineated from an individual's behavior. Even the individual herself or himself does not have full internal mental access to understand her or his own preferences.

Marvin Minsky, the former MIT professor, and expert in a variety of fields including artificial intelligence, told this story. "I was scheduled to have breakfast with President Ford (after he had left office). I overslept breakfast, and I do not have a habit of oversleeping." … [Pause for drama] … "I have never been prouder of my subconscious."

The neoclassical economic perspective is that although Professor Minsky agreed to the breakfast, he did not *really* want to meet with President Ford. Thus, his true preferences were revealed by his behavior, not his prior words.

From this perspective, an individual might express dissatisfaction with her or his choice (Professor Minsky was proud), but because behavior is the manifestation of preferences within constraints, almost all choices are optimal from the neoclassical view.

The only caveats to this Panglossian "best of all worlds" view are inconsistencies of a technical sense (discussed at more length in Burnham and Phelan 2019). Paul Samuelson, a founder of neoclassical economics, and preference theory in particular, writes, "If an individual selects batch one over batch two, he does not at the same time select two over one" (Samuelson 1938, p. 65).

In neoclassical economics, people do not have (or need) self-control. Behavior is optimal unless the individual makes inconsistent choices in a very limited, technical manner in the "batch one, batch two" Samuelson sense.

Behavioral economics, in sharp contrast, embraces the notion of self-control struggles. In fact, Richard Thaler credits a (lack of) self-control story as the epiphany that led him to become a behavioral economist.

Professor Thaler writes, "At a dinner party for fellow economics graduate students I put out a large bowl of cashew nuts to accompany drinks while waiting for dinner to finish cooking. In a short period of time, we devoured half the bowl of nuts. Seeing that our appetites (and waistlines) were in danger, I removed the bowl and left it in the kitchen pantry. When I returned everyone thanked me." (Thaler 2018, p. 1265).

A neoclassical economist would prefer to have easy access to the cashews. An assumption of standard economic theory is that more choices are always preferred to fewer because it is possible to turn down the extra option. The fact that the graduate students thanked Richard Thaler for reducing the available options was the surprise that catalyzed his career.

As with the cashew epiphany, behavioral economics starts by observing human behavior. In his review article, Richard Thaler lists five findings that he believes are among the most important aspects of behavioral economics (Thaler 2018).

- *Self-control:* The brain is not a cohesive agent and therefore can have internal conflict.
- *Mental accounting:* Money is not treated equally across different areas of a person's life creating inefficiency.
- *Fairness:* People care about the impact of their decisions on other people.
- *"Mugs":* The starting position (endowment) impacts the outcomes in ways that violate neoclassical economics.
- *Finance:* The neoclassical Efficient Markets Hypothesis that asset market "prices reflect all information" is not true.

According to behavioral economics, because people exhibit biases and heuristics, it is possible to influence people's choices through intervention (e.g., removing the cashews). Richard Thaler labels attempts to help people as 'nudges,' and attempts to exploit people's flaws as 'sludges.'

Here is one famous nudge based on one aspect of the self-control problem. People are inconsistent in their decision-making. When asked to select a movie to watch three months from today, for example, they tend to choose a movie that they feel they ought to watch, such as *Schindler's List*. On the day these people are scheduled to

Table 2 Economics and self-control circa 2020

Phenomenon	People struggle with self-control. People want to perform some behaviors that are bad. People do not want to perform some behaviors that are good.
Neoclassical economics	People do not have self-control problems. Behavior is optimal. All behaviors that are performed are good. All behaviors that are avoided are bad.
Behavioral economics	People suffer from biases and heuristics. Some excellent observations and prescriptive nudges. No underlying theory of the source of self-control issues, and no comprehensive approach to solutions. *Post hoc* and *ad hoc*.

watch these weighty, possibly foreign-language, educational movies, however, they commonly prefer to switch to a less serious, light-hearted movie such as a comedy.

Imagining the disciplined Future You while living a more hedonistic today, is labelled "present bias." It is documented in a variety of settings beyond movie-watching choices.

One of the more famous and practical nudges utilizes the "mayonnaise on the brownie" insight to defeat present bias and increase financial saving. Using the SMarT (Save More Tomorrow) program, people agree to increase their savings at the time of future pay raises.

SMarT accounts are reported to significantly increase savings rates (Thaler and Benartzi 2004). Rather than hoping that Future You will be disciplined, have the Present You make a decision to improve the chances of the good outcome.

What is there not to like about behavioral economics? We see two areas with room for improvement.

First, we would like to know the evolutionary and biological origin of the "anomalies" documented by behavioral economists. Why has evolution by natural selection—which has forged so many beautiful and amazing organisms, such as eagles and orchids—produced humans that struggle (and fail) to control so many of our behaviors?

Second, does the evolutionary and biological perspective provide a taxonomy or framework for tilting the balance in self-control situations? Such a taxonomy would improve insight into these internal conflicts, as well as provide approaches to improve the outcomes. Table 2 summarizes the current state of economics with regard to self-control.

3 Evolutionary and biological origin of self-control problems

Preferences are shaped by natural selection to produce behaviors—from diet choice (Román Palacios et al. 2019) to mate choice (Bonduriansky 2001; Gavrilets et al. 2001) to habitat choice (Ravigné et al. 2009) and more (Real 1991)—that maximize relative genetic success.

When an organism is in sync with its environment, it will derive maximal pleasure from behaving so as to maximize the evolutionary success of the versions of genes that it carries.

Male elephant seals, we argue, experience the equivalent of tremendous joy from engaging in the bloody and deadly battles for control of valuable beach territory. Control of that territory converts into genetic replication. Winning dominance interactions increases dopamine levels in fish (Carpenter et al. 2009; Pavlidis et al. 2011), reptiles (Korzan et al. 2000; Ling et al. 2010), and various mammalian species (Haney et al. 1990; Caramaschi et al. 2008).

Similarly, a small mammal burying a nut experiences more pleasure, in the form of dopamine release and the activation of brain reward circuitry, from the act of storage than it would from eating the food (Yang et al. 2011). In rats, lesions that block dopamine release result in an immediate cessation of food storage, while subsequent administration of dopamine restores the behavior (Kelley and Stinus 1985).

When genes and the environment are in equilibrium, there is no conflict between pleasure and payoff. Live for today accomplishes planning for tomorrow.

With mismatch, however, preferences can be out of sync with the environment with important consequences. Seeking pleasure in equilibrium leads to genetic replication. Seeking pleasure in novel environments can lead to both unhappiness and no genetic replication.

Mismatch is essential to understanding human behavior because our genes are out of sync with modern environments. And the degree of mismatch is only going to increase. Genetic equilibrium between a population and its environment can take hundreds or thousands of generations. Human evolution continues and gene frequencies change with each generation. We have not stopped evolving. However, because technology changes every day, genetic evolution can't keep up.

Because equilibrium and mismatch are so important to understanding difficulties with self-control, we divide the ultimate causes of self-control problems into equilibrium and mismatch (non-equilibrium) causes. We start with the conceptually easier case of mismatch (see Burnham and Phelan 2020a for a fuller description).

Cause 1: Mismatch cause of self-control issues

To understand mismatch, consider the Aché—a group of modern South American foragers—and the Big Mac. When the Aché hunted and gathered for a living, anthropologists recorded detailed observations of their behavior, including the number of work hours and the calories consumed (Hill and Hurtado 2017).

Unsurprisingly, the Aché were very good at foraging. Their decisions were close to optimal in terms of obtaining the most and best food for themselves while minimizing effort in the form of hours of work and processing time for the food. The Aché achieved more food per unit of effort than some other modern foragers such as the !Kung San (Lee 1979).

The Aché wanted to consume as many calories as possible while satisfying their necessary nutrient needs. To accomplish these goals, they ate every possible part of the animals they killed (up to 71% of the weight of the average animal). And they minimized the time spent walking, killing, butchering, and cooking their animals. They were also experts at utilizing the local plants.

On average, the Aché acquired 870 kilocalories (kcal) of food per hour of foraging, and consumed a total of about 3000 kcals per day (Hill et al. 1984). When living a foraging lifestyle, the !Kung San of the Kalahari desert have been estimated to consume about 2140 kcals per day (Lee 1969, 1979).

A Big Mac Meal including fries and a sugary soda exceeds 1100 kcals. Moreover, for the person eating the meal, the total energy expenditure to obtain and eat a Big Mac can be close to zero.

The Big Mac Meal is a potent example of mismatch:

- Because foraging humans seek large packets of energy for the lowest energetic expenditure (Winterhalder 2001), the Big Mac Meal would be a bonanza for a hunter-gatherer.
- Because modern humans carry similar genes descended from our foraging ancestors, and a Big Mac would have led to evolutionary success for our ancestors, we derive intense pleasure from such a meal.

Table 3 illustrates the role of mismatch in self-control. The table contains the same areas of internal conflict as Table 1 with the addition of approximate dates of invention. Given the recent invention of the products that cause self-control problems, and the number of generations required for genetic adaptation, human genes have not had time to reach equilibrium (Burnham and Phelan 2020a).

When are human genes going to reach equilibrium with our environment?

Never.

Mismatch can continue indefinitely, even when it imposes high costs and occurs in a stable environment. Consider the enzyme RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) used by plants to "fix" carbon. This molecule enables plants to pluck invisible, gaseous carbon from the air and use it to build solid, edible organic molecules such as glucose, which are used by organisms including humans.

RuBisCO is the most plentiful protein on earth and may be the most important enzyme in the world—life as we know it would be impossible without RuBisCO. Yet for all its importance to nearly every species on earth, RuBisCO can be sloppy and inefficient in catalyzing carbon fixation.

Table 3 Mismatch causes self-control problems

		Feels	
		Good	Bad
Consequence	Good		Colonoscopy (1969), flossing (1815), saving money (6th century BC for coins), college (970), vaccines (1796)
	Bad	Crack cocaine (1970s), Big Mac (1967), TV (1927), motorcycle (1885), pizza (1889), artificial trans fats (1900s), cigarettes (19th century)	

Approximately 30% of the energy that drives photosynthesis is lost in a process called photorespiration (Erb and Zarzycki 2018). Photorespiration occurs in photosynthesizing plant cells when RuBisCO mistakenly binds to oxygen in the air rather than carbon. When this happens, carbon fixation does not occur, sugars are not produced, and valuable energy is wasted.

Why does RuBisCO mistakenly bind to the wrong molecule? The answer is mismatch.

It's unusual for an enzyme to bind the wrong molecule. In this case, the proximate cause is that the forms of oxygen and carbon in the atmosphere—O_2 and CO_2–are chemically very similar. Additionally, when evolution first led to organisms that used RuBisCO to conduct photosynthesis, the concentration of oxygen in earth's atmosphere was extremely low. In that early environment there was little downside to using an enzyme that happened to have an affinity for oxygen as well as carbon dioxide (Phelan 2018).

But one by-product of photosynthesis is the production of oxygen. And as a consequence of the tremendous success of photosynthetic species and the resulting accumulation of oxygen in earth's atmosphere, RuBisCO became 'out of sync' with this new environment. It is because there is now so much oxygen in the atmosphere that RuBisCO mistakenly binds to it so frequently. More than three billion years have passed, but RuBisCO still suffers from mismatch.

As a side note, there is an interesting parallel between mismatch for humans and RuBisCO. Many species are experiencing mismatch because another species—humans—is changing their environment. Orangutans in the wild, for example, face extinction because of human utilization and destruction of their habitat.

Humans are different in that we are creating mismatch for ourselves. Similarly, RuBisCO is responsible for its own mismatch, in the form of dramatically increasing the amount of oxygen in the environment.

Humans suffer mismatch because technology is changing our environment faster than our genes evolve. RuBisCO has been stuck at a suboptimal outcome for more than three billion years. Given that the iPhone was invented in 2007, and much phone innovation is specifically directed toward garnering more of our attention, we should not be surprised that we look at our phone more than we want.

Mismatch can occur when novel products—think iPhone, social media platforms, and crack cocaine—are invented. It can also occur when already existing products become available more reliably and/or in significantly greater amounts—think food.

Food was not overly abundant nor easy to obtain for foragers including the Aché and our ancestors. When food is scarce, being skinny is a terrible survival strategy.

The human ability to save for an uncertain future in the form of stored energy in our fat cells is an evolutionary adaptation. All humans are excellent natural savers. We are built to unconsciously and automatically save for the future when we encounter excess calories.

The mismatch between thrifty genes and newly plentiful food leads to the problem of too much weight – a problem that almost never occurs to animals in their natural settings.

Cause 2: Non-mismatch cause of self-control issues

Is mismatch the sole cause of human self-control problems? Would our foraging ancestors, living before the invention of agriculture, have lived an angst-free life, pursuing short-term pleasure that reliably led to long-term success?

No.

There is strong empirical and theoretical rationale to believe that even foraging humans, during the Pleistocene and long before the invention of agriculture, struggled for self-control.

The best empirical evidence of ancestral will power battles is the very fact that humans have some ability to exert self-control. It is an adaptive trait humans share across all populations and cultures. We can hold our breath, resist eating junk food, save for retirement, "just say no" to drugs, and accomplish other feats of self-control.

Without question, we struggle with these behaviors. Yet in comparison with other apes, we are significantly and universally superior. Humans are the only animals, for example, who will suffer a burned hand carrying a hot pan over a nice rug.

More formally, across a wide range of experimental settings, non-human apes and other animal species demonstrate poor ability to exert self-control (Beran 2018). In a classic experimental setup, chimpanzees initially are taught that symbols convert to food. When they point at three rocks, they receive three pieces of food. When they point at one rock, they receive one piece of food, etc.

These symbolically-trained chimpanzees are then placed in a 'reversed reinforcement' experiment. In this treatment, the rewards are reversed. The chimpanzee gets a quantity of food based on the option that they do not choose, while a different chimpanzee gets the alternative outcome.

Specifically, the chimpanzees are presented with two different sets of symbols for receiving rewards: 1 and 3 rocks. If a chimpanzee points at the symbol of 3 rocks, it receives 1 piece of food, while a different chimpanzee gets 3. If the chimpanzee instead points at 1 rock, it receives 3 pieces of food.

What do the chimpanzees do in this 'reversed reinforcement' setting? After just a single trial, the chimpanzees learn to maximize their own outcome by pointing at the smaller set.

But it is the next phase of the experiment that reveals the failure of chimpanzees to control their behavior. In this phase, rather than being shown symbols of 1 rock or 3 rocks that correspond to the food rewards, actual pieces of food (candy) are shown: 3 pieces vs. 1 piece.

When the items shown to the chimpanzees are candy, rather than rocks that symbolize candy, the chimpanzees *always* point to the larger pile. Time after time, the chimpanzees pick the bigger group and then receive the smaller amount (Boysen et al. 1996). They appear to be so excited by the candy that they are unable to exert self-control. And this failure to exhibit control leads to a bad outcome.

Why are humans better at self-control? The proximate, mechanistic explanation is that the human prefrontal cortex is much larger than that of other apes. As a proportion of cortical gray matter, the human pre-frontal cortex is 1.7 times as large as that of chimpanzees (Donahue et al. 2018). Humans are better at abstract cognition and executive functions, including self-control, because our brains are bigger, specifically in those evolved structures specialized for these types of tasks.

The proximate cause of humans' relatively strong self-control is our brain. What is the ultimate cause of human self-control? Self-control is a biological adaptation that may reduce the amount of dopamine released today but increase replication over our lifetime. Adaptations only arise in response to evolutionary selective pressure. Thus, we infer that foraging humans must have had self-control problems.

If self-control can improve evolutionary outcomes, why is this ability so much more powerful in humans than in other animals? The answer includes luck (with certainty) and, possibly, different evolutionary payoffs.

The evolution of an adaptation always requires at least a bit of luck. We know this from theory, and also from the Long Term Evolution Experiment (LTEE) run by Professor Richard Lenski and colleagues (Lenski et al. 1991). The goal of the LTEE is to study evolution as it occurs, rather than the more traditional approach of looking backward at what has occurred in nature. The experiment started in 1988, with twelve identical populations of bacteria living, propagating, and dying in a laboratory.

The LTEE has now been underway for more than 70,000 generations, the equivalent of 1.4 million years in human terms. The twelve bacterial populations have been isolated from each other and, consequently, they have diverged, with each having its own unique evolutionary trajectory. Because the evolution in the LTEE occurs in a laboratory, every aspect, in every generation, can be studied and explored.

These bacteria need carbon to survive. Carbon is present in the bacteria's LTEE environment in two forms: relatively abundant citrate and relatively scarce glucose. Initially, all twelve populations were dependent on glucose, and did not have the ability to metabolize citrate.

After 31,000 generations, one of the twelve populations evolved the ability to utilize citrate (Blount et al. 2012). Because there is significantly more citrate than glucose in the environment, the citrate-utilizing bacteria strains are able to grow faster. In separate head-to-head competitions, they drive their glucose-dependent competitors to extinction.

Why did one population in the LTEE—but not the others—evolve this valuable new ability? The answer is luck. All the populations were identical at the start, derived from the same starting population.

Periodically, throughout the experiment, the genomes of each population have been sequenced. These genetic sequence data allow a detailed, molecular understanding of the evolution of this critical adaptation. It began with a series of genetic mutations that arose sometime after 20,000 generations, and it culminated in citrate-utilization by generation 31,000.

The appearance of a new adaptation in any species is similarly dependent on luck to produce novel, beneficial genes. We know with certainty that the 'origin story' of human self-control includes the chance appearance of genes that build a larger prefrontal cortex as well as other genes controlling brain function.

A second factor playing a role in the origin of human self-control may be the emergence of a different set of evolutionary pressures. These could be a reduced cost of building a better brain and/or an increased value in having a better brain. Here's one scenario by which this might have occurred.

The "cooking hypothesis" argues that humans gained access to the increased amount of energy necessary to build big, effective brains by mastering the use of fire (Wrangham et al. 1999). With controlled fire, humans could cook food. And the process of cooking significantly increases the availability of nutrients, such as protein, while reducing the amount of energy required by the digestive system to process foods. Cooking thus frees up energy for non-digestive uses.

The cooking hypothesis proposes that this advance in food preparation made the evolution of bigger human brains feasible. This idea is a hypothesis (not yet a validated theory); we describe it simply to illustrate one possible route to the evolution of human self-control.

In summary, humans have faced self-control problems since at least the Pleistocene. Self-control problems can arise from technological change creating mismatch as well as from other non-mismatch reasons.

Let us now turn to strategies to utilize our relatively large prefrontal cortexes for improved self-control.

4 Solutions to self-control problems

Solutions to self-control problems all fall into one or more of four categories. We describe them here, organized in a "taxonomy of self-control." While limited to four distinct strategies, the specific applications are unlimited. Here we describe examples that illustrate each of the four categories of self-control solution strategies (Table 4).

Two caveats before we begin. First, in many cases, we do not have a complete understanding of the long-term consequences of behaviors. It seems reasonable to us that eating a calorically-rich, nutritionally-poor airplane brownie is bad for health and longevity. In most cases, however, the long-term impacts are unknown.

Second, there is tremendous variation among people and the nature of their self-control problems. Most people do not get enough exercise and, consequently, physical fitness is an area of internal conflict. But dislike of physical activity is not universal. Nonetheless, every person has internal conflict, just with a different set of issues.

Table 4 Prototypical self-control problems

		Feels	
		Good	Bad
Consequence	Good		Physical exercise
	Bad	Airplane brownie Big Mac Cigarette Sitting on couch Risky behaviors	

Strategy 1: Will power

Will power is the ability to exert control over impulses and feelings. It enables us to suppress short-term drives or temptations so as to better meet long-term goals (Mischel et al. 1996). In 2012, Tom Sietas set a world record by holding his breath for 22 min and 22 s. Presumably, during most of this time some portion of his brain was screaming for air.

There are foundational issues underlying the concept of will power. From a revealed preference perspective, for example, the notion becomes virtually meaningless. Neoclassical economics would argue that during the 22 min, Tom Sietas did not *really* want to breathe, just as Marvin Minsky did not *really* want to dine with Gerald Ford.

We disagree with neoclassical economics and this application of revealed preference. To us, self-control problems are real, and, in some situations, people can, indeed, exert will power (Tangney et al. 2004; Duckworth 2011; Moffitt et al. 2011; Muraven 2012).

In most cases, however, people who desire to change their behavior—from saving money (Benartzi and Thaler 2013) to academic performance (Duckworth et al. 2019) to weight management (Dansinger et al. 2007) to alcohol consumption and other addictive behaviors (Marlatt and Donovan 2005)—have tried will power and not achieved success.

"Quitting smoking is easy. I have done it a thousand times." Every person who wants to quit smoking and relapsed, has already tried will power, often repeatedly. The same is true for our failed resolutions to exercise more, to be more patient with the neighbors' children, to be a better parent, to save more, etc.

At this point, we could bemoan our inability to use will power. Alternatively, we can recognize the underlying rationale to our behavior. Tom Sietas is famous for not breathing for a long time, precisely because that is a difficult feat. Breathing helped our ancestors produce us. Similarly, most of us struggle to lose weight, precisely because our ancestors had better evolutionary outcomes if they gained weight.

"So at birth the twig is already bent a little bit—what are we to make of that?" (Wilson 1978, p. 132). Many of our toughest battles today are with ourselves. Rather than bemoan our lack of will power, we make two suggestions.

First, recognize that these self-control challenges are not arbitrary or unpredictable obstacles meant to frustrate us. They're meaningful preferences that helped our ancestors effectively navigate a dangerous world. Second, recognize and appreciate that humans have an unmatched ability to alter our behavior through strategy and tactics (Duckworth et al. 2018).

Strategy 2: Innovation

"Tastes Great. Less Filling" was the advertising slogan for the first light beer. Technological change is a primary source of mismatch-induced self-control problems. However, innovation can also be a strategy for obtaining better outcomes.

Innovation in food seeks to create new products, such as light beer, that reduce or remove the need for self-control. Junk food or steamed broccoli for dinner? With these two choices, we often will choose junk food. But what if we could choose between junk food, steamed broccoli, and a third option that tastes better than junk food *and*

Table 5 Innovation reduces the need for self-control

		Feels	
		Good	Bad
Consequence	Good	Wonder food—tastes better than junk food and is better for you than steamed broccoli	Steamed broccoli
	Bad	Junk-food	

is more healthful than broccoli? With such a new, wonder food, there would be no self-control issue (Table 5).

Innovation allows us to have our dopamine today without sacrificing our good lives tomorrow. New creations can help in every struggle for self-control.

Consider risk-taking. People take risks and sometimes die as a consequence—each year 9% of all deaths occur from injuries (World Health Organization 2014). While many of these deaths have nothing to do with voluntary risk taking, some dangerous choices contribute to some injury-caused mortality. Falling while rock climbing, for example, is largely attributable to choosing risk. Driving too fast, and not wearing a seat belt, too, are voluntary risks with potentially fatal consequences.

Why do people take risks, particularly risks that might seem to promise no reward? The proximate or mechanistic cause is dopamine. Risky behaviors produce pleasure, and we are built to repeat those behaviors that make us feel good.

"Action Park," was a water park in New Jersey, notorious as much for its appeal to thrill-seekers as it was for poorly-designed rides, under-trained staff, and the fact that at least six people died in accidents on rides at the park.

Actress Alison Becker reminisced about her experiences at the park, "There was a physics-defying cluster of short, fast water slides that ended by shooting you out into a lake. It would slam you into a wall and then project your gnarled body into a gooey pond of crying kids and water snakes. It was awesome."

What is the ultimate explanation for our attraction to risk? The answer is that we did not descend from those humans who hid in caves and took no chances. Rather, our ancestors made conscious and unconscious trade-offs between risk and reward, and we carry their genes that make risk exciting.

Consider the risk-taking that led to genetic success in Europe. All Europeans who lived between approximately 37,000 years ago and 14,000 years ago, descended from a single founding population. These immigrants arrived in Europe about 45,000 years ago. From an evolutionary perspective, their risky drive to explore the unknown was spectacularly successful; they displaced all of the other humans they encountered (Fu et al. 2016).

From a molecular genetic perspective, evidence suggests these risky migrators disproportionately carried genes that code for less sensitive DRD4 dopamine receptors (Matthews and Butler 2011). These less-sensitive receptors, in turn led to greater risk-taking behaviors in pursuit of reward-center activation. The same scenario has played out in all regions over time; our ancestors were risk-takers.

Innovation allows us to obtain the risk-equivalent of "Tastes great. Less filling." Our ancestors stimulated their dopamine receptors with risky behaviors that included an actual possibility of death.

Today, we can satisfy those same risk-taking passions with very little chance of death. (Action Park was closed permanently in 1996.) Modern roller-coasters are carefully designed to terrify, yet not cause any harm. Many people enjoy horror movies for similar reasons; plenty of thrills, with none of the injuries.

While innovation can allow us to indulge our passions with minimal consequences, it can also work against our self-control strategies. Video games exemplify both of these features.

On the positive side, gamers can, for example, role play in warfare and other risky, virtual settings without risk of actually dying. Gamers also can experience beneficial prosocial effects (Greitemeyer and Osswald 2010), and can improve visual-spatial skills (Green and Bavelier 2007) as well as physical fitness (Roopchand-Martin et al. 2015). But there can be significant negative impacts as well, such as inciting aggressive thoughts and feelings (Anderson and Dill 2000), and overuse bordering on addiction.

Innovation is therefore a double-edged sword in our battle for self-control. Novel products create mismatch, and with that comes possible exploitation. New creations, however, can also allow us to enjoy our temptations at a reduced cost.

Strategy 3: Mast strapping

In the psychology literature, Jay's strategy of covering the brownie in mayonnaise is labelled mast strapping, in reference to the story of Odysseus contained in Homer's *Odyssey*.

When Odysseus was returning home to Greece after the Trojan War, his ship would need to sail past the Sirens. This was dangerous because the Sirens sang in such an appealing manner that mariners would die after crashing their ships onto the rocky shore while attempting to get closer to the Sirens and the pleasure of their singing.

Odysseus had himself strapped to his ship's mast, used wax to plug the ears of his crew so they would not be exposed to the enticing-but-dangerous singing, and gave orders for his men to ignore his gestures and expressions.

Mast-strapping succeeds by reducing the available options, not by changing preferences (see Table 6). While hearing the singing, Odysseus wanted to go to the Sirens and embrace them—which would lead to him crashing his ship. His prior planning, however, removed his ability to issue the self-destructive orders and ensured that his men could not hear his commands. Similarly, Jay's brownie was not tempting with its mayonnaise covering.

Table 6 Mast strapping constrains bad choices

		Feels	
		Good	Bad
Consequence	Good		
	Bad	~~Airplane brownie~~	

Mast strapping works by constraining or removing possible behaviors. Here are some examples of mast strapping choices.

- Live on the fourth floor of a building with no elevator.
- Auto-deduct retirement contributions from your paycheck.
- Do not take your credit card with you to Las Vegas.
- Delete the day-trading app from your phone.
- Put a lock on your refrigerator.
- Get a parking permit for a lot that is a mile from your office.
- Do not get the key to the hotel minibar.
- Give your cell phone to your partner when they leave for the day.
- Use Richard Thaler's SMarT method to save more.
- Get dropped off five miles from your house before starting a run.
- Move to Singapore (to stop taking drugs).

Mast-strapping can work. With relatively brief moments of strength and foresight, we can structure our world to reduce future temptations.

Strategy 4: Dopamine modulation

"Dopamine modulation" is a self-control strategy of reducing the pleasure that we receive from behaviors that we seek to avoid, or, increasing the pleasure from behaviors that we seek to perform. Dopamine is the primary currency of temptation. Food, sex, money, and drugs all stimulate dopamine release in the brain's reward centers (Burnham and Phelan 2020b).

A low-tech approach to dopamine modulation is to eat before going to the grocery store. The amount of dopamine released when eating increases significantly with appetite (Roseberry 2015). This is an effective adaptation that induces humans (and other animals) to acquire resources.

Imagine a gazelle that is trading off the risk of being killed by a lion with the value of eating. The hungrier the gazelle, the more that its brain favors taking the risk of predation in order to eat.

Human brains are built with the same hunger-motivating brain circuitry. The hungrier we are, the more our brains push us toward eating, and to acquire that food in calorically-dense bundles. By eating before we go shopping, we mute the "Get Calories Now!" signal in our brain.

A nicotine vaccine is a high-tech version of the same strategy of dopamine modulation. Smoking cigarettes activates the brain's reward pathway, resulting in dopamine released in the brain's pleasure center. The "smoking-leads-to-pleasure-leads-to-addiction-leads-to-cancer" pathway is canalized as nicotine binds to receptors inside the brain.

Nicotine vaccines have been designed that stimulate antibodies to prevent the pleasure of smoking. They work by enlisting the immune system to inactivate the nicotine before it gets into the brain. Thus, smoking when vaccinated still introduces the same chemicals into the body, but the vaccine short-circuits the mechanism that would otherwise lead to dopamine release (Table 7).

Table 7 Dopamine modulation changes the reward to temptations

		Feels	
		Good	Bad
Consequence	Good		
	Bad	Cigarette → → → →	Cigarette after vaccination

5 Concluding thoughts

Happiness is a genetic incentive system, shaped by natural selection, to induce evolutionarily successful behaviors (Burnham and Phelan 2020b).

Self-control problems existed prior to the invention of agriculture, but have become more prevalent and pernicious as a consequence of technological innovation. Human genes are increasingly out of sync with our environment owing to agriculture, the industrial revolution, information technology, robotics, and more.

Success today, more than ever, requires self-control. Fortunately, we have powerful brains and a rich set of strategies enabling us to influence our behavior. We need not be lumbering, myopic robots doomed to seeking dopamine today while suffering bad consequences tomorrow.

- *Will power* allows us to choose paths that lead to long-term success. Humans have unmatched abilities to control our appetites and to contemplate and implement behavioral strategies.
- *Innovation* can create novel approaches to generate dopamine without sabotaging our long-term goals.
- *Mast-strapping* employs our prefrontal cortex to anticipate future temptations. We can win by engineering environments that foster success.
- *Dopamine modulation* transforms the payoffs for good and bad choices. We can alter the mental landscape to favor productive behaviors over destructive.

"We have met the enemy and he is us." – Walt Kelly. Our self-control battles derive from adaptations that guided our ancestors to high relative replication rates. Our existence is a consequence of the very drives with which we struggle.

The evolutionary and genetic nature of our conflict has two implications. First, the game is not easily won, nor is any victory permanent. The internal adversary is powerful and persistent. Second, and relatedly, we should not judge too harshly our lapses. Failures of self-control are part of human nature and therefore life. In fact, appreciating the inevitability of temptation can motivate us to deploy (and re-deploy, as necessary) the array of self-control strategies detailed in this article (Table 8).

Table 8 Self-control with evolutionary biology

Phenomenon	People struggle with self-control. People want to perform some behaviors that are bad. People do not want to perform some behaviors that are good.
Neoclassical economics	People do not have self-control problems. Behavior is optimal. All behaviors that are performed are good. All behaviors that are avoided are bad.
Behavioral economics	People suffer from biases and heuristics. Some excellent observations and prescriptive nudges. No underlying theory of the source of self-control issues and no comprehensive approach to solutions. *Post hoc* and *ad hoc*.
Evolutionary biology	Causes: Mismatch and selfish genes. We live in an alien environment. Happiness is a tool built by genes to advance evolutionary goals. Solutions: Will power, innovation, mast strapping, and dopamine modulation.

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