The Limits of Self-Control: Self-Control, Illusory Control, and Risky Financial Decision Making

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ABSTRACT
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Can high self-control have drawbacks? Extensive research has shown the lifelong benefits of self-control for important outcomes such as education, health, income, and happiness. Far less work has been done on its potential negative impacts, where an overwhelmingly positive trait can end up having a less than positive effect on behavior. Recent research suggests that one such side effect may be an increased susceptibility to illusory control (IOC): in situations where actual control is limited but the potential for illusory control is high, high self-controllers may end up being more prone to overconfidence than low self-controllers, and this susceptibility may play out in suboptimal risk-taking behavior. Here, a series of five studies tests this causal chain, exploring the links between self-control and illusory control and the resulting impact of the relationship on risky decisions in the financial domain.

In studies 1 and 2, high self-controllers consistently underperformed low self-controllers on two tasks of risk-taking, the Columbia Card Task and the Lottery Gambling Task. These effects persisted both under stress and in normal conditions. Individuals high in self-control failed to learn as well from negative feedback and were more prone to overconfidence, leading us to posit a causal mechanism rooted in the illusion of control, and specifically, in the positive affect that accompanies it.
Studies 3 through 5 proceeded to test this relationship directly, on a decision-making task that looked specifically at financial risk-taking, the Behavioral Investment Allocation Strategy (BIAS). Across the three studies, we validated our findings from Studies 1 and 2 in the new risk-taking task, by showing that individuals low in self-control consistently outperformed those in high self-control by making more optimal choices and fewer errors throughout the game.

We next tested the precise causal mechanism of the observed decision making patterns by manipulating IOC (Study 3), positive affect (Study 4), and perceived self-control (Study 5). We found that inducing IOC increased the number of errors committed by both high and low self-controllers across the board: individuals in the IOC condition made fewer optimal choices and performed worse overall, confirming our suspicion that IOC can be responsible for sub-optimal choices on financial risk-taking in stochastic environments. However, because the effect was non-selective, the precise causal mechanism and its relations to self-control still remained to be determined.

In Studies 4 and 5, we were able to disambiguate the mechanism behind the underperformance caused by IOC. Specifically, we demonstrated that inducing positive affect (Study 4) reduced the number of optimal choices for low self-controllers on the BIAS task, making them look more like high self-controllers in their decisions. Surprisingly, the induction actually improved performance by high self-controllers. The perceived self-control induction (Study 5) also had a differential effect on high and low self-controllers. It decreased the number of optimal choices made by low self-controllers, again making them look more like high-self-controllers—but, just as with the positive affect induction, it increased the number of optimal choices made by high self-controllers.
The increase in positive affect that accompanied the self-control induction was a significant mediator of the effect, a mediation that held when we pooled data from all three studies into a single affective mediation analysis.

The induction results for low self-controllers confirm our hypothesis that the positive affect that usually accompanies both the illusion of control and high self-control can be an Achilles heel of high self-control in certain environments with limited actual control, creating a feeling of overconfidence that translates into suboptimal decision making. We explain the surprising improvement in performance of high self-controllers under induction conditions, as compared to baseline, by the higher self-reflection ability that accompanies high self-control. Specifically, a situation that is normally “hot” for high self-controllers is cooled through an induction that draws their attention to their high baseline self-control and accompanying positive affect. As a result, they reflect on their choices to a greater extent and act more in line with their usual optimal decision making ability.

We thus both identify a specific environment where high self-control can prove to be a limiting factor for optimal decision making, and suggest a possible way to remedy that limitation, by providing a cooling period and drawing the attention of high self-controllers to the reasons for their sub-optimal strategy (namely, their positive feelings and high opinion of their own self-control). Together, the findings provide tantalizing implications for the sub-optimal market choices that even the most intelligent and successful individuals will make under the right conditions—and equally tantalizing ways to make those choices more sound.
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DEDICATION

To my family, for their endless support—and especially for my mom, Jane, for always being there when I was close to giving up, time and time again.
INTRODUCTION

“I’d be a bum on the street with a tin cup if the markets were efficient,” quipped Warren Buffet in a 1995 interview with *Fortune* (Pare & McDonald, 1995). Booms and busts, bubbles and troughs, panics, depressions, recessions, and simple day-to-day extremes that sometimes make a stock fall to a fraction of its value in a matter of minutes: the erratic back-and-forth of the financial markets make one doubt whether the markets even begin to approach so-called efficient behavior—something that the great investors, including Buffett, are quick to grasp. But why is that the case? Why don’t markets move more efficiently—and how to you explain seemingly inefficient market behavior? What makes the same intelligent, motivated people who otherwise seem perfectly in control of their decisions turn suddenly irrational? What makes them make investment decisions that perpetuate the cycles of boom and bust that have plagued the financial markets for the last century?¹

When the stock market crashed in late 2007, a number of possible explanations was soon put forth: overconfidence; inevitable market cycles; the pursuit of profit at any cost, including unacceptable risk; greed, pure and simple. But what was the underlying cause of the behavioral changes observed in investors?

Studies on intertemporal choice have shown that IQ, income, and education are all inversely related to discounting (Green, Myerson, Lichtman, Rosen, & Fry, 1996; de Wit, Flory, Acheson, McCloskey, & Mauck, 2007; Kirby, Winston, & Santiesteban, 2005). And yet, when it comes to the markets, individuals high on some, if not all, of these measures—the investment professionals and investors most involved in the 2007-8 crisis—repeatedly behave in a manner that seems more in line with the actions normally

¹ Even if we accept the argument that such cycles are an intrinsic part of natural market movement, few
associated with greater discounting and a lack of focus on future events. Increased
discounting and impulsive behaviors are normally studied in relation to pathologies, such
as ADHD, alcoholism and drug abuse, and pathological gambling, but in this instance,
the best and the brightest followed those same behavioral patterns. What went wrong?

One answer lies, paradoxically, in the very thing that makes these investors
successful to begin with: high self-control ability. Could it be the case that a quality that
is normally so beneficial could sometimes backfire, by making individuals more
susceptible to the illusion of control, a perception of still being in control even when
events have fallen outside your immediate power – as, say, in a casino—or a stock
market? It is to the exploration of this possibility that we now turn.

**Theoretical background**

_The benefits of self-control_

The ability to exert self-control is consistently—and almost universally—a
positive life predictor. Centuries before any empirical evidence of its benefits would be
observed, the Greeks were already singing its praises to the skies. Aristotle (2004) went
as far as to include self-control in his list of moral (or ethical) virtues – the subject to
which he devoted one of his most famous works, *Nichomachean Ethics*.

Aristotle’s inclination to raise self-control on an ethical pedestal has, in more
modern times, been proven consistently well-founded. The ability to exercise self-control
has been tied repeatedly to positive outcomes over the entire life course, from general
outcomes, such as income, education, health, and happiness (Mischel et al., 2011; Moffitt
et al., 2011), to more localized outcomes, such as better performance under “hot”
stimulus conditions (Metcalf & Mischel, 1999). As adolescents, children who more
successfully delayed gratification on the original “marshmallow test” (Mischel, Ebbesen, & Zeiss, 1972) have better self-control and are generally more attentive, better able to concentrate, and better at tolerating frustration (Mischel, Shoda, & Peake, 1988; Shoda, Mischel, & Peake, 1990). They also score better on measures of education, such as the Scholastic Aptitude Test (SAT), and have better cognitive and social coping skills (Mischel et al., 1988; Mischel, Shoda, & Rodriguez, 1989; Shoda et al., 1990). As adults, they have greater self-esteem, generally achieve better educational and economic outcomes, and are less likely to use drugs (Ayduk et al., 2000; Mischel et al., 2011). They are also more likely to have lower BMI (Schlam, Wilson, Shoda, Mischel, & Ayduk, 2013), and to be conscientious, both directly and with respect to compliance with norms and academic motivation (Eisenberg, Duckworth, Spinrad, & Valiente, 2012).

Children high in childhood delay ability are also more likely to develop spontaneous self-reflective, metacognitive monitoring strategies earlier and more effectively than those who are low in that ability (Mischel & Mischel, 1983). In other words, they are better able to reflect on their own cognition, learn from past behavior, and develop appropriate response strategies (such as “cooling” a hot stimulus, like a marshmallow, by putting it out of sight or reinterpreting it as a fluffy cloud). Such enhanced metacognition and self-reflection have, in turn, been shown to impact the ability of adults to learn from past errors (Keith & Frese, 2005), to reason more effectively, and to make better decisions (Fletcher & Carruthers, 2012).

The positive effects of self-control extend to other populations, as well. Prisoners serving a prison sentence were less likely to re-offend within a 72-month period if they scored higher on several measures of self-control, even when other risk factors, such as
age of first offense and length of sentence, were taken into account (Grieger, Hosser, & Schmidt, 2011). Children high in self-control at age three were found to be over two times less likely to engage in disordered gambling at ages 21 and 32 than those who had scored low on self-control measures (Slutske, Moffitt, Poulton, & Caspi, 2012).

In a longitudinal study (the Dunedin Multidisciplinary Health and Development Study) that followed 1,000 children from birth to the age of 32 and examined how their childhood self-control influenced later health, earnings, and likelihood to commit criminal offenses, Terrie Moffitt and colleagues discovered that early self-control ability predicted improved physical health and personal finances, as well as a lowered likelihood of substance dependence and criminal behavior (Moffitt et al., 2011). On the flip side, individuals with poor self-control were less able to plan financially for the future, had more money management problems and credit difficulties, were more likely to be convicted of a criminal offense, and were more likely to have problems with drugs or alcohol. These effects held irrespective of intelligence, social class, and mistakes made as adolescents (such as tobacco use, dropping out of school, or having a child).

A number of individuals in the study, however, had managed to move up the self-control gradient: they had overcome low childhood self-control, becoming more self-controlled as they reached young adulthood. These individuals exhibited outcomes akin to those who had always been high in self-control, suggesting that this ability, whether self-taught or externally imposed, can have direct effects on positive life outcomes.

For those unable to increase self-control, the outcome is not nearly as positive. The Moffitt group also looked at a sample of 500 sibling pairs from the Environmental-Risk Longitudinal Twin Study, a study of British twins that had been tracked from birth
in 1994-5 to the present day. Within each pair, the sibling with lower self-control ability had poorer life outcomes into adolescence, despite having shared a substantially similar childhood and family background. Specifically, the twin who had lower self-control was more likely to begin smoking, perform poorly in school, and engage in antisocial behaviors.

Recent brain imaging data suggests that the ability to delay gratification in favor of larger later rewards is tied to prefrontal regions, whereas the choice of immediate rewards is related to limbic, or emotional brain regions (Casey et al., 2011; McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; Rangel, Camerer, & Montague, 2008; Sanfey, 2007; Ochsner & Gross, 2005; Heatherton & Wagner, 2011). Specifically, when it comes to the ability to delay an immediate response, the inferior frontal gyrus is involved in resolving interference among competing actions, such as whether to go or not go on a Go/No-go test of cognitive control (Casey, Tottenham, & Fossella, 2002; Aron, Roberts, & Poldrack, 2004).

When 27 of the original participants in the marshmallow test of delay ability completed two delay tasks while in an fMRI scanner, the low delayers—those who had consistently exhibited lower self-control ability from early childhood—had diminished activity in the right prefrontal cortex, which has been implicated in response inhibition (Somerville, Hare, & Casey, 2011; Casey et al., 1997; Durston, Thomas, Worden, Yang, & Casey, 2002; Ochsner et al, 2004), and increased activity in the ventral striatum, an area that has been implicated in the processing of rewarding and positive cues (Somerville et al., 2011; Galvan et al., 2005; Delgado, Nystrom, Fissell, Noll, & Fiez, 2000), as compared to the individuals with high delay ability (Casey et al., 2011).
Specifically, low delayers had diminished recruitment relative to high delayers of the right inferior frontal gyrus and increased recruitment of the ventral striatum.

These results suggest that high self-control is related to the ability to deploy attention in a flexible manner, governed by the prefrontal circuitry, and to cool, or resist, emotionally hot stimuli—abilities that should have positive effects in myriad circumstances, when cognitive cooling and attentional control can make the difference between a choice that is optimal and one that is less so.

But could there be a negative side to self-control, as well? Could individuals generally high in self-control be more likely to fall prey to certain biases in their decision making, despite their otherwise positive attention and emotion regulation abilities, that could in turn cause them to make decisions less successfully under certain conditions than those lower in self-control? While we know that baseline self-control does not always equal high self-control in a given situation, as self-control can be depleted (Muraven & Baumeister, 2000) and can fluctuate depending on trigger conditions such as stress (Metcalf & Jacobs, 1998), individuals high in self-control have, to our knowledge, never been shown to be more susceptible to performance-deterring phenomena than those low in self-control.

**Illusion of control, overconfidence, and self-control**

Self-control and the illusion of control are seen as, at best, scarcely related topics, and, at worst, opposite ends of a spectrum. For, whereas the former presupposes an active ability to control oneself and, in so doing, control to some extent one’s interaction with the environment, the latter is defined by a semblance of control where none actually
exists, or indeed is even possible. And yet, what if these two concepts were much more closely related than would seem to be the case?

Originally defined by Langer as “an expectancy of a personal success probability inappropriately higher than the objective probability would warrant” (Langer, 1975), illusory control (IOC) has since been implicated in a variety of behaviors where individuals feel inappropriately confident in either their skills or their ability to predict future outcomes given the circumstances. It has received attention in risky lottery investments (Charness & Gneezy, 2010), stock market behavior and financial decision making (Shefrin, 2000; Shiller, 2000), and portfolio diversification strategies (Fellner, 2009). In financial markets, overconfidence has been tied to excess volatility, as stocks overreact to private information (Daniel, Hirshleifer, & Subrahmanyan, 1998), and to poor performance. One study followed 107 traders in four London banks and found that those with the highest illusion of control performed the worst, as measured by managers’ ratings of performance and total renumeration (Fenton-O’Creevy, Nicholson, & Willman, 2003).

Overconfidence is inherent in illusory control: if you perceive yourself to be in control when, in fact, you are not, your confidence in your ability relative to the environment will necessarily be mismatched. Thus, wherever there is illusory control, there is overconfidence—and overconfidence is often the main way in which the effects of illusory control are seen behaviorally. In one classic demonstration of the effect (Oskamp, 1965), clinical psychologists were asked to give confidence judgments on a personality profile. They were given a case report in four parts, based on an actual clinical case, and asked after each part to answer a series of questions about the patient’s
personality, such as his behavioral patterns, interests, and typical reactions to life events. They were also asked to rate their confidence in their responses. With each section, background information about the case increased. As the psychologists learned more, their confidence rose—but accuracy remained at a plateau. Indeed, all but two of the clinicians became overconfident, and while the mean level of confidence rose from 33 percent at the first stage to 53 percent by the last, the accuracy hovered at under 28 percent (where 20 percent was chance, given the question setup).

In her exploration of illusory control, Langer (1975) found a similar effect of information on perceived control and attendant confidence. The more information individuals had about a pure chance lottery, the more confident they were in their ability to win—to the point where they actively refused a chance to trade their original ticket for one where the objective chances of winning were better. What’s more, when participants were given time to familiarize themselves with and practice on a task of pure luck, they rated their confidence in their ability to succeed in that task as significantly higher—even though the chance nature of the task had not changed in any way.

While the literature on illusory control and overconfidence remains distinct from that on self-control, some of the same factors tied to the former have been identified as key correlates in the latter, suggesting a closer relationship than may at first appear to be the case. Overconfidence has been shown to increase with age, education, and knowledge (Bhandari & Deaves, 2006)—three elements that are also associated with high self-control (Mischel et al., 2011). Overconfidence also increases as a function of past success and expertise (Billett & Qian, 2008; Maciejovsky & Kirchler, 2011), again, two elements often associated with high self-control (as high self-controllers tend to experience greater
success in employment and educational outcomes) (Mischel et al., 2011; Moffitt et al., 2011). In one real world example of that dynamic, financial analysts who were more accurate at predicting earnings in the previous four quarters were found to be less accurate in subsequent predictions—without suffering a concomitant loss in confidence (Hilary & Menzly, 2006). As individuals high in self-control normally are highly successful in their life choices, does it not stand to reason that they may be prone to acquiring some of those same biases and predilections? Overconfidence has also been shown to increase with power: the more powerful someone feels, the more overconfident—and the poorer in quality—his decisions (Fast, Sivanathan, Mayer, & Galinsky, 2012). Since high self-controllers tend to be more successful in their career outcomes, it is likely that they are more often in positions of power—and hence, more susceptible to some of these same effects.

Given the chance for honesty, most of us find that, when it comes right down to it, we’re above-average in just about everything we do, whether it be driving (Svenson, 1981) or performing successfully in our professional lives (Camerer & Lovallo, 1999). We also tend to believe that we have above-average chances of attaining positive life outcomes—and below-average chances of chancing upon negative ones (Weinstein, 1980; Taylor & Brown, 1988). But while that perceptual fallacy is usually just that, a fallacy—given symmetrical distributions, only half of the population can be above-average on any given trait or ability, and perceived probabilities of events are usually far removed from actual probabilities (and certainly aren’t related to the positivity or negativity of the outcome in question)—individuals who are high in self-control normally really are above-average in most things, and do have above-average chances of reaching
better life outcomes – and not experiencing some of the more unpleasant possibilities, especially as they relate to earnings and health. Little wonder that they would be more likely victims of the illusion of control.

While little experimental work has been done to determine whether individuals who are higher in actual self-control may also be more likely to fall prey to the illusion of control, such a possibility is not only theoretically justified, but may well shed light on the mechanisms of illusion of control biases, as well as provide a causal mechanism for observed poor performance by high self-controllers in financial risk-taking tasks.

Specifically, we posit the following scenario: in situations where the potential for illusory control is high (i.e., the conditions are most conducive for its development) and actual control is limited, individuals who are normally high in self-control may be more prone to overconfidence and resulting errors in judgment and decision making. Such situations are most likely to arise in environments where (Langer, 1975; Kahneman, 1998):

1. an individual is actively involved as opposed to being a passive observer;
2. there is an opportunity for choice;
3. the outcome sequence seems favorable (i.e., people think they are doing well at the start; one example is the famous hot hand fallacy);
4. there is an extent of familiarity (i.e., the environment or task is a relatively comfortable one);
5. information is available;
6. past success has been achieved; and
7. there is a lack of predictability.
Just such an environment is found in the stock market.

*Stock markets, emotion, and irrationality: A hotbed of overconfidence*

John Maynard Keynes, one of the most influential economists of the twentieth century, believed that the markets he studied were far removed from rational behavior. Instead, he argued, many of the decisions that drove markets one way or the other were the result of little more than a so-called animal spirit. “Most, probably, of our decisions to do something positive,” he wrote, “the full consequences of which will be drawn out over many days to come, can only be taken as the result of animal spirits of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities” (Keynes, 1936, Chapter 12, Section VII). People making weighty financial decisions weren’t being nearly as weighty, as it were, as they thought. Instead, more often then not, they were making choices based on little more than a “spontaneous urge.”

While Keynes’s view remains a controversial one—on the flipside, we have the proponents of Efficient Markets Theory, who argue that markets are driven by rational expectations and that people will act upon the same information in much the same way given the same circumstances—it has been widely adopted by the school of behavioral economics – and by highly successful investors like Warren Buffett. Behavioral economists agree in large part with that idea of the guiding animal spirit: while some rational appraisals are indeed possible, the market’s inherent uncertainty and riskiness makes it a prime environment for emotional decision making and risk-taking decisions that are driven by something other than pure rationality.
What kind of an effect would that have on decision making? In their classic treatment of decision making under risk, Prospect Theory, Kahneman and Tversky (1979) argue that, while people are more sensitive to losses than gains in general, they are risk seeking in long-shot and near-certain loss situations and risk averse in choices involving certain gains. They are also highly susceptible to the framing effects of gains and losses and will exhibit inconsistent preferences with different choice presentations. In situations of stress, such as those marked by high uncertainty and risk, these effects tend to be exacerbated (e.g., Porcelli & Delgado, 2009). Kahneman has since gone on to argue that nowhere is the exacerbation—as well as the role of additional biases that he and Tversky went on to identify over decades of research—more extreme or pronounced than in investor decision making (Kahneman, 1998).

Financial decisions, Kahneman argues, are made in an environment that is inherently complex and high on uncertainty. As such, it precludes the reliance of decision makers on fixed rules, and pushes them instead to go by first-gut responses and intuition. Among the biases that are most likely to affect subsequent investment decisions, overconfidence tops the list. The reason is simple: stock markets are complicated, they are uncertain, they are risky, and they are random. And yet, just as these characteristics should make investors more cautious, they instead open them up to the possibility of interpreting events as they see fit.

We know that, when it comes to agency, randomness is more often perceived as the result of free choice than more deterministic actions (Ebert & Wegner, 2011) and that people are very quick to see a casual regularity in a series of events that is actually random (Gilovich, Vallone, & Tversky, 1985). Just as in basketball, fans of the game are
certain that professional players are sometimes “hot” and sometimes “cold” relative to their overall average, even though in reality, there are no more deviations from long-term percentages than are expected by chance (the “hot hand” fallacy), so in finance, certain fund managers or traders or even inanimate stocks are seen as behaving in better or worse streaks. A random set of market outcomes is thus interpreted as causal when it is in fact no such thing—a misperception of illusory control and false meaning that quickly results in overconfidence and decreased trading performance (Odean, 1999). And while we might expect investors to learn from their mistakes and act more in keeping with rational expectations in the future, we see no such thing. Instead, the exact same forces that made them more prone to overconfidence and an excess sense of control to begin with lead them to hindsight bias, a perception of the past whereby even unanticipated events are explained as inevitable (Christensen-Szalanski & Willham, 1991; Biais & Weber, 2009; Gärling, Kirchler, Lewis, & Raaij, 2009; Kahneman & Riepe, 1998).

The result? Kahneman writes, “The combination of overconfidence and optimism is a potent brew, which causes people to overestimate their knowledge, underestimate risks, and exaggerate their ability to control events. It also leaves them vulnerable to statistical surprises” (1998).

If individuals high in self-control are also more likely to fall prey to illusory control, a stock-market-like environment—and certainly one with high risk and uncertainty—seems like the ideal set of circumstances in which that relationship would come to the forefront.

The current research
In my dissertation, I propose to test the relationship between illusory control and self-control and the effects of that relationship on overconfidence and subsequent choice by examining behavior on a series of risky decision tasks that have the elements necessary for illusory control to develop. I suggest that individuals high in self-control may systematically underperform relative to low self-controllers in stochastic environments, such as the stock market, where actual control is low, and that the relationship is mainly driven by an affective mechanism: namely, that because high self-controllers are generally in control and happier, they may fail to moderate their behavior as necessary in situations where actual control is limited.

On the one hand, given the impressive value demonstrated for self-control in many domains, one might assume that high self-controllers would also make more appropriate decisions on financial risk-taking tasks. Self-control and the ability to delay gratification should make it easier to stay “cool” and rational under conditions of stress and frustration (Mischel et al., 1989; Metcalfe & Mischel, 1999). On the other hand, the life-long success experiences of high self-controllers may result in greater confidence in their decision-making ability and their ability to control personal outcomes, leading to greater illusory control. Hence, it may lead to risk-taking behavior that does not sufficiently incorporate negative external environmental cues, resulting in worse performance under conditions where such incorporation would be helpful to performance.

Here, I focus specifically on the possibility that decision-makers high in self-control might be more likely to succumb to overconfidence and illusory control, and that these biases may in turn affect risk-taking behavior. To test this possibility, I present a series of five studies that will strive to address the relationship between self-control and
the illusion of control—and explore how that relationship in turn affects risky financial
decision making, specifically in stock-market-like environments. The first two studies are
correlational in nature, exploring the connection between self-control, illusory control,
overconfidence, and non-value-optimizing decisions on two games of risky decision
making, the Columbia Card Task (CCT; Figner, Mackinlay, Wilkening, & Weber, 2009;
Figner & Weber, in press) and the Lottery Gambling Task (LGT; Gneezy & Potters,
1997). The subsequent three studies are designed to experimentally manipulate the
observed relationship, to show a more causal link between self-control, susceptibility to
illusory control, overconfidence, and resulting risk-taking decisions, specifically through
manipulating the illusion of control (Study 3), positive affect (Study 4), and perceived
self-control (Study 5), in a stock picking task, the Behavioral Investment Allocation
Strategy (BIAS; Kuhnen & Knutson, 2005), that is more germane to our environment and
behavior of interest. These studies are also aimed to further elucidate the exact
mechanism of action for the observed effects.

At the end of the series of experiments, I hope to demonstrate the following:

(1) High self-control creates above-average susceptibility to illusory control and
overconfidence in situations where actual control is limited.

(2) This susceptibility, in turn, manifests itself in sub-optimal choices on tasks of
risky financial decision making.

(3) The main driver of the observed effects is affective. Namely, individuals high in
self-control have higher positive affect, which leads to lowered sensitivity to
specific task demands and feedback.
(4) If individuals low in self-control are artificially induced to look more like individuals high in self-control, through illusory control, positive affect, or self-control inductions, they, too, will start making fewer optimal choices.

(5) Affect inductions will have the strongest effect, suggesting affect as the main driver of the behavioral differences between low and high self-controllers.

(6) When high self-controllers become aware of their positive affect or self-perceptions, they will improve their performance and begin to look more like low self-controllers, as they are generally superior decision makers.

In exploring these claims, I hope to shed light on the oft-observed irrationality of otherwise highly intelligent and successful market actors and provide means by which such irrationality may be productively addressed.
STUDY 1²

Why is it that, when it comes to the stock market, perfectly rational and highly intelligent individuals sometimes make less than ideal choices, choices that in retrospect seem to belie their intellect and usual control ability? Prompted by the 2007-2008 stock market crash, we decided to examine this question through the lens of self-control ability and stress. Could the crisis have been exacerbated by some bad choices made by decision makers as a function of their self-control?

Since the manipulation of stress in financial-market decisions was not feasible in a field setting, we used an online study to assess vulnerability to illusory control and overconfidence and compare performance of high and low self-controllers on two financial risk-taking tasks—the Columbia Card Task (CCT) (Figner, Mackinlay, Wilkening, & Weber, 2009; Figner & Weber, in press) and the Lottery Gambling Task (LGT) (Gneezy & Potters, 1997)—in a non-stress condition versus a stress condition that used a time-pressure manipulation (to simulate the time pressures experienced by individuals involved in real-world stock trades, where moment-by-moment price fluctuations are often an important element of business success). The CCT measures dynamic risk-taking, with degree of risk increasing over the course of a trial; relatively conservative risk-taking is optimal, as participants face large losses and relatively smaller gains. The LGT measures static risk-taking, as the probability of winning and losing remains constant; optimal behavior is risk-seeking, as the expected value (EV) of the risky investment option is positive. The two tasks were chosen specifically for the flipped

² Results of Studies 1 and 2 were submitted for review as “Can self-control backfire? Illusory control, stress, and financial risk taking.” Konnikova, M., Figner, B., Mischel, W., and Weber, E.U.
risk, to disambiguate behavioral adjustment from general risk-taking propensities from the onset.

We measured self-control both behaviorally (using a Go/No-Go task, where subjects must respond to target stimuli but suppress responses to non-target stimuli) and by self-report (using the Barratt Impulsivity Scale, BIS-11) (Patton, Stanford, & Barratt, 1995). Go/No-Go performance predicts delay of gratification in a longitudinal study of children (Eigsti et al., 2006) and lifetime self-control levels (Mischel et al., 2011; Casey et al., 2011), and there is evidence that performance on both the Delay of Gratification paradigm and the Go/No-Go recruits similar biological and neural systems (Casey et al., 2011; Mischel & Ayduk, 2004). The BIS-11 is also associated with lifetime self-control (Mischel et al., 2011).

We initially expected that high self-controllers would have better metacognitive understanding of the overall strategy for each task and that their performance would be less affected by stress than that of low self-controllers. Consequently, we expected that they would perform better overall on the CCT and the LGT in both the no-stress and stress conditions. We predicted that they would better judge optimal risk, thus employing a better strategy, and consequently, end up with better financial outcomes than low self-controllers.

Instead, we found that high self-controllers failed to adjust behavior as a function of situational information, especially under stress, on the two tasks. We show that the explanation for this surprising result lies in illusory control and the accompanying overconfidence in one’s chosen actions: high self-controllers, in an environment where uncertainty and chance play a role, felt more in control (and hence, more confident and
less anxious) than warranted, and consequently, failed to react to external feedback and modify their behavior when such modification was needed, remaining confident in their initial choice of strategy. In contrast, low self-controllers were more likely to react to environmental cues, namely stress, changes in loss information on the CCT, and feedback from past trials on both tasks, and modify their behavior as a result, thus improving their overall performance.

**Method**

*Participants*

141 participants (102 male, 39 female; mean age = 29 years, *SD* = 4.64) from a national online panel maintained by the Center for Decision Sciences at Columbia University participated in this study, after providing informed consent. Participants received a minimum of $4, but could earn up to $24, depending on their choices.

*Materials and Procedure*

**Go/No-Go Paradigm.** A Go/No-Go task (2 blocks of 140 trials each) paid money for correct and fast “go” responses (button press in response to target letter “X” appearing on the screen) and subtracted money for incorrect responses (button press in response to non-target letter “K” appearing on the screen). Go (X) and No-Go (K) stimuli were presented in unpredictable sequences, each for 500ms, with Go stimuli being much more frequent than No-Go stimuli (each Go stimulus was preceded by 1 to 7 No-Go stimuli). Stimuli were separated by an interstimulus interval (fixation cross) of 500ms. Participants completed this task twice: once at the start of the experiment, and once near the end, before demographic and debriefing questions.

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3 The sample skewed younger and male to represent financial industry demographics. No gender differences were found in this initial sample.
After the first Go/No-Go task, participants were randomly assigned to a no-stress or stress condition of the CCT and the LGT (described below). Stress and no-stress conditions were identical except for a time-pressure manipulation (a timer that counted down in seconds and milliseconds and turned from green to red at the halfway mark) for task responses in the stress condition.

**The Columbia Card Task (CCT).** We used an incentive-compatible 24-round version of the computer-administered CCT (Figner et al., 2009; Figner & Weber, in press). Each round presented participants with 32 facedown cards, arranged in four rows of eight cards. The display indicated how many cards were loss cards (“probability”) and how much was gained or lost for each gain or loss card (“gain amount” and “loss amount”). Participants could turn over cards either until they decided to stop and collect gains for the round, or until they encountered a loss card, at which point the round ended and the loss amount was subtracted from the score of the current round. In the stress condition, participants had 18 seconds to complete each round, and failing to complete the round in that time resulted in the round’s end and a score of zero.4

A full factorial within-subject design varied probability (1 or 3 loss cards), gain amount (10 or 30 points), and loss amount (250 or 750 points). Each combination of factor levels was presented three times, for 24 independent trials, randomly ordered within each block. All feedback was unrigged and three randomly chosen trials were later paid out in real money.

**The Lottery Gambling Task (LGT).** The Lottery Gambling Task (Gneezy & Potters, 1997) had nine identical but independent rounds of an incentive-compatible two-part choice. For each of the rounds, participants received $1 and had to decide how much,

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4 This situation did not occur. Results were not affected.
from nothing to the full dollar, to bet in a lottery that had a 2/3 probability of losing the amount bet and a 1/3 probability of winning 2.5 times the amount bet. For all rounds, the EV of betting was positive. In the stress condition, participants had eight seconds to complete each round. Failure to place a bet in that time resulted in a default bet of zero and advancement to the next round.

Each participant completed both the CCT and LGT, in counterbalanced order.⁵ A stress manipulation check and questions regarding the experience of playing the game followed each task. Participants also completed the BIS-11, the PANAS (Watson et al., 1988), and standard demographic questions.

**Results**

**Self-control measure**

To measure self-control, we created a composite score of average commission errors on both administrations of the Go/No-Go task and scores on the BIS-11 self-control subscale. To arrive at the score, all measures were first standardized, then averaged. Average number of commission errors in the Go/No-Go tasks correlated with the BIS-11 at $r = .32$ ($p < .001$). Commission errors on the two administrations of the Go/No-Go correlated at $r = .7$ ($p < .001$).

As high self-controllers tend to earn more over their lifetime (Mischel et al., 2011; Moffitt et al., 2011), we examined reported income and found that greater self-control was in fact associated with higher incomes, $r = .25$ ($p = .003$) in our sample.

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⁵ No order effects were found.
Participants were divided into high and low self-controllers by a median split\(^6\) on the composite score.

**Perception of stress**

Stress manipulation checks examined participants’ self-reported stress levels following each risk-taking task, as well as the stress items from the PANAS.\(^7\) We combined these two measures into a stress perception score that ranged from one to nine. Stress perception was significantly higher in the stress than the no-stress condition \((F(1,141) = 4.21, p = .04)\). Participants low in self-control perceived greater stress in both conditions than did high self-controllers \((condition, F(1,141) = 4.7, p = .03)\), and greater perceived stress was, in turn, associated with decreased risk-taking on both the CCT, \(r(140) = -.61, p = < .001\), and the LGT, \(r(141) = -.18, p = .03\).

**Illusion of control**

To explain the initially surprising result that better self-control was not accompanied by better risk-taking strategy in either the LGT or the CCT (described in detail below), we examined whether high self-controllers felt more in control, both in general and under stress, and thus failed to adjust their risk strategy to external cues.

To determine whether illusory control was responsible for our behavioral results, we examined participants’ answers to the questions of whether they felt that their success was a result of skill (rather than luck) and whether their strategy was the result of analysis (rather than intuition or gut-feeling). As shown in Figure 1(a), high self-controllers believed more that their success was the result of skill, \(t(138) = 2.42, p = .02\), that they

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\(^6\) A median split was used instead of a continuous measure in keeping with the traditional presentation of self-control findings. Results remain essentially unchanged with self-control as a continuous variable.

\(^7\) The “distressed” item correlated with the other stress items as follows: upset \(r = .52 (p < .001)\); nervous \(r = .47 (p < .001)\); jittery \(r = .76 (p < .001)\); and afraid \(r = .51 (p < .001)\).
reached their solution by a mathematical approach, \( t(138) = 2.54, p = .01 \), and through careful thinking, \( t(138) = 2.88, p = .005 \), and that they used all available information in each trial, \( t(138) = 3.03, p = .003 \), all suggesting that high self-controllers, compared to low self-controllers, perceived their decisions to be based more strongly on skill and analysis. Their self-assessment of performance thus was consistent with a perception of being in control of one’s outcomes.

Consistent with an enhanced perception of their performance as a result of overconfidence, high self-controllers (more than low) reported focusing on the gain amount on each CCT trial, \( t(138) = 2.26, p = .03 \), and thought they did better compared to others, \( t(138) = 2.34, p = .02 \), and were in general lucky at games of chance, \( t(138) = 2.18, p = .03 \), a finding that is especially congruent with illusory control, as, by definition, it is impossible to perform better than others at games of chance. At an emotional level, shown by the PANAS scores in Figure 1(b), high self-controllers felt less upset, \( t(132) = -2.09 (p < .001) \), nervous \( t(134) = -2.55 (p < .001) \), and afraid, \( t(137) = -2.43 (p = .004) \) than low self-controllers. Conversely, they reported feeling stronger \( t(137) = 2.67 (p = .03) \), more excited \( t(137) = 3.76 (p = .02) \), more determined \( t(126) = 3.29 (p < .001) \), and more active \( t(124) = 3.53 (p < .001) \). These reported emotional states often accompany a high sense of control (Camerer & Lovallo, 1999; Alloy & Abramson, 1982; Bandura & Cervone, 1983), and would be expected to drive behavior consistent with feeling in control.

**Risk-taking**

**Lottery Gambling Task (LGT).** Risk-taking on the LGT was assessed by average bet size, with larger bets indicating greater risk-taking. Optimal strategy, based
on maximizing EV,$^8$ would be betting the maximum possible amount, or $1.00, on all trials. An ANOVA with stress and self-control as predictors and average bet size as the dependent variable found that high self-controllers took significantly less risk than low self-controllers ($F(1,141) = 8.79, p = .004$). As shown in Figure 2(a), they bet on average $0.45$ in the no-stress condition and $0.48$ under stress, as compared to bets of $0.62$ and $0.58$, respectively, by low self-controllers.

**Columbia Card Task (CCT).** Risk-taking on the CCT was assessed by the average number of cards turned over across rounds, with a higher number of cards indicating greater risk-taking. An ANOVA with stress and self-control as predictors and average number of cards turned over as the dependent variable found that both high and low self-controllers took less risk in the stress condition than in the no-stress condition, as shown in Figure 3, though the overall difference did not reach significance ($F(1,141) = 2.58; p = .11$). On this task, unlike on the LGT, high self-controllers took more risk than low self-controllers in both conditions ($F(1,141) = 7.25, p = .008$). Just like on the LGT, however, they adjusted their risk-taking less than low self-controllers as a function of situational influences, taking on average 0.86 fewer cards in the stress compared to the no-stress condition, in contrast with the 1.16 fewer cards taken by low self-controllers, though the difference was only a trend and not significant.

Unlike the LGT, the CCT varies by round in the information provided (probability, gain amount, and loss amount). We were therefore also able to see whether any of these external cues were driving differences in risk-taking. Individual-subject regressions of risk taking across rounds provided regression coefficients (betas) for the

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$^8$ Our results do not change in pattern if we assume instead that people show typical levels of risk aversion, rather than assuming them to be risk neutral.
effects of probability, gain amount, and loss amount on risk-taking for each participant. A separate ANOVA for each beta examined the effects of stress condition and self-control level on these betas. The only significant difference between low and high self-controllers was in sensitivity to loss amounts \(F(1, 141) = 14.64, p < .001\). Low self-controllers adjusted their strategy more than high self-controllers when faced with larger losses. High self-controllers in our task largely ignored loss information. This finding is consistent with less anxiety and more confidence among high self-controllers, consistent with high self-controllers experiencing larger illusion of control effects.

**Mediation**

A mediation analysis using multiple mediation bootstrapping (Shrout & Bolger, 2002) examined whether anxiety and/or confidence (aggregated from participant PANAS scores)\(^9\) mediated the relationship between self-control and risk-taking on the CCT.\(^10\) Simultaneously adding the two factors decreased the effect of self-control from \(B = 1.54\) \((p = .01)\) to \(B = .43\) \((p = .44)\), indicating significant partial mediation \((R^2 = .37; F(3,137) = 26.41; p < .0001)\). As shown in Figure 4, higher self-control was associated with decreased anxiety (-.55, \(p = .02\)), and lower anxiety increased risk-taking (-1.6, \(p < .0001\)). While higher self-control was associated with increased confidence (.64, \(p < .001\)), the effect of confidence on risk-taking was not significant, suggesting that it is the absence of anxiety in high self-controllers that drives their increased risk taking, a finding consistent with high self-controllers’ perceived control and lower reports of feeling stressed.

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\(^9\)“Anxiety” incorporates the nervous, upset, and afraid items on the PANAS; “confidence” incorporates the proud, enthusiastic, excited, and interested items.

\(^{10}\) For the LGT, we found only weak evidence for mediation, as the direct effect of self-control on risk-taking remained significant and was only marginally reduced (from \(B = -.14\) \((p = .002)\) to \(B = -.13\) \((p = .01)\), \(R^2 = .08\).
Discussion

Though high self-control is usually highly beneficial, Study 1 identified decision-making situations in which it may actually be seriously disadvantageous. A generalized expectation of control, particularly when unwarranted by circumstances, may lead to selective misreading of information and failure to align risk-taking strategy with local circumstances. Higher self-control can thus increase the likelihood that illusory control, and its emotional correlates, such as low anxiety and high confidence, will encourage non-optimal risk-taking.

We found that high self-controllers perceive less stress than low self-controllers, in both non-stress and stress conditions. Perceived stress decreases risk-taking in both the CCT and the LGT, as one would expect if decision makers misattributed their feeling of stress to the choice task (Loewenstein, Weber, Hsee, & Welch, 2001; Schwarz & Clore, 1983). Consistent with such an effect, we found that overall, low self-controllers play closer to optimal strategy in the CCT, while high self-controllers consistently take more risk than prudent. And, while high self-controllers minimally adjust their risk-taking downward under stress, they do not do so enough to improve performance and not as much as those with low self-control. Similarly, although with a flipped risk pattern, high self-controllers consistently take less risk than advisable in the LGT, while low self-controllers take greater risks and are again closer to optimal strategy.

What would explain this pattern of results? Unpacking the drivers of risk-taking showed greater incorporation of negative information, like stress or losses, into risk-taking decisions by low self-controllers than high self-controllers. Low self-controllers, unlike high, react to large potential losses on the CCT by adjusting their risk downward.
While both groups take more risk after experiencing a loss in both the CCT and the LGT, low self-controllers do so more in both games. In contrast, high self-controllers, unlike low, gradually increase risk-taking in the LGT after winning. This reaction to a chance outcome suggests they feel more likely to win on subsequent rounds as a result and indicates greater susceptibility to illusory control.

Thus, low self-controllers seem more sensitive to external factors, while high self-controllers appear to disregard feedback that runs counter to their sense of situational control. We find further evidence for the presence of illusory control from self-reports, where high self-controllers perceive their decisions as resulting from skill and thought, perceive themselves as generally lucky in chance situations, perceive their results as better than others’, and report low anxiety and high confidence. Actual risky choices are consistent with those beliefs: increasing risk after initial wins on the LGT suggests that a win could confirm the “I am lucky” bias, while ignoring negative information and stress and not adjusting strategy accordingly in either game confirms that disconfirming elements are not incorporated into risk-taking decisions.

These findings have intriguing implications for understanding some of the dynamics that might have played a role in real world financial crises like the 2008 market crash. Plausibly, high self-controllers continued to take too much risk for too long, perceiving themselves to be more in control than warranted and misreading data based on this illusory control, preferentially focusing on the positive. Such dynamics might have contributed to both the formation of the pre-crash bubble and failure to read the warning signs of the crash.
However, Study 1 provides only correlation evidence, on an artificially skewed sample, with limited measures of illusory control. We thus proceed to Study 2, where we run the study on a broader sample and include additional measures of IOC and confidence, to see if the effects will hold.
STUDY 2

Study 2 was run to determine if the self-control and illusion of control effects observed in Study 1 would generalize across age and gender, to observe in greater detail the specific impact of the two emotional correlates of the illusion of control, namely, absence of anxiety and presence of confidence (or overconfidence, as the case may be), and to explore possible repercussions for actual financial behavior. It also included new measures to assess perceived control and confidence.

We replicated the effects observed in Study 1 across gender and age, further validated the measure of self-control with real-world financial outcomes, and demonstrated the connection between self-control and IOC with additional self-report measures and measures of real-world financial behavior.

Method

Participants

185 participants (75 male; 110 female; mean age = 38.83 years, $SD = 15.61$) participated in the study, after providing informed consent. All participants were from a national online panel maintained by the Center for Decision Sciences at Columbia University.

Materials and Procedures

The procedure in Study 2 was identical to Study 1, with the exception of additional measures of confidence, sense of control, and real-world financial behavior. In Study 1, our measure of illusory control and overconfidence was confined to self-report statements, such as “I am generally lucky in games of chance,” and relevant items from
the Positive and Negative Affect Scale (PANAS) (Watson & Tellegen, 1988). Study 2 included additional questions on confidence and sense of control.

**Results**

**Self-control measure**

We used the same compound measure of self-control as in Study 1, and assessed several additional variables known to correlate with high self-control (Mischel et al., 2011; Moffitt et al., 2011). Validating our measure of self-control, we found it positively correlated with education, $r = .16$ ($p = .05$) and income, $r = .21$ ($p = .01$), and inversely with body mass index (BMI), $r = -.18$ ($p = .03$). This replicates the results from Study 1 on income, and adds two additional measures, BMI and education.

**Illusion of control**

To establish whether our results generalize to both genders and a wider range of age groups, we first analyzed the results of Study 2 separately for the two genders, breaking the sample into three age groups (18-28, 29-41, and 42-77), and found very similar results for most parts, albeit typically with stronger effects for young males. Thus, we report the results for the combined sample.\(^{11}\) As shown in Figure 1(a), once again, high self-controllers actually believe that they follow their feelings less than do low self-controllers, $t(177) = -1.87$ ($p = .03$), relying instead on more analytic approaches, consistent with a belief in having specific control over their outcomes.\(^ {12}\) On the PANAS, shown in Figure 1(b) they reported themselves as less scared, $t(182) = -1.8$ ($p = .04$) and less afraid, $t(182) = -1.63$ ($p = .05$), and conversely, more inspired, $t(182) = 2.48$ ($p$

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\(^{11}\) As we were testing specific directional predictions based on Study 1, all of the t-tests reported here are one-tailed.

\(^{12}\) Note that for this and all subsequent illusion of control variables, results are stronger when we only look at younger males, in keeping with the initial sample. However, as we wanted to see if the initial findings would generalize, we are only reporting results for the full sample.
more active, $t(182) = 3.08 \ (p = .001)$, more excited, $t(182) = 2.62 \ (p = .01)$, and more attentive, $t(182) = 1.84 \ (p = .04)$. High self-controllers were also less anxious overall, $t(182) = -0.06 \ (p = .10)$ and more confident $t(182) = 1.76 \ (p = .05)$. These emotional reports are again consistent with the emotional correlates of feeling in control. High self-controllers were also more likely to report that they were following a safe overall strategy on the CCT, $t(182) = 2.22 \ (p = .01)$. Finally, with respect to questions specific to financial confidence, high self-controllers thought they were better than average in their financial decision making ability, $t(183) = 2.77 \ (p = .003)$, were more likely to think they were proficient at managing their finances, $t(183) = 1.59 \ (p = .05)$, were more confident in their ability to make good financial decisions, $t(183) = 1.48 \ (p = .07)$ and get out of difficult financial situations, $t(183) = 1.72 \ (p = .04)$, more satisfied with their overall finances, $t(183) = 2.37 \ (p = .01)$, and ranked their overall financial situation “these days” as significantly better than others’, $t(183) = 2.92 \ (p = .002)$, suggesting that their confidence extends to the real-world financial domain.

Finally, we found that high self-controllers were more likely than low self-controllers to be currently invested in the stock market, $t(182) = 3.02 \ (p = .002)$, and to have been investing there for longer periods of time, between 4-8 years, $t(183) = 3.14 \ (p = .001)$. They were also more likely to have been invested in the market at the time of the 2008 crash, $t(183) = 3.36 \ (p < .001)$, to report having lost a significant portion of their investment in the crash, $t(183) = 3.05 \ (p = .002)$, and to report that the recession had a significant impact on their investment approach, $t(183) = 2.83 \ (p < .001)$. They were also more likely to follow the financial news $t(183) = 1.73 \ (p = .04)$. These findings, even though only self reports, at least begin to suggest potential real-world
ramifications for risky financial decisions for high self-controllers. Moreover, if taken with the behavioral results that suggest a lower risk-taking adjustment in response to negative environmental cues, they suggest that high self-controllers may not always be aware of their own behavior. In other words, even though they report that the recession significantly altered their investment behavior, our experimental evidence, namely that high self-controllers adjust their risk-taking less than low under stress, suggests that this may not actually be the case. If it is true that there is in fact a disconnect between high self-controllers’ perception of their behavior adjustment in the real world and the degree of that actual adjustment, it would provide greater evidence for illusory control and overconfidence biases, as they would perceive themselves to be changing behavior when they are not in fact doing so.

**Effects of illusion of control on risk-taking**

To see how the illusion of control affected risk-taking in the two tasks, in conjunction with self-control and stress, we ran two separate ANOVAs with stress, self-control, and the two emotional correlates of the illusion of control identified earlier, namely anxiety and confidence, as the predictor variables and LGT average bet size as the dependent variable in the first case, and CCT average number of cards chosen in the second. Anxiety and confidence were arrived at by a factor analysis of the PANAS self-report associated emotions.  

\[ F(1,171) = 2.79 \ (p = .09) \]

\[ F(1,171) = 3.24 \ (p = .07) \]

The interaction of stress × confidence was significant \[ F(1,171) = 6.62 \ (p = .01) \].

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13 The following components loaded on the anxiety factor: Distressed, upset, jittery, nervous, afraid, scared, guilty, hostile, irritable, and ashamed. The following components loaded on the confidence factor: Strong, proud, enthusiastic, determined, attentive, active, and excited.
Behaviorally, these results translate to high self-controllers again betting less overall than low self-controllers ($0.44, SE = .03$ as opposed to $0.51, SE = .03$) on the LGT. Anxiety, however, led to an increase in betting, with individuals high in anxiety betting on average $0.51 (SE = .03)$, in contrast to low anxiety individuals, who bet on average $0.44 (SE = .03)$. This effect points to the possibility that a generalized state of anxiety, irrespective of the potential losses associated with a given task, may lead to greater sensitivity to environmental feedback, and consequently, more nuanced behavioral adjustment based on that feedback. Here, then, we also see negative states leading to more optimal decisions, and again, the benefit is conferred on the low self-controllers more so than the high, because they experience greater anxiety. Figure 2(b) shows anxiety’s effect on risk-taking separately for high versus low self-controllers.\footnote{\textsuperscript{14} There are far fewer high anxiety/high self-control individuals in general; hence, while the effect on them is as strong as on low self-control individuals, the subset is quite small relative to the sample of high self-controllers.}

For the CCT, we found a significant interaction, self-control $\times$ anxiety $\times$ stress ($F(1,179) = 4.11; p = .04$), which is shown by stress condition in Figure 3(b) and (c). For low self-controllers, anxiety decreased the number of cards chosen in the stress condition, leading to better overall performance, with 7.6 cards taken ($SE = 0.57$): among the low self-controllers, this was the best performing group (a difference of 1.36 cards as compared to the worst performers, the low-anxiety/high self-control stress group, at 8.96 cards, $SE = .47$), consistent with our prior observations that both stress and the presence of anxiety tend to decrease risk-taking in this paradigm and improve performance for those low in self-control. For high self-controllers, neither anxiety nor stress had an appreciable impact on risk-taking behavior, again consistent with our hypothesis that high self-controllers tend to disregard negative environmental cues and that such cues bear
little on their behavior. The difference between the best and worst performing high self-controller group was only .55 cards.

On the CCT, we were again able to parse out the effect of the three components that varied between rounds (loss amount, gain amount, and probability) on risk-taking, and run separate ANOVAs predicting each of these effects, as described in Study 1, with the addition of anxiety and confidence as predictor variables. Once again, the only major difference between high and low self-controllers was in their response to loss amount, with high self-controllers being less sensitive to loss amount. We found a significant effect for anxiety, \(F(1,178) = 6.57 \ (p = .01)\), though the interaction for self-control \(\times\) anxiety was not significant, \(F(1,178) = 2.56 \ (p = .11)\). The presence of anxiety increased sensitivity to loss amount, with higher anxiety individuals adjusting more to losses, and low self-controllers adjusted to losses more than did high self-controllers, in both the high and low-anxiety groups. As in Study 1, there were no significant differences between groups on the effects of gain amount or probability levels on risk-taking.

Thus, we again see low self-controllers exhibiting greater responsiveness to negative external inputs, be it to stress or to loss information, through heightened anxiety and subsequent adjustment of their behavior, while high self-controllers do not exhibit this effect, remaining both lower in anxiety and higher in confidence and failing to adequately adjust risk-taking on our tasks of risky choice.

*Why the distinct risk-taking patterns?*

One outstanding questions concerns the differential patterns of risk observed on the LGT and the CCT. One possible explanation is that the two tasks are perceived differently. The LGT requires a single decision that translates directly to a monetary
outcome. How much of my money should I bet? On the CCT, there is a disconnect between risk-taking and financial outcomes. Initial decisions generally do not lead to the final financial outcome, and if the participant is lucky (i.e., does not encounter a loss card), he can keep earning without losing, thus encountering more positive than negative feedback, since more gain than loss cards are turned over during the game. That may well be why high self-controllers take more risk on the CCT, driven by the illusion of control and confidence effects described, but not on the LGT, which becomes a much more discrete and specifically financial decision.

While that reasoning is suggested by both studies 1 and 2, results from Study 2 offer additional support, by way of our direct questions about preferred real-life financial strategy in stock market investment. High self-controllers, as opposed to low, stated that they follow a moderate returns approach, whereby they hope to return some profit and not to lose their whole investment, $t(183) = 3.67 (p < .001)$. Furthermore, they reported that they are less likely to take risks in general, $t(183) = -1.68 (p = .05)$. It would therefore make sense that when they perceive the risk of losing real money, their earnings, to be real, they take less risk, despite their general absence of anxiety and confidence in their own ability; those two factors come into play when the prospect of immediate financial loss, based on a discrete investment decision, is not as salient, as on the CCT.

**Discussion**

Study 1 used a sample that was heavily male and young, to mimic the demographics of financial professionals. Our replication with a broader sample in Study 2 shows that the illusion of control effects identified in the first study did indeed generalize across age and gender, and that the emotional correlates drove risk-taking
behavior in the same direction: namely, higher anxiety led to improved risk-taking (more risk on the LGT, less on the CCT), while higher confidence led to increases in risk-taking on both tasks. Low self-controllers again seemed to incorporate negative information more into their behavior than did high, reacting more to stress and exhibiting higher overall anxiety in both paradigms.

We expand the effect to include the perception of real-world financial behaviors and further demonstrate that the emotional correlates that are consistent with an illusion of control impact risk-taking behavior on the CCT and the LGT, and more specifically, the adjustment to negative external cues, such as stress and loss information (which, in both Study 1 and Study 2, is the only differentiating factor on the CCT between high and low self-controllers). High self-controllers experience less anxiety and greater confidence. This affective experience in turn leads to a lack of behavioral adjustment when such adjustment may actually be advantageous. Moreover, the effects of anxiety are stronger in low self-controllers than in high.

Consistent with such an effect, we find that overall, high self-controllers consistently take less risk than do low self-controllers in the LGT, while low self-controllers take greater risks and are thus closer to the optimal strategy (using risk and loss neutrality as benchmark for optimal decisions that maximize financial outcomes in the task). On this task, anxiety leads to an increase in betting, an effect that selectively aids the performance of low self-controllers: low self-controllers, who are high in anxiety, outperform high self-controllers, who are low in anxiety, by an average of $0.27 (out of $1) on each round. On the CCT, we find that high self-controllers take more risk than advisable (Study 1), or fail to adjust their risk-taking sufficiently (Study 2), thus allowing
those low in self-control to either overtake them in performance or continue outperforming them when stress is increased. In Study 2, we show that both anxiety and stress play into this difference in performance and behavioral adjustment.

One possible explanation for the discrepant risk-taking patterns is the differential nature of the financial loss prospect in the two tasks. The LGT has surface similarity to financial investing tasks, whereas the CCT has the surface features of a gambling task. Numerous studies find that people show different degrees of risk taking in investing vs. gambling situations (Weber, Blais, & Betz, 2002), though typically, risk-taking in these two contexts is not analyzed as a function of the self-control ability of the decision makers. As high self-controllers report wanting to follow a more moderate investment strategy, to avoid the possibility of large losses, and report a lower willingness to take risks, in a situation such as the LGT where the risk and loss are specifically financial and both immediate and salient, they may scale down their risk-taking, be it beneficial or not. In contrast, on the CCT, absent the same immediacy, they can rely on their confidence in their own luck in chance environments. In both cases, erroneous starting beliefs lead to poor strategic choices, which are then compounded by a subsequent failure to reassess or adjust the strategy given the circumstances. It would stand to reason, then, that the true failure is to update risk-taking strategy strategically in an environment where there is little control over actual outcomes and where negative environmental cues might actually contain important information, sticking instead to a strategy dictated more by original surface considerations.

While high self-controllers would still be expected to perform well in any environment where they actually have control over their outcomes, or where there is no
disconnect between their initial strategic assessment and the situation at hand, they may falter in a stochastic environment where either of the following is true: (1) There are salient financial choices that may lead to immediate actual loss, as in the LGT, where high self-controllers’ general aversion to risking their own capital and taking something that they perceive to be a financial risk might lead them to take too little risk at the end of the day; or (2) The financial gains and losses are somewhat masked by the non-immediacy of the potential loss, as in the CCT, where the incremental perception that control is possible is further compounded by the fact that only three rounds will actually matter, so if a high self-controller believes himself to be lucky, he has two reasons to take greater risks: the first, that he won’t hit a loss card because he is “good” in chance situations, and the second, that even if he were to hit a loss round, it is not likely to count, as again, his luck will see him through to payment of the more successful rounds. We have, then, two major factors at play, namely, the nature of the perceived situation and the disconnect between perceived control and actual control. Each of these factors can impede performance for high self-controllers under circumstances where there is little actual control, and an initial assessment of game strategy may differ from the assessment one would obtain by looking at feedback from the environment.

These findings strengthen our hypotheses about the dynamics that might have played a role in real world financial crises like the 2008 market crash, which seems to have more of the characteristics of the CCT: financial losses are possible, but not immediate, and decisions are made incrementally and not as all-or-none decisions. They show that the effects of Study 1 are consistent, not an anomaly, and that they generalize across age and gender. However, they remain correlational—and the CCT and LGT are
still removed from the world of stock market decisions. Thus, for our next series of studies, we propose to use a new task which looks at more germane financial behavior, and we further propose to manipulate the three variables of interest—the illusion of control, affect, and self-control—to determine what are the precise causal mechanisms underlying the observed differences in risk-taking behavior between low and high self-controllers.
STUDY 3

In Study 3, we wanted to move beyond the observed correlations of Studies 1 and 2—and to do so with a task that was less removed from the real-world financial behavior we were trying to capture. To do so, we manipulated the illusion of control, adapting a standard measure from the 1970s (Langer & Roth, 1975) to an online, incentive-compatible environment, and used as our main dependent variable the Behavioral Investment Allocation Strategy (BIAS; Kuhnen & Knutson, 2005), which—apart from being a more direct measure of financial risk-taking in a stock market-like setting—is known to be mediated by affect (Kuhnen & Knutson, 2005; Knutson & Bossaerts, 2007; Samanez-Larkin, Wagner, & Knutson, 2010), in line with our predicted mediation.

We found that, once again, high self-controllers were outperformed by low self-controllers when it came to making optimal decisions. We further found that inducing IOC increased the number of errors committed on the BIAS task by both high and low self-controllers: individuals in the IOC condition made fewer optimal choices and performed worse overall, confirming our suspicion that IOC can be responsible for sub-optimal choices on financial risk-taking in stochastic environments.

Method

Participants

133 participants (64 male, 69 female; mean age = 36.3, SD = 12.33) from a national sample took part in the study, after providing informed consent. For this and all subsequent studies (Study 4 and Study 5), we used participants from an online sample known as Mechanical Turks, an online labor system run by Amazon.com. These workers have been shown to be highly reliable and motivated, providing data in keeping with
strict quality standards and responses that are largely in line with traditional laboratory samples (Mason & Sury, 2010; Goodman, Cryder, & Cheema, 2012). Paolacci, Chandler, and Ipeirotis (2010) are among the groups that are currently replicating classic findings from social and cognitive psychology in this group, and so far, have demonstrated a successful replication of three classic experimental studies: the Asian Disease Problem (Tversky & Kahneman, 1981), the Linda problem (Tversky & Kahneman, 1983), and the physician problem (Baron & Hershey, 1988; Experiment 1, Cases 1 and 2).

In keeping with Amazon best practices, participants were paid $2 for their participation (significantly higher than the average hourly wage for the site). They were also entered into a lottery where they would be eligible to win the payouts from their decisions in the entire study, as all behavioral measures were incentive-compatible.

**Materials and Procedure**

**Go/No-Go Paradigm.** The same Go/No-Go task (2 blocks of 140 trials each) that was used in Studies 1 and 2 was used to assess self-control in Study 3. Stimuli were separated by an interstimulus interval (fixation cross) of 500ms.

After completing the Go/No-Go, participants were randomly assigned to an illusion of control (IOC) induction or control condition, two versions of the Coin Flip game.

**Coin Flip.** The Coin Flip is an IOC manipulation adapted from Langer & Roth (1975). Simplifying Langer’s original design, we employed a simple descending active vs. random active design, the two conditions that were found to have the highest and lowest effect, respectively, in Langer’s original study and subsequent replications. Participants in both conditions had to actively choose heads or tails on 30 rounds of a coin toss. After
each choice, the computer flipped the coin, and the participant saw whether he won or lost. The sequence of wins and losses was predetermined in both conditions, using the sequences originally developed by Langer. In the descending (IOC) induction condition, wins were clustered at the beginning of the trials, to form the following sequence, with W signifying a win and L, a loss:

WWWLWWWLLLWWWLLWLWWWLLLL

In the random (control) condition, the wins were interspersed with the losses in a seemingly random pattern, to form the following sequence:

WLWLWLWLWWLWLWLWLWWWLWLWLWLW

The total number of wins and losses was constant for both sequences; the only difference was the order of the outcomes.

We further modified Langer’s original induction by including an incentive-compatible dimension as a direct measure of confidence. On each round, participants could make a sliding bet on each outcome, from $0 to $0.05. They were told that they would be entered into a lottery where the winnings (or losses) from the game would be added to (or subtracted from) their total earnings for the study, creating a strong incentive for bets that corresponded to actual confidence in outcome correctness. Following the task, we also included Langer’s standard induction check questions: (1) How good do you think you are at predicting outcomes like these? (0 = very bad; 5 = average; 10 = pretty good); (2) How well do you think you would do on the task if you were distracted? (0 = much worse; 10 = much better); and (3) How much do you think you would improve with practice? (0 = not at all; 5 = some improvement; 10 = a good deal). We anticipated,

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15 While bets of $0-$0.05 may not seem like a great deal of money, recall that participants were being paid only $2 for a study that lasted close to one hour and that these earnings presented an opportunity to change that amount significantly—by up to $1.50, or almost the entire base earnings amount.
however, that the bet size would be a more valid indicator of induction strength and subsequent choice confidence, as it had actual consequences for overall earnings.

Behavioral Investment Allocation Strategy (BIAS). After completing the Coin Flip task, participants proceeded to the major dependent measure of the study, the Behavioral Investment Allocation Strategy (BIAS; Kuhnen & Knutson, 2005).

The task was an incentive-compatible, computer-administered game of financial risk-taking, with 10 blocks of 10 trials each. On each trial, participants were presented with three assets: two stocks and one bond. At the beginning of each block, the two stocks were randomly assigned to either a “good” stock or a “bad” stock condition, such that in any block, one stock was always good and the other, always bad. The good stock always had the following payoff probabilities: +$10 with a 50% probability; +$0 with a 25% probability; -$10 with a 25% probability. The bad stock, on the other hand, always had flipped payoff probabilities: +$10 with a 25% probability; +$0 with a 25% probability; and -$10 with a 50% probability. The bond always paid out $1. On each trial, earnings were drawn independently from these distributions. The assignment of “good” and “bad” stock was repeated at the start of each block of 10 trials.

Each trial proceeded as follows (See Figure 5). First, participants saw the three assets on a screen. The word “CHOOSE” then appeared, and participants pressed one of three keys (1 for Stock T, 2 for Bond C, and 3 for Stock R), to select one of the three assets. They were then shown their earnings for the current trial and the experiment up to that point, and after a delay of 2 seconds, they were shown the “market” value of all three assets (in other words, what they would have gained or lost had they chosen any one of the three) (Figure 5).
They then moved on to the next trial.

Participants were given full information about the task, including the possible probability distributions, at the start of the game. They also completed five practice trials and answered questions about possible payoffs to ensure full understanding of game rules. Incorrect answers prevented participants from advancing to the main task. At the start of each block of trials, participants were once again reminded of the rules, and were told to keep in mind that the good and bad stock assignments would be repeated at the start of the block, irrespective of stock identity in preceding blocks.

To create a more life-like environment, participants were also subjected to a time constraint: they had three seconds to make their choice on each trial. A failure to make a choice would result in no earnings for the trial.

Participants were told that one-tenth of their earnings from the BIAS task would be added to their total earnings for the study, and that they would be entered into a lottery to collect those earnings after study completion.

Immediately following the BIAS, participants completed the PANAS, as an affect check, and answered a series of questions about their perception of the task, including their confidence in their responses and their level of stress during the task (See Appendix A).

**BIAS background and use rationale**

Our decision to switch from the CCT and LGT to the BIAS was motivated by several factors. First, the BIAS is an actual investment task, with stocks and bonds. As such, it taps into the financial decisions we are trying to capture and helps increase the
apparent controllability of the outcomes (even though they are still both risky and uncertain, as in the real stock market). It also allows us to observe learning patterns, as participants must sample to determine the nature of each stocks. It captures two types of deviations from optimal rational strategy, both important to investment success, as would be predicted by a pattern of Bayesian updating: risk-seeking mistakes (choosing a stock when the probability distributions given past choices favor a bond) and risk-aversion mistakes (choosing a bond when the probability distributions given past choices favor a stock). Finally, it has been tied to affective differences in the brain, thus supplementing a causal affect story for the observed behaviors.

The BIAS task was first created by Camelia Kuhnen and Brian Knutson (2005) to examine investor behavior in picking stocks: namely, why did individual investors systematically deviate from optimal behavior, be it by taking on too little or too much risk relative to the available information? Kuhnen and Knutson assumed that emotion might be to blame, positing that neural activation, specifically, in the nucleus accumbens (NAcc) of the ventral striatum and anterior insula—linked to anticipation of monetary gains and positive aroused affect in the former case (Knutson, Delgado, & Phillips, 2008; Knutson & Bossaerts, 2007; Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001; Knutson, Taylor, Kaufman, Peterson, & Glover, 2005; Bjork et al., 2003) and to negative affect in the latter (Wager, Phan, Liberzon & Taylor, 2003; Simmons, Matthews, Stein, & Paulus, 2004)—would predict financial choices. They found that NAcc activation preceded both risky choices and risk-seeking mistakes and that anterior insula activation preceded riskless choices and risk-aversion mistakes, lending support to an affective model of sub-optimal economic decision making in a stock market environment.
In a 2010 follow-up (Samanez-Larkin, Wagner, and Knutson, 2010), they further found that rational choices on the BIAS correlated with real-world financial assets. That is, individuals who had made a greater number of rational choices also reported having more real-world wealth. They also found that rational choices decreased with age, even after controlling for education, numeracy, and performance on a number of tasks of cognitive ability, namely Letter-Number Sequencing, Digit Span, and Trail-Making Test. Specifically, they saw an increase in risk-seeking and confusion mistakes (see also Mata, Josef, Samanez-Larking, & Hertwig, 2011). They posited that a learning deficit may lead to greater risk-taking on the task, and that older adults were not learning as quickly—the same prediction we made, in turn, for high self-controllers.

**Individual difference measures.** In addition to our main variables of interest, the study included several individual difference measures that were chosen for their relation to self-control and illusory control. Specifically, we administered the Internal-External Locus of Control Scale (Rotter, 1966); the Generalized Expectancy for Success Scale (GESS; Fibel & Hale, 1978); the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995); and the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). We also included a number of health and demographic measures.

The individual difference measures were interspersed throughout the study and counterbalanced with the IOC induction to avoid any order effects.\(^{16}\) Demographic information was always completed as the final step in the study.

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\(^{16}\) No order effects were found.
Results

Self-control measure

Following the results of Casey et al. (2011; also see Eigsti et al., 2006), whose findings demonstrated that performance on the delay of gratification task in childhood predicted the efficiency of performance on the Go/No-go (as seen specifically by difficulty suppressing an inappropriate “go” response on the “nogo” trials) in adulthood, we used total commission errors, or false alarms, on the Go/No-go as our measure of self-control. While we also looked at reaction time (RT) and errors of omission, those were used in exclusion criteria and not as part of the self-control measure, in keeping with the methodology of Casey et al. (2011).

To validate our measure of self-control, we looked at correlations with other known correlates of self-control, such as the BIS-11 scale and age. As expected, the commission errors correlated significantly with the BIS-11 self-control subscale ($r = .22$; $p = .01$), the BIS-11 attention subscale ($r = .21$, $p = .02$), the BIS-11 attentional second-order factor subscale ($r = .19$, $p = .03$), and the BIS-11 non-planning second-order factor subscale ($r = .17$, $p = .05$). We found a negative correlation with age ($r = -.195$, $p = .03$), in keeping with the common finding that self-control tends to increase in older adults.

Effect of the illusion of control induction

Induction validation

An independent samples t-test was conducted to compare the illusion of control in the induction versus the control condition. We had one major behavioral measure of illusory control in the coin flip: the amount of money each participant bet on the

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17 In Studies 3-5, the correlation with the BIS-11 self-control subscale remained significant but was not high enough to warrant the creation of a composite measure. We felt that commission errors alone would provide a cleaner analysis and used the BIS-11 as further validation of our measure.
correctness of his guess on each trial, a direct behavioral measure of outcome confidence. We found a significant difference in total amount bet ($M_{control} = .74$, $SD_{control} = .48$, $M_{induction} = .96$, $SD_{induction} = .52$; $t(131) = -2.52, p = .013$) in the two conditions. In other words, those in the induction condition bet on average $0.22$ more over the course of the coin flip’s 30 trials, suggesting a greater degree of confidence in the correctness of their choices and validating our induction manipulation.

*Induction effect on BIAS self-reported IOC*

As a result of increased bet size, participants in the IOC condition actually earned significantly less than those in the control condition ($M_{control} = .03$, $SD_{control} = .07$, $M_{induction} = -.01$, $SD_{induction} = .06$; $t(131) = 3.66, p < .001$) on the coin flip – and yet, their perception of superior performance remained largely in place throughout the remainder of the study, affecting their subsequent perception of their performance in the BIAS game. Specifically, those in the induction condition thought that they were following the best strategy in the game more often than those in the control condition ($M_{control} = 2.61$, $SD_{control} = 1.31$, $M_{induction} = 3.06$, $SD_{induction} = 1.31$; $t(131) = -1.79, p = .07$) and stated that they felt more in control during the game than did those in the control condition ($M_{control} = 2.5$, $SD_{control} = 1.26$, $M_{induction} = 2.96$, $SD_{induction} = 1.49$; $t(131) = -1.9, p = .06$). They also reported marginally lower levels of stress ($M_{control} = 2.68$, $SD_{control} = 1.45$, $M_{induction} = 2.3$, $SD_{induction} = 1.37$; $t(131) = 1.56, p = .12$).

*Induction effect on PANAS affect measure*

We then turned to our main measure of affect, the PANAS. The IOC manipulation impacted negative affect in our sample: specifically, those in the induction condition reported feeling less guilty ($M_{control} = 1.47$, $SD_{control} = .99$, $M_{induction} = 1.20$;
$SD_{induction} = .62; t(131) = 1.91, p = .05$, nervous ($M_{control} = 1.81, SD_{control} = 1.11, M_{induction} = 1.52; SD_{induction} = .86; t(131) = 1.67, p = .09$), and afraid ($M_{control} = 1.39, SD_{control} = .86, M_{induction} = 1.17; SD_{induction} = .53; t(131) = 1.79, p = .09$) than those in the control condition. Overall level of anxiety was marginally significant ($M_{control} = 6.79, SD_{control} = 3.38, M_{induction} = 5.93; SD_{induction} = 3.01; t(131) = 1.55, p = .12$).

As predicted, then, participants felt less anxious as their illusion of control increased.

**Induction effect on high versus low self-controllers**

At the beginning of the study, we were afraid that high self-controllers would exhibit a ceiling effect in their overall IOC levels, resulting in a lack of induction efficacy for half the sample. We therefore performed an ANOVA, with amount bet on the coin flip as the dependent variable and induction condition and self-control level as the independent variables, to see whether the manipulation had a differential effect on high versus low self-controllers. We found that self-control was highly significant ($F(1,133) = 10.36, p = .002$) and the IOC induction was significant ($F(1,133) = 4.50, p = .04$). The interaction effect, however, was non-significant ($p = .94$), suggesting that the induction worked with equal strength on both high and low self-controllers. Both high and low self-controllers continued to bet more overall in the IOC induction condition, regardless of baseline level of control (see Figure 6).

**Risk-Taking and performance on BIAS**

Our main measure of interest was performance on the BIAS task: how would high self-controllers perform relative to low, and would the IOC induction make a difference in performance? To answer these questions, we first computed the optimal choice for
each participant for each trial of each block, given the available information. We defined optimal behavior as the choice a risk-neutral agent would make on any given trial. Specifically, the rational risk-neutral actor should only choose the stock if he expects the payoff to be at least as large as the $1 risk-free payoff associated with the bond. On every round, he should update his belief in the probability that each stock is the optimal one according to Bayes’ rule.

To compute the optimal portfolio selection strategy, we followed the methodology outlined by Kuhnen & Knutson (2005; also see Samanez-Larkin et al., 2010), the creators of the BIAS task. Thus, for this study, as well as Studies 4 and 5, we make the following assumptions.

Calculating optimal portfolio selection strategy

During each trial, $\tau$, in each block, the risk-neutral rational agent should pick stock $i$ if he expects the dividend, $D_i\tau$, from the stock to be at least as large as the earnings he would receive from choosing the bond, or $1$. In other words, he will pick the stock if:

$$E[D_i\tau|I_{\tau-1}] \geq E[DB\tau|I_{\tau-1}] = 1,$$

where $I_{\tau-1}$ is the information set, up to trial $\tau-1$. So, $I_{\tau-1} = \{D_i|\forall t \leq \tau-1, \forall i \in \{Stock~T,~Stock~R,~Bond~C}\}$.

Let $x_i\tau = Pr\{Stock ~i = Good | I_{\tau-1}\}$. Then:

$$E[D_i\tau|I_{\tau-1}] = x_i\tau [0.5*10+0.25*(-10)+0.25*0] + (1-x_i\tau)[0.5*(-10)+0.25*10+0.25*0] = 2.5*(2x_i\tau - 1)$$
The rational risk-neutral agent will only pick stock $i$ when his belief $xτi$ is such that:

$$3.5 \times (2xτi - 1) \geq 1 \iff \geq 0.7$$

If the rational risk-neutral agent’s beliefs are weak (in other words, if $xτi < 0.7$, $∀i \in \{Stock T, Stock R\}$, the optimal strategy continues to be for the agent to choose the sure payoff of the $1 bond. In each round, he will update his belief according to Bayes’ Rule and choose accordingly.

As per Kuhnen & Knutson (2005), we define the uncertainty of each trial as $\min (xτi, xτj)$, where $i, j \in \{Stock T, Stock R\}$ and $i \neq j$.

**Measuring optimal choice and risk-seeking and risk-aversion mistakes**

After computing the optimal strategy for each trial, we created a simple binary variable for each participant for each trial of each block: 0 for a non-optimal choice, and 1 for the optimal choice. We then created a second variable, to code for each non-optimal choice. If the first binary variable was 0 (i.e., a non-optimal choice), we then ran a comparison between observed choice and optimal choice to code for either risk-averse or risk-seeking errors in behavior. We then proceeded to analyze both the overall effect of self-control and the effect of the IOC induction on BIAS behavior.

To mirror our approach in Studies 1 and 2 and for ease of interpretation and report, in keeping with usual reporting of results in studies of self-control (see, for example, Casey et al., 2011; Mischel et al., 2011), we performed a median split on our key measure of self-control and proceeded to analyze the data with a series of ANOVAs. However, as this approach does gloss over much of the individual-level data provided in the BIAS, we
supplemented this analysis with a hierarchical (i.e., mixed) generalized linear model fit by restricted maximum likelihood ratios (REML). The results of the analyses, while providing greater granularity of interpretation, mirror substantially the results presented in the bodies of Study 3, 4, and 5. The full models and findings are provided in Appendix B. Here, as well as in the Results section of studies 4 and 5, I will be reporting only the results of the median split ANOVA analyses.

Risk-taking in high and low self-controllers on the BIAS

To measure behavior on the BIAS, we performed three separate ANOVAs, with self-control and IOC induction condition as the predictor variables and optimal choices, risk-seeking choices, and risk-averse choices as the dependent measures in the first, second, and third ANOVA, respectively.\(^{18}\) We found that, just as they had done on the CCT and LGT, high self-controllers once again performed worse overall on this task of financial risk-taking: they committed more errors across the board. They made more risk-averse mistakes in all conditions, \(F(1,129) = 5.92\ (p = .02)\), committing an average of 44.39 errors (\(SD = 21.57\)), as compared to the 39.04 errors (\(SD = 18.99\)) committed by their low self-control counterparts. Condition was also highly significant, \(F(1,129) = 6.44\) (\(p = .01\)), with both high and low self-controllers committing more errors in the IOC induction (\(M_{low,control} = 32.00; SD_{low,control} = 18.27; M_{low,induction} = 43.51, SD_{low,induction} = 18.27; M_{high,control} = 42.31; SD_{high,control} = 20.28; M_{high,induction} = 46.6, SD_{high,induction} = 23.00\) (see Figure 7). For risk-seeking mistakes, the results were only marginally significant, \(F(1,129) = 3.38\ (p = .06)\), and the optimal choice analysis, while directionally correct (high self-controllers made fewer optimal choices as compared to low across the board, and especially in the IOC induction condition), was non-significant.

\(^{18}\) For all analyses, we did not find any significant age or gender effects.
Affect mediation

A mediation analysis using multiple mediation bootstrapping (Shrout & Bolger, 2002) examined whether anxiety and/or confidence (aggregated from participant PANAS scores)\textsuperscript{19} mediated the relationship between self-control and risk-taking. Unfortunately, we found no significant mediation in this study: while there was a marginally significant effect of confidence on risk-averse mistakes ($B = .37, p = .06$), the baseline effect of self-control remained significant even after the mediation ($B = .37, p = .05$ before mediation; $B = .37, p = .04$ after mediation).

Discussion

In Study 3, we replicated the behavioral results of Studies 1 and 2 by showing that individuals high in self-control committed more errors and performed worse on a task of risky decision making. As the BIAS is a much more germane measure to our main behavior of interest, real-world financial risk-taking in a stock market environment, finding this overall effect was an important first step in translating our earlier findings to a more realistic setting.

We then went a step beyond earlier work by experimentally manipulating the illusion of control. In theory, if increased susceptibility to illusionary control is indeed responsible for the relatively poor performance of high self-controllers in such stochastic environments, inducing IOC in low self-controllers should have an adverse impact on their performance. In practice, we found just such an effect, with low self-controllers committing more errors in the induction as opposed to the baseline condition.

\textsuperscript{19} Our positive affect “confidence” composite measure consisted of the interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, and active items of the PANAS. Our negative affect “anxiety” composite measure consisted of the distressed, upset, nervous, and afraid items of the PANAS. The same aggregate measures are used in Study 4 and Study 5.
However, we did not find an interaction effect between self-control and condition, nor did we find a significant affect mediation, as we had expected. We attribute this to the strong effects of baseline self-control relative to the IOC induction: while the induction did affect initial self-perception and behavior, it was not strong enough to override the baseline differences in the two groups.

From Study 3, we can conclude that the IOC does in fact cause a decrease in performance accuracy in risky financial decision making, and that the relationship is causal, not purely correlational. We do not, however, have deeper insight into the precise reasons for this effect.

We now turn to two further manipulations, one of affect (Study 4), and one of self-control directly (Study 5), in an attempt to further clarify the relationship between self-control, illusory control, and financial risk-taking, and pinpoint why exactly the illusion of control impedes performance – and how low and high self-controllers differ from one another in their behavior and perceptions.
STUDY 4

Study 4 was designed to further clarify the causal link between self-control, illusory control, and risk-taking behavior, by disambiguating the exact mechanism through which illusory control impedes performance—and, ideally, seeing why that mechanism is so prevalent in high self-controllers, even in a baseline state. Motivated by the tantalizing differences in affect observed in Studies 1 and 2, findings that have linked high self-control to higher overall happiness levels and higher self-esteem (Ayduk et al., 2000; Mischel et al., 2011), and work that has linked performance errors on the BIAS to anticipatory affect (Kuhnen and Knutson, 2005), we posited that affect might be the key driver of the observed behavioral effects. In Study 4, we tested the affect mediation hypothesis: does the illusion of control promote risk-taking and inhibit optimal learning by boosting positive affect?

We found that a positive affect induction reduced the number of optimal choices for low self-controllers on the BIAS task, making them look more like high self-controllers in their decisions. This finding confirmed our initial suspicion that affect may be the main driver of the behavioral differences between low and high self-controllers and may be the key mediating mechanism in the susceptibility of high self-controllers to the illusion of control in limited control environments.

Surprisingly, we also found that the induction actually improved performance by high self-controllers. Taken with parallel results from Study 5 (see Study 5 Results and Discussion), we attribute this improvement to a self-reflection and self-distancing mechanism, whereby drawing high self-controllers’ attention to their positive affect gives them the distance required for accurate reflection (e.g., Schwarz & Clore, 1983)—and a
subsequent behavioral adjustment on the risk-taking task (See Discussion section for full explanation).

**Method**

**Participants**

112 participants (57 female, 55 male; mean age = 38.04, $SD = 12.35$) from an online national sample, Amazon’s Mechanical Turks, took part in the study, after providing informed consent. They were paid $2 for their participation and entered into a lottery to win the remaining earnings from the study.

**Materials and Procedure**

Study 4 was structured identically to Study 3, with the exception of the induction condition. Instead of the IOC coin flip manipulation, immediately after the Go/No-go concluded, participants were randomly assigned to either a positive affect induction or a control condition. We used a standard positive affect induction, where participants were asked to write a brief paragraph about a time they made money in the stock market. In the control condition, they were asked to briefly describe a familiar stock.\(^{20}\) Our induction centered on the stock market so as to ensure that the affect was integral and not incidental to the study (for a discussion on the importance of the distinction, see, for example, Cohen, Pham, & Andrade, 2008 and Bodenhausen, Mussweiler, Gabriel, & Moreno, 2001).

**Results**

**Self-control measure**

We employed identical methodology to Study 3 for our measure of self-control. We once again used total commission errors on the Go/No-go as our main measure and

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\(^{20}\) See Appendix A for full induction text.
subsequently performed a median split to separate our sample into low and high selfcontrollers. We validated the measure by once again comparing it to other standard correlates of self-control. This time, commission errors correlated only marginally with the BIS-11 attention subscale ($r = .16, p = .1$) and the BIS-11 attentional second-order factor subscale ($r = .17, p = .07$). However, we found the same significant inverse relationship with age as previously ($r = -.23, p = .02$), once again validating the known relationship between age and self-control, with self-control increasing as a function of age.

**Effect of the affect induction**

*Induction validation*

An independent samples t-test was conducted to compare positive and negative affect in the induction versus the control condition. Our major measure of affect was self-reported affect in the PANAS, as well as a measure of how stressful participants found the BIAS task. Individuals in the induction condition reported feeling significantly more excited ($M_{control} = 2.78, SD_{control} = 1.16, M_{induction} = 3.37, SD_{induction} = 1.29; t(110) = 2.57, p = .01$), enthusiastic ($M_{control} = 2.97, SD_{control} = 1.18, M_{induction} = 3.37, SD_{induction} = 1.28; t(110) = 1.74, p = .09$), proud ($M_{control} = 2.50, SD_{control} = 1.19, M_{induction} = 2.94, SD_{induction} = 1.34; t(110) = 1.86, p = .07$), and determined ($M_{control} = 3.29, SD_{control} = 1.34, M_{induction} = 3.70, SD_{induction} = 1.14; t(110) = 1.74, p = .09$) than those in the control condition, with an overall significant greater positive affect ($M_{control} = 34.26, SD_{control} = 9.62, M_{induction} = 37.83, SD_{induction} = 9.42; t(110) = 1.99, p = .05$). They also reported feeling significantly less upset ($M_{control} = 1.90, SD_{control} = 1.2, M_{induction} = 1.50, SD_{induction} = .84; t(110) = -2.02, p = .05$) and ashamed ($M_{control} = 1.55, SD_{control} = 1.06, M_{induction} = 1.2, SD_{induction} = .63$);
\( t(110) = -2.09, \ p = .04 \). On the illusion of control questions that followed the BIAS, they reported themselves more likely to have performed well overall than did those in the control condition \( (M_{control} = 2.83, SD_{control} = 1.31, M_{induction} = 3.39, SD_{induction} = 1.27; \ t(110) = 2.30, \ p = .02) \) and reported having followed a safer overall strategy \( (M_{control} = 3.21, SD_{control} = 1.21, M_{induction} = 3.72, SD_{induction} = 1.24; \ t(110) = 2.23, \ p = .03) \), in keeping with prior findings that individuals higher in self-control (and thereby, in positive affect) are more likely to perceive themselves as behaving in a less risky fashion than warranted by actual behavior.

**Induction effect on high versus low self-controllers**

We suspected that we might find a ceiling effect in high self-controllers, reducing the efficacy of the induction on that group. To determine whether the induction condition differentially affected high versus low self-controllers, we performed an ANOVA, with the PANAS total positive affect score as the dependent variable and induction condition and self-control level as the independent variables. While the affect induction remained significant \( (F(1,111) = 4.23, \ p = .04) \), the interaction was insignificant \( (p = .26) \), suggesting that the induction had the same effect on both groups and no ceiling effect existed.

**Risk-taking and performance on BIAS**

To determine performance on the BIAS, we used the same approach as in Study 3, creating a dichotomous variable for optimal versus non-optimal choices, based on our optimal portfolio selection strategy (detailed in Study 3), as would be predicted by a rational risk-neutral agent who uses a Bayesian updating strategy from round to round. We then once again took each non-optimal choice and coded it as either a risk-seeking or
risk-averse error by comparing it to the optimal strategy for each round. We then used the three resulting variables for optimal choice, risk-seeking error, and risk-averse error as our dependent variables in three separate ANOVAs, with self-control level and induction condition as the predictor variables.

In keeping with our expectations, we found a highly significant interaction effect between self-control and induction condition in predicting optimal choice on the BIAS task, $F(1,109) = 7.67, p = .007$, our main variable of interest. Individuals low in self-control made fewer optimal choices in the induction condition than they did in the control condition, resembling high self-controllers in their decreased performance. Individuals high in self-control, however showed the opposite pattern: their optimal choices increased as a result of the induction. So, while their performance in the control condition was significantly worse than was that of low self-controllers, as expected, their dramatic increase in the induction condition put them above low self-controllers (See Figure 8).

While the latter result was unexpected, we repeated it in Study 5 (see below) and attribute it to the higher overall level of self-reflective ability associated with high self-control: once high self-controllers’ attention was drawn to their positive affect, they were better able to account for that affect and thus, improve their decision making. No other effects were significant in the optimal choice ANOVA.

When we examined the prevalence of risk-seeking errors, we found significant effects for both self-control ($F(1,109) = 4.78, p = .03$) and affect induction ($F(1,109) = 7.54, p = .01$). The affect induction increased the number of risk-seeking errors for both low and high self-controllers, again making low self-controllers perform worse than they otherwise would as a result (see Figure 9). While high self-controllers made fewer risk-
seeking errors than low in both conditions, they still performed worse overall, as they
made a greater number of *total* errors, including errors of risk aversion, in keeping with
our predictions and the results of the ANOVA for optimal choice. When we looked at
risk-averse errors, we found significant effects for both self-control \((F(1,109) = 3.92; p
= .05)\) and the induction condition \((F(1,109) = 6.88; p = .01)\). Both high and low self-
controllers made fewer errors of risk-aversion in the induction condition.

It thus seems that the main behavioral driver of the decreased performance of low
self-controllers in the affect condition is an increase in risk-seeking errors: while one type
of error (risk-averse) decreased as a result of the induction, the decrease wasn’t enough to
offset the increase in risk-seeking errors that led, ultimately, to a drop in optimal choice
and overall performance.

**Discussion**

In Study 4, we begin to develop a more nuanced picture of the precise causal
mechanism through which the illusion of control negatively impacts high self-controllers’
performance on financial risk-taking tasks in stock market-like environments. Positive
affect appears to be an incredibly strong driver of the observed behavior. Low self-
controllers, when induced into the positive affective state normally associated with high
self-control, saw significant decreases in their performance, largely driven by an uptick in
risk-seeking errors (again in keeping with illusory control and increased confidence
relative to performance, i.e., overconfidence, which is often tied to increased risk-seeking
behavior). These findings strengthen the possibility that the mechanism of action behind
high self-controllers’ increased susceptibility to the illusion of control is indeed an
affective one, with a selective preference for positive feedback and worse performance as a result.

Why did the induction improve performance for high self-controllers? One explanation lies in their increased self-reflection and distancing abilities. We know that metacognitive knowledge increases as a result of educational achievement and cognitive ability (Flavell, 1979), and that high self-controllers have better life outcomes on these and other related measures (Mischel et al., 2011; Casey et al., 2011; Moffitt et al, 2011). We also know that individuals high in childhood delay ability are better at a metacognitive and self-reflective monitoring and regulation of their behavior (Mischel & Mischel, 1983). We thus expect individuals high in self-control to be better at attaining the kind of self-knowledge that is instrumental to behavioral improvement. We further know that, in the case of affect specifically, drawing one’s attention to a source of affect can eliminate the effect of that affect on behavior (Schwarz & Clore, 1983, 2003).

From this, several things follow. High self-controllers have a generally higher positive affect, derived in part from their high average positive life outcomes—including better self-image and mental health (Shoda et al., 1990; Ayduk et al, 2000; Mischel et al., 2011). Normally, that affect is a background driver of behavior. However, as they are also more self-aware, when the affect that is usually a subconscious motivator is made salient—as through a positive affect induction—they are suddenly alerted to its possible impact, and thus, manage their behavior accordingly. In compensating for their overconfidence relative to environments where actual control is limited, they are able to improve their behavior to the high levels that they are capable of achieving under normal circumstances. Low self-controllers, however, absent that general enhanced self-
reflection ability, cognitive skill, and baseline high positive affect react to the induction as would be expected, and begin to resemble high self-controllers who have not had affect made salient and continue to act without compensating for its effects.

This explanation provides an interesting suggestion for one way to improve the performance of high self-control individuals in situations where they might otherwise fall prey to overconfidence and illusory control, by drawing their attention to the relevant affective factors and thereby allowing them to reflect on the likely effect of those factors—and compensate accordingly in their subsequent behavior.
STUDY 5

Study 5 was designed as the last in the series of experiments to tease apart the exact causal mechanisms at play in the relationship between self-control, illusory control, and financial risk-taking. While the strong results of the affect manipulation in Study 4, coupled with our a priori hypotheses and earlier findings led us to suspect the primacy of affect in the observed behavioral shortcomings of high self-controllers in environments where actual control is impossible, one additional causal mechanism remained to be tested: a boost in perceived self-control. While the mechanism of action behind such a boost may well also be affective, it is possible that one’s feelings of control per se are also responsible for the observed effects.

In designing this experiment, we had two possibilities in mind. The first is that the same affective mechanisms observed in Study 4 would be responsible for any differences in behavior with a self-control induction—in other words, that inducing higher self-control would increase positive affect and as a result, make low self-controllers act more like high. The second possibility is that there is an additional, non-affective mechanism in play, rooted in a more cognitive perception of control.

We found that, like the affect induction of Study 4, the self-control induction had a significant differential effect on high and low self-controllers. It decreased the number of optimal choices made by low self-controllers, again making them look more like high-self-controllers—but, just as with the positive affect induction, it actually increased the number of optimal choices made by high self-controllers, lending further credence to our self-reflection and distancing explanation of high self-controllers’ improved performance in Study 4. The increase in positive affect that accompanied the self-control induction
was a significant mediator of the effect, leading us to conclude that the main mechanism of action is indeed an affective rather than a purely cognitive one.

Method

Participants

107 participants (60 female, 47 male), median age = 34.79 ($SD = 12.29$) took part in the study, after providing informed consent. As in studies 3 and 4, we used a national online sample consisting of Amazon Mechanical Turks. All participants were compensated $2 for their time and were entered into a lottery where they had the chance to win all of their additional earnings from the study,

Materials and procedures

The study was designed identically to Studies 3 and 4, with the exception of the induction condition. Instead of the IOC coin flip or affect manipulation, we used a standard self-control induction, where participants were asked to describe four separate occasions on which they had exercised self-control. In the control condition, they were asked to describe four shopping decisions.\textsuperscript{21} Our induction was meant to boost levels of perceived self-control in study participants.

Results

Self-control measure

We once again used errors of commission on the Go/No-go as our major measure of self-control. For our main behavioral analyses, we used a median split on the commission variable to divide participants into high and low self-controllers.

As in prior studies, we validated our measure of self-control by examining correlations with other known measures of self-control. The commission errors correlated

\textsuperscript{21} For full text of induction and control, see Appendix A.
significantly with the BIS attention subscale ($r = .231, p = .01$), the BIS cognitive
instability subscale ($r = .24, p = .01$), the BIS self-control subscale ($r = .16, p = .05$), and
the BIS attentional second-order factor subscale ($r = .27, p = .003$). This time, the
expected negative correlation with age was directionally accurate but only marginally
significant ($r = -.14, p = .08$). However, the correlation with BMI—a known correlate of
lifetime self-control (Schlam et al., 2013)—was highly significant ($r = .26, p = .005$),
providing further validation of our measure.

**Effect of self-control induction**

*Induction validation*

An independent samples t-test was conducted to compare reported self-control in
the induction versus the control condition. In keeping with previously observed results
for individuals who are high in self-control, participants in the induction condition
reported taking significantly more risk on the BIAS ($M_{control} = 3.10, SD_{control} = 1.19,
M_{induction} = 3.60, SD_{induction} = 1.37; t(104) = -2.01, p = .05$) and feeling less stressed
($M_{control} = 3.08, SD_{control} = 1.35, M_{induction} = 2.60, SD_{induction} = 1.31; t(104) = 1.85,
 p = .07$).

Their self-reports of several additional measures of self-control also changed. They
reported a more internalized locus of control, in keeping with the internal locus
associated with high self-controllers ($M_{control} = 12.31, SD_{control} = 4.39, M_{induction} = 10.86,
SD_{induction} = 4.44$), where lower scores signify a more internalized locus and higher, a more
externalized; $t(105) = 2.57, p = .09$), and significantly lower scores on the attention and
attentional second-order subscales of the BIS-11, where, once again, higher scores
correspond to lower self-control (attention: $M_{control} = 10.35, SD_{control} = 3.01, M_{induction} =
9.16, SD_{induction} = 2.57; t(105) = 2.21, p = .03$; attention second-order: $M_{control} = 16.65,$
SD\textsubscript{control} = 3.99, M\textsubscript{induction} = 15.07, SD\textsubscript{induction} = 3.80; t(105) = 2.09, \( p = .04 \). Thus, self-report measures for individuals in the self-control induction condition were in keeping with expected self-reports of individuals who are high in baseline self-control.

*Induction effect on high versus low self-controllers*

We expected a likely ceiling effect in our induction. To determine whether the induction condition differentially affected high versus low self-controllers, we performed separate ANOVAs with our main independent self-report measures of self-control—the BIS-11 attention subscale, the BIS-11 attentional second-order subscale, and the BIS-11 self-control subscale—as the dependent variables and induction condition and self-control level as the independent variables. This time, we did see a significant interaction effect, in all three ANOVAs, as expected (i.e., we would not expect individuals already high on self-control to show post-induction changes, due to a ceiling effect.)

For the BIS-11 attention subscale, while scores for high self-controllers remained unchanged from control to induction, for low self-controllers they fell significantly in the induction condition \((F(1,107) = 3.69, p = .05)\), from an average score of 11.34 \((SD = 2.9)\) to an average score of 9.11 \((SD = 2.64)\). For the BIS-11 attentional second-order factor subscale, scores for high self-controllers once again remained unchanged, while for low self-controllers, they again fell significantly \((F(1,107) = 4.70, p = .03)\), from an average of 18.24 \((SD = 3.92)\) to an average of 15.1 \((SD = 3.74)\). Finally, for the BIS-11 self-control subscale, high self-controllers again exhibited no change, but low self-controllers in the induction condition scored lower, going from an average score of 13.6 \((SD = 2.71)\) to one of 12.14 \((SD = 2.99)\), a drop that indicates significantly higher levels of perceived self-control \((F(1,107) = 4.92, p = .03)\) (see Figure 10).
Thus, as expected, we see the self-control induction working strongly in low self-controllers, but having little effect on individuals already high in self-control.

**Risk-taking and performance on BIAS**

To determine performance on the BIAS task, we performed an identical analysis to that used in Study 3 and Study 4. We coded optimal choices according to the optimal portfolio allocation strategy specified in Study 3, then took non-optimal choices and coded them as either risk-seeking or risk-averse by comparing them to the choice that a rational risk-neutral agent would make if he were updating his behavior according to Bayes’ Rule. We used the three resulting variables as dependent measures in three separate ANOVAs, with self-control and induction as the predictor variables.

We found a significant interaction effect for self-control and induction condition for the analysis of optimal choice behavior \( F(1,105) = 4.21, p = .04 \). While in the control condition, individuals high in self-control significantly underperformed relative to those low in self-control, making significantly fewer optimal choices as expected, in the induction condition their behavior was nearly equalized: the self-control induction decreased performance for low self-controllers, as expected—but also improved performance for high self-controllers, much as was the case in the affect induction condition (see Figure 11). Thus, we replicated our findings from Study 4 on both counts. No other analyses were significant.

**Affect mediation**

To determine whether the observed changes were a result of affective mechanisms, we performed a mediation analysis using multiple mediation bootstrapping (Shrout & Bolger, 2002). We used the same aggregated PANAS anxiety and confidence
levels as in earlier studies and looked at optimal behavior as the dependent variable.

Simultaneously adding the two factors decreased the effect of self-control from $B = .238$ ($p = .01$) to $B = .22$ ($p = .02$), indicating significant (though admittedly slight) partial mediation ($R^2 = .11$; $F(3,100) = 4.29$; $p = .01$). As shown in Figure 12, higher self-control was associated with increased confidence (.15, $p = .11$), and increased confidence in turn led to a decrease in optimal choice (-.27, $p = .02$). While higher self-control was also associated with decreased anxiety (-.04, $p = .28$), the effect was marginal and non-significant, as was the effect of anxiety level on optimal choice, suggesting that the positive affect boost is driving the small observed partial mediation.

**Affect mediation with pooled data, Studies 3-5**

Due to the affect-driven results observed in studies 3 through 5, we performed one final mediation analysis, using combined data from all three studies for increased power. We once again used multiple mediation bootstrapping (Shrout & Bolger, 2002), with BIAS choice as the dependent variable, self-control as the independent variable, and the composite PANAS measures of confidence and anxiety as the mediators. We found a significant partial mediation overall ($R^2 = .04$; $F(3,342) = 4.84$, $p = .003$), with confidence as the main driver of the effect: its addition made the previously significant relationship between self-control and optimal choice (higher self-control leads to fewer optimal choices) non-significant – though its action was in the same direction as that original effect (self-control was significantly associated with increased confidence ($2.15$, $p = .03$), which in turn meant significantly fewer optimal choices, ($-.21$, $p = .002$)) (see Figure 13).
Discussion

When we induced perceived self-control in low self-controllers, their performance on the BIAS plummeted: the number of optimal choices that they made in the task was significantly lower than that of low self-controllers in the control condition. In short, low self-controllers in the induction condition began to act in the same sub-optimal way that we have observed with high self-controllers in this environment. The induction, however, had the opposite effect on high self-controllers. While their perceived level of control didn’t change, they were made more aware of their perception of control, and adjusted their behavior accordingly: their performance became more optimal when self-control was made salient (i.e., the induction condition).

In these findings, we replicated the results of the affect induction in Study 4. We further wanted to see whether the cause was similarly affective. In other words, did we observe these behavioral effects because manipulating self-control levels also increased feelings of confidence? A mediation analysis suggested that that was in fact the case.

To confirm the strength of positive affect as the main driving factor, we then performed the same mediation for pooled data from Studies 3, 4, and 5. We found a significant partial mediation across all conditions in all three studies, confirming our hypothesis that the main driver of sub-optimal behavior in high self-controllers is an affective one: the greater confidence that comes from high self-control can lead to overconfidence and hence, impeded performance in uncertain and risky environments where the actual control that high self-controllers experience as a matter of course is limited.
GENERAL DISCUSSION

Summary of Results

In a series of five studies, we examined the relationship between self-control, illusory control, and risky financial decision making. Our work was inspired by a conundrum presented by the stock market crash of 2007-2008—and by investor behavior more broadly: how could otherwise intelligent, successful people, with characteristics normally associated with better delay ability and sounder financial and numeracy-related judgments, make such irrational and seemingly out-of-character decisions as characterized the poor judgments that led to the crash, specifically, and to poor market decisions, more broadly? We hypothesized that the answer might lie in an underexplored aspect of high self-control: could something so generally positive have a paradoxical negative effect in certain risky, uncertain environments where the ability to exercise actual control is limited, such as the stock market?

First (Study 1 and Study 2), we examined the performance of high versus low self-controllers on two tasks of risk-taking, the Columbia Card Task (CCT) and the Lottery Gambling Task (LGT). The tasks were chosen for two main reasons: they presented risky, uncertain environments, suggestive of that found in the stock market, and they necessitated opposite risk-taking patterns. Specifically, the CCT is a dynamic risk-taking task, where it is optimal for a risk-neutral agent to take fewer risks, whereas the LGT is a static risk-taking task, where the optimal strategy for a risk-neutral agent is a risk-seeking one. We found that high self-controllers performed consistently worse on both tasks, both under stress and in normal conditions. They took too much risk on the
CCT and too little risk on the LGT, failing to learn from negative feedback and opening themselves up to errors of overconfidence.

Our results suggested several things. First, the observed poor performance was not a direct result of a general risk-seeking or risk-averse propensity on the part of high self-controllers; had that been the case, we would have seen similar risk-taking patterns on both tasks—and necessarily, better performance on one of the two as a result. Instead, performance was universally poor. Second, there was a good chance that the sub-optimal choices were instead the result of a causal mechanism that stemmed from the illusion of control, and specifically, the positive affect and overconfidence that accompany it. In these initial studies, individuals high in self-control also scored higher on self-reported measures of illusory control—and showed an increased positive affect consistent with illusory control and overconfidence. What’s more, increased confidence and decreased anxiety were shown to be significant partial mediators of the non-optimal risk-taking patterns on the CCT. We thus had an initial hint that affect was serving as a major driving force of the surprisingly poor behavior in high self-controllers. However, our behavioral data remained purely correlational, and our measure of risk-taking, a ways removed from the type of risks that we’d normally associate with stock market behavior.

We then proceeded to test the observed relationship between self-control, illusory control, and financial risk-taking directly, in an environment that was more germane to our main behavior of interest, risk-taking in the stock market. In studies 3, 4, and 5 the Behavioral Investment Allocation Strategy (BIAS) task replaced the CCT and LGT as our main measure of interest. In Study 3, we first validated our behavioral findings from Studies 1 and 2, showing that individuals high in self-control performed worse overall
than those low in self-control, making more errors in their choice of risk-taking strategy. We then looked at the effect of the study’s main induction, a classic illusion of control (IOC) manipulation that used a series of coin flips to induce feelings of being in control. We found that inducing IOC increased the number of errors committed by both high and low self-controllers. Individuals in the induction condition made fewer optimal choices than those in the control condition and performed worse as a result. Our results from this study both validated the possible downside of self-control (as high self-control individuals in the control condition significantly underperformed relative to low self-control individuals) and confirmed causally what had previously been merely correlational: not only is illusory control tied to decreased performance, but actively inducing IOC leads to a decrease in performance.

We then turned to the underlying mechanism of the IOC-self-control connection: why was it that the high self-controllers were underperforming? What was it, specifically, about the illusion of control that lead to an increase in risk-taking errors? In Study 4, we demonstrated that the main driver of the relationship was an affective one, namely, the increased confidence and positive affect associated with high self-control and confidence—or overconfidence, depending on the circumstances. When we induced positive affect in low self-controllers, we saw a significant reduction in the optimal choices they made on the BIAS. In other words, their decisions began to look remarkably like those of high self-controllers. We were initially surprised to see the opposite pattern in high self-controllers: the affect induction actually improved, instead of hurting, their performance. We explained this surprising result (which we replicated in Study 5) through a self-distancing mechanism, whereby the induction encourages increased self-
awareness and self-reflection in high self-controllers, prompting them to monitor their behavior accordingly.

Under normal circumstances, high self-controllers are not aware of their positive affect and the possible effects their baseline confidence may have on their susceptibility to overconfidence errors in stochastic environments where only limited control is possible. For them, the elements associated with high self-control—positivity, controllability, and the like—are a default base state, not something to be paid attention to. Usually, such a default is incredibly helpful and powerful, leading to better health, a better self-image, and better life outcomes (Shoda et al., 1990; Ayduk et al., 2000; Mischel et al., 2011). As such, there is no benefit in trying to control for it or take it into account when making decisions. When, however, there is an environment conducive to illusory control, the normal benefit is flipped: now, it would be useful to remove some of that positivity and confidence in order to realize that you are in an environment that is largely governed by chance. If you are to succeed in those conditions, you must learn quickly and carefully rather than unreflectively persevere in your initial decision strategy. But why would you do so all of a sudden, without any external prompting, if you’re not used to taking your baseline state into account— and that state is usually so beneficial?

When we provide an opportunity for high self-controllers to reflect on their positive affect in the induction writing exercise, we do two things: first, we draw their attention to that affect, making it salient where in the past, it was simply a part of the background, and second, we provide a reflective pause prior to the start of the decision making task. In so doing, we accomplish what a simple IOC behavioral induction cannot:
make high self-controllers aware of their baseline state and thus enable them to compensate behaviorally in the subsequent task.

We know from studies of affect and priming that the effect of a prime will disappear if one is made explicitly aware of the affect in question. In Schwarz and Clore’s (1983) study of weather and life satisfaction, the researchers found that people reported greater feelings of life satisfaction on sunny days than on rainy days. If, however, participants were first explicitly asked about the weather, the effect disappeared (see also Schwartz & Clore, 2003). Studies of psychological distance further demonstrate that distancing exercises that encourage a step away from the self, toward a more big-picture perspective, enhance wise reasoning and lead to behavioral improvements (Kross & Grossman, 2011) and that higher-level mental construals lead to higher self-control and decreases in delaydiscounting (Fujita, Trope, Lieberman, & Levin-Sagi, 2006; Fujita & Carnevale, 2012).

Our inductions in studies 4 and 5 inadvertently accomplished both of these goals. We drew high self-controllers’ attention to their high baseline positive affect and self-image (Shoda et al., 1990; Ayduk et al, 2000; Mischel et al., 2011), and we provided them with a space for self-reflection prior to action, a kind of look-before-you-leap opportunity prompted by writing about the self. As high self-controllers are made more self-aware, the affect that normally works on a subconscious level becomes salient and begins to be taken into account in subsequent behavior in a way that it wouldn’t be otherwise. Thus, the high self-controllers are able to improve their behavior and bring it to the high levels that they are capable of achieving under normal circumstances.
That potential impact, however, is largely overshadowed in low self-controllers by the direct effects of the induction itself. We know from studies of self-control within a dual-system framework (Metcalf & Mischel, 1999) that high self-controllers are more able to “cool” hot affective stimuli to begin with. They have better spontaneous self-monitoring strategies (Mischel & Mischel, 1983) than low self-controllers and are generally more likely to improve those strategies over time, as metacognitive and self-reflective knowledge increases with education and cognitive ability (Flavell, 1979), two areas where individuals with high delay ability excel (Mischel et al., 2011; Casey et al., 2011; Moffitt et al., 2011). As such, individuals high in self-control are more likely to have the self-reflection that is necessary to learn more effectively and make better decisions to begin with (Keith & Frese, 2005; Fletcher & Carruthers, 2012).

Low self-controllers, on the other hand, lack two things: they do not have that overall self-reflective learning boost and they lack the baseline high positive affect that high self-controllers possess. As a result, they are both less likely to self-identify with the prime and to react in a self-reflective fashion to its reasonably subtle framing, taking it at face value rather than spontaneously pausing to assess themselves and their own behavior, as we’d expect high self-controllers to do. (Also note that, even if they do pause, they are less able to employ self-assessment strategies to begin with, and so will not likely have the time to reach the same conclusions and make the same behavioral adjustment as high self-controllers in such a short space.) So, the induction works as would be expected, and low self-controllers begin to resemble high self-controllers who have not had affect made salient and continue to act without compensating for its effects.
While on the one hand, it would seem like any distancing manipulation may accomplish the goal of cooling the “hot” behavior on the tasks of financial risk-taking, we believe that the content of the manipulation is just as important as the distance itself. In our control conditions for Study 4 and Study 5, we did not find the improved performance boost for high self-controllers. We can therefore conclude that it is not enough to be forced to perform some filler task or reflective exercise; there must be something in that task that stimulates the proper mindset and self-reflection. It could indeed be the case, however, that an explicit distancing instruction, such as a manipulation that would instruct participants to imagine themselves as flies on a wall observing their own behavior (Kross & Grossman, 2011) would be sufficient to improve behavior. Daniel Kahneman (2011) suggests that manipulations that boost the vigilance of System 2 (the “cool” system in the Metcalfe & Mischel, 1999 framework), such as distancing and vigilant mindset frames, should reduce overconfidence and lead to behavioral improvements. Future studies will need to explicitly address the boundary conditions of effective inductions.

Another possible consideration is that, whereas in the type of stochastic environment that we see in our studies, self-control goals may not be top of mind—that is, high self-controllers usually know precisely what the “right” answer is to any given situation, but in an uncertain, risky decision environment, there may not be an easily visible strategy—when we prime affect and self-control, we once again re-frame the environment in terms of classic self-control strategies, making the usual approach seem valid: we enable self-controllers to evaluate the task in self-relevant experiential terms, thus allowing them to employ strategies that have been successful in the past. We may
also be increasing construct accessibility in a way that again enables performance improvement.

In Study 5, we manipulated perceived self-control and found that, like affect, it had a differential effect on high and low self-controllers. Low self-controllers in the self-control induction made fewer optimal choices as compared to their control group counterparts, looking quite similar to high self-controllers at baseline in terms of their sub-optimal behavior. High self-controllers, on the other hand, exhibited an effect remarkably similar to that observed in Study 4: once again, they performed more, not less, optimally in the high induction condition—although their levels of reported self-control remained unchanged. This finding further validated our initial hypothesis, that drawing attention to the main causes of illusory control and overconfidence (positive affect, perceived control) provided high self-controllers with a self-awareness that in turn helped them “cool” their strategy in the BIAS task, so that it fell more in line with optimal behavior.

Why, however, did the self-control induction work as it did for low self-controllers? Was it a cognitive mechanism—or once again a more affective one? Because of our prior results, we suspected the latter. We performed an affect mediation and found that the presence of confidence was a significant partial mediator of the effects of self-control on BIAS strategy use. We thus concluded that the main driver of our observed effects was an essentially affective one, a conclusion borne out by one final mediation analysis, where we pooled data from Study 3, Study 4, and Study 5 and found a significant partial mediation of the effects of self-control on BIAS performance: in all three studies, increased confidence was a significant mediator of optimal strategy use.
Conclusions

As a result of these studies, we can conclude several things. First, self-control has a definite dark side. The normally positive trait can make individuals more susceptible to overconfidence and illusory control biases in risky, uncertain environments where there is limited ability to exercise actual control. Luckily, such environments are rare. Unluckily, some of them—most notably, the stock market—have far-reaching effects that extend beyond the individual decision maker’s sub-optimal choices.

Second, the main driver of this effect is an affective one. A major reason that high self-controllers are prone to overconfidence and illusory control is because of their higher overall positive affect and general confidence levels. Positive affect normally lends all matters of protective results to its bearers, from better health to increased longevity and life satisfaction—but it can also make them more susceptible to certain risky decision making biases that result in worse choices than would be the case in its absence. High self-controllers are generally higher in positive affect. Hence, they are specifically affected by this dynamic.

Third, this pitfall of high self-control is relatively easy to address. Because high self-controllers are generally better at self-reflection and self-evaluation, they are able to adjust their behavior along more optimal lines if their attention is directed toward those elements that make them most susceptible to errors in judgment, namely, their positive affect and high perceived control.

Thus, while it may be true that the type of person who succeeds on Wall Street in the short term is more similar to the law-of-the-jungle type of low self-controller that we stereotypically associate with the trading floor, as low self-controllers are more likely to
make optimal choices in such environments in the immediate term, it is equally true that over the long term, high self-controllers have ample opportunity for reflection—and have the ability to quickly correct for their biases in a way that low self-controllers do not. So, when positive affect or perceived control are naturally manipulated in the course of everyday trading and decision making (such as, for instance, making a sudden large profit or seeming to anticipate a stock or bond movement before it happens), low self-controllers may find themselves falling prey to the same mistakes they had been protected from before—while high self-controllers may suddenly find themselves ever-more aware of their own shortcomings, and ready to compensate accordingly.

What’s more, they may be better at evaluation the environment to begin with: different environments lend themselves better to different types of learning. In our studies, we look at the immediate term, a circumscribed point in time where learning from immediate feedback leads to improvements in performance. In the real world, however, immediate behavioral adjustment is not always beneficial. Indeed, it may lead to overtrading and poor long-term financial decisions. It may be better in these circumstances to accumulate more information over a longer period of time—and only then to make behavioral adjustments. In this sense, once again, high self-controllers may have something of an edge: whereas they may perform worse at one point in time, over may instances, they are more likely to employ relevant self-reflective strategies that enable them to gain an overall advantage.

**Future directions**

Our results suggest that the connection between self-control and illusory control ought to be examined further, exploring the various domains and circumstances under
which this connection may be more or less strong, such as the presence of environmental uncertainty, and its impact on decision tasks, learning, and risk-taking.

In future studies, we hope to accomplish several goals. First, we would like to explore the boundary conditions of the observed effects: in what circumstances are they most likely to manifest themselves, and where are they least likely to be visible? We would ideally use a number of different decision tasks to see where the effect holds—and where it breaks down—and what we can learn from each instance. We would also like to see whether primary reinforcement environments, such as shocks or food, would lead to similar patterns of behavior, or whether our findings are somehow specific to the financial domain.

It is also important to include additional behavioral measures of self-control, such as, for instance, the Stroop Task, to see if we obtain the same results no matter the behavioral approach. What’s more, it would be useful to administer our behavioral measure of self-control at a different point in time from the dependent measures, so as to ensure that, first of all, there is no connection between measuring self-control in and of itself and the illusion of control, and second, that the measure itself isn’t serving as a self-control prime.

We would also like to re-introduce stress manipulations, to see what effect the ratcheting up of anxiety would have on the observed behaviors and relationships, especially when it comes to different financial decision tasks. An intriguing possibility would be to observe real traders in a natural setting over a period of several weeks, to be able to look at real instances of high stress and compare those to instances of relative calm. In laboratory and natural settings, we might also examine actual financial records
and spending histories over time as a function of the investors’ assessed degree of self-control.

We would also like to compare the behavior of traders and other financial professionals in their work environment, such as on the trading floor, and in other environments, to examine the effects of peer presence on behavior. It may be the case that the trading floor in itself changes self-control behavior, by introducing peer motivational goals and that as such, it serves as a hot trigger by eliminating self-control goals and in their stead, creating other goals, such as riskiness. It would be beneficial to measure baseline self-control levels in traders, specifically, and other financial professionals, more broadly, and to compare these levels to a general population: could it be the case that high self-controllers are discouraged from pursuing certain careers to begin with, because of the incongruity between their baseline state and the relevant environment?

Future studies will also consider additional ways to counteract the susceptibility to illusory control, overconfidence, and resulting decision errors, such as instructing participants in better self-control strategies at the onset of the study and manipulating participants’ immediate goals. We would also like to focus explicitly on the mechanisms that we observed in Study 4 and Study 5: the self-reflection benefits that results from self-distancing and higher-level construal, as well as the behavioral de-biasing that comes from making implicit primes instead explicit opportunities for self-reflection. To do so, we would like to both introduce measures of metacognition and test alternative mechanisms, such as mindset and self-control frame, that may instead be responsible for the perceived performance boost.
In general, we hope to have the opportunity to explore the limits of self-control, the conditions under which it may prove costly, and the ways in which these conditions and the resulting sub-optimal behaviors can be mitigated, not just in the laboratory, but in real-world settings where they could have significant societal repercussions. Our hope is that this initial series of studies will invite further explorations of the possible darker side of self-control, opening a window for systematic research on the interaction of self-control, illusory control, and stress in risk-taking behavior.
REFERENCES


Science, 21, 248-252.


BIAS post-game self-assessment

Please respond to the following, on a scale of 1-10.

(1) How good do you think you are at predicting outcomes like these? (0 = very bad; 5 = average; 10 = pretty good); *

(2) How well do you think you would do on the task if you were distracted? (0 = much worse; 10 = much better); and

(3) How much do you think you would improve with practice? (0 = not at all; 5 = some improvement; 10 = a good deal).*

On a scale of 1-5, 1 being don't agree at all and 5 being very much agree, please respond to the following:

1. During the game, I took risks.
2. During the game, I followed a safe strategy.
3. During the game, I felt in control.*
4. I was able to figure out the best strategy to use in the game.*
5. I followed the best strategy for this game.*
6. In this game, it is financially rewarding to take risks.
7. In this game, it is financially rewarding to play it safe.
8. I felt in control during the game.*
9. I felt I performed well overall.*
10. I felt I performed better than others did.*
11. I felt I could have performed better if I had more time.
12. I thought the game was stressful.

*Starred items indicate measures that were pooled for a total IOC score for the BIAS.
Positive affect induction

"In the space below, please write a short paragraph (3-5 sentences or so) that describes a time when you made a lot of money by making a positive investment. The investment can be in the stock market or elsewhere."

Positive affect control

"In the space below, please write a short paragraph (3-5 sentences or so) that describes a stock or a company that you are familiar with."

Self-control induction

Below, please list 4 (four) separate occasions when you exercised self-control: you didn't do something you really wanted to do. You do not need to use complete sentences. Please number your list.

Self-control control

Below, please list 4 (four) separate occasions when you changed your mind about a shopping decision. You do not need to use complete sentences. Please number your list.
APPENDIX B

To capture the multi-level nature of the BIAS task, we used a generalized hierarchical (i.e., mixed effects) linear model, fit with REML, to supplement our analysis. We used commission errors, our measure of self control, as the independent variable. For the dependent measure, we used two measures. First, we created a dichotomous variable (0,1) for optimal choices. Then, we created a second dichotomous variable to code for risk-averse (1) or risk-seeking (0) choices. We used block and subject as random effects, to capture the repeated measure nature of our dependent variable and correlations within block and subject induced by a nested classification structure. For the individual-level model, we used a logit model specification. To perform the analysis, we used the LME4 package within R.

We ran a model to test for the effects of several covariates of interest—age, gender, income, and education. As none had any significant effect, we dropped them from all further analyses.

The studies are listed in order, and following the three studies, we show analyses for the pooled data for Study 3, Study 4, and Study 5 combined. For space considerations, we only report significant results here.
STUDY 3

Risk averse/seeking errors

Baseline

Models:

fit.glmmC0: $ra \sim 1 + (1 \mid serial) + (1 \mid block)$

fit.glmmC01: $ra \sim (commission\_errors.x > 14) + (1 \mid serial) + (1 \mid block)$

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<th>BIC</th>
<th>logLik</th>
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<td>6.97</td>
<td>1</td>
<td>0.008**</td>
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</table>

Baseline versus induction

Models:

fit.glmmC01: $ra \sim (commission\_errors.x > 14) + (1 \mid serial) + (1 \mid block)$

fit.glmmC11: $ra \sim (commission\_errors.x > 14) + coin\_trial\_type + (1 \mid serial) + (1 \mid block)$

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<td>4.2003</td>
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22 “Baseline” will always refer to the base condition: does self-control have an effect on the DV of interest?

23 “Baseline versus induction” will always refer to the effect of the induction condition
Summary of model with baseline, induction

Random effects

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<td>-0.03848</td>
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STUDY 4

Optimal decisions

Baseline versus induction

Models:

fit.glmmAF0: opc ~ commission_errors + (1 | serial) + (1 | block)

fit.glmmAF1: opc ~ commission_errors + affcon + (1 | serial) + (1 | block)

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Summary of model with baseline, induction

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**Risk averse/seeking errors**

**Baseline versus induction**

*Models:*

fit.glmmAF0: \( ra \sim I(\text{commission\_errors.x} > 14) + (1 \mid \text{serial}) + (1 \mid \text{block}) \)

fit.glmmAF1: \( ra \sim I(\text{commission\_errors.x} > 14) + \text{affcon} + (1 \mid \text{serial}) + (1 \mid \text{block}) \)

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**Summary of model with baseline, induction**

*Random effects*

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*Fixed effects*

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Risk averse-seeking errors, affect mediation

Models:

fit.glmmAF1: opc ~ I(commission_errors.x > 14) + affcon + (1 | serial) + (1 | block)

fit.glmmAF4: opc ~ I(commission_errors.x > 14) + affcon + as.numeric(PANAS_positive_total) +

fit.glmmAF4: (1 | serial) + (1 | block)

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Summary of model with affect mediation

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### Fixed effects

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STUDY 5

Optimal decisions

Baseline

Models:

fit.glmmSC00: opc ~ 1 + (1 | serial) + (1 | block)

fit.glmmSC0: opc ~ commission_errors + (1 | serial) + (1 | block)

<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>Chisq</th>
<th>Chi Df</th>
<th>PR(&gt;Chisq)</th>
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<tbody>
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</tr>
<tr>
<td>fit.glmmSC0</td>
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<td>13304</td>
<td>13340</td>
<td>-6646.9</td>
<td>6.736</td>
<td>1</td>
<td>0.009**</td>
</tr>
</tbody>
</table>

Baseline and interaction

Models:

fit.glmmSC2: opc ~ I(commission_errors.x > 14) + sccon + (1 | serial) + (1 | block)

fit.glmmSC2: opc ~ sccon + (1 | serial) + (1 | block)

fit.glmmSC3: opc ~ I(commission_errors.x > 14) + sccon + I(I(commission_errors.x > 14) * sccon) + (1 | serial) + (1 | block)

<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>Chisq</th>
<th>Chi Df</th>
<th>PR(&gt;Chisq)</th>
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</thead>
<tbody>
<tr>
<td>fit.glmmSC2</td>
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<td>5.4475</td>
<td>1</td>
<td>0.0196 *</td>
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</table>
### Summary of model with baseline, induction, interaction

**Random effects**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial</td>
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<td>0.00712180</td>
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<tr>
<td>Block</td>
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<tr>
<td>Residual</td>
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**Fixed effects**

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.31795</td>
<td>0.02036</td>
<td>15.619</td>
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<tr>
<td>Baseline self-control</td>
<td>0.07871</td>
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<td>2.819</td>
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<tr>
<td>Self-control induction</td>
<td>0.05767</td>
<td>0.02648</td>
<td>2.178</td>
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<tr>
<td>Baseline self-control*induction</td>
<td>-0.08941</td>
<td>0.03831</td>
<td>-2.334</td>
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</tbody>
</table>

**Risk averse/seeking errors**

**Baseline**

*Models:*

- `glmm.ras00: ra ~ 1 + (1 | serial) + (1 | block)`
- `glmm.ras0: ra ~ commission_errors.x + (1 | serial) + (1 | block)`
<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>Chisq</th>
<th>Chi Df</th>
<th>PR(&gt;Chisq)</th>
</tr>
</thead>
<tbody>
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<td>0.05*</td>
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</tbody>
</table>

**Summary of model**

**Random effects**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial</td>
<td>(Intercept)</td>
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</tr>
<tr>
<td>Block</td>
<td>(Intercept)</td>
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<td>0.057497</td>
</tr>
<tr>
<td>Residual</td>
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**Fixed effects**

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<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
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<tr>
<td>Self-control</td>
<td>-0.002978</td>
<td>0.001531</td>
<td>-1.945</td>
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</table>
COMBINED DATA, STUDIES 3, 4, and 5

Optimal decisions

Baseline

Models:

fit.glmm0: opc ~ 1 + (1 | serial) + (1 | block)

fit.glmm1: opc ~ commission_errors + (1 | serial) + (1 | block)

<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>Chisq</th>
<th>Chi Df</th>
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<tbody>
<tr>
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<td>41233</td>
<td>-20591</td>
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</table>

Summary of model with affect mediation

Random effects

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial</td>
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<tr>
<td>Block</td>
<td>(Intercept)</td>
<td>0.00023108</td>
<td>0.015201</td>
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<tr>
<td>Residual</td>
<td></td>
<td>0.22069556</td>
<td>0.469782</td>
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</tbody>
</table>

Fixed effects

| (Intercept) | 0.3344093 | 0.0114461 | 29.22   |
| Self-control| 0.0014624 | 0.0005645 | 2.59    |
Optimal decisions, affect mediation

Models:

fit.glmmPC0: opc ~ commission_errors + (1 | serial) + (1 | block)
fit.glmmPC1: opc ~ commission_errors + as.numeric(pod[, 24]) + as.numeric(pod[, 25]) + (1 | serial) + (1 | block)

<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>Chisq</th>
<th>Chi Df</th>
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<tbody>
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<td>fit.glmmAF1</td>
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<td>41233</td>
<td>-20591</td>
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</table>

Summary of model with affect mediation

Random effects

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial</td>
<td>(Intercept)</td>
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<tr>
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<td>(Intercept)</td>
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<tr>
<td>Residual</td>
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<td>0.220413</td>
<td>0.46948</td>
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Fixed effects

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
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<td>0.0263</td>
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<tr>
<td>Self-control</td>
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<td>2.325</td>
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<tr>
<td>Confidence mediation</td>
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<td>0.0006</td>
<td>-2.581</td>
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<tr>
<td>Anxiety mediation</td>
<td>0.001293</td>
<td>0.0015</td>
<td>0.814</td>
</tr>
</tbody>
</table>
Figure 1. Self-reports of (a) response strategies and (b) emotional states (PANAS) as a function of self-control level, indicative of illusory control by high self-controllers. All differences shown are significant at the .05 level. The top panels indicate results from Study 1, and the bottom, from Study 2. Error bars represent the standard error of the mean in all graphs.
Figure 2

**Risk-taking: LGT**

(a) Study 1

(b) Study 2

Figure 2. Risk-taking in the Lottery Gambling Task (LGT) as a function of self-control level and stress: (a) Average bets in Study 1; (b) Average bets in Study 2.
Figure 3. Responses in the Columbia Card Task (CCT) as a function of self-control level and stress condition: (a) Risk-taking, i.e., average number of cards taken over the 24 trials, in Study 1; (b) and (c) Risk-taking in Study 2, as a function of self-control and anxiety level.
Figure 4. Mediation analysis for CCT. Regression coefficients are shown adjacent to the arrows. The coefficient labeled “after” indicates the results for the relation between condition and risk-taking after the mediators, anxiety and confidence, were added to the equation.
Figure 5

BIAS trial structure

Figure 5. Structure of the Behavioral Investment Allocation Strategy trials. First, participants see the three assets. Then, the word “CHOOSE” appears. After they make their choice, they see the Outcome screen, which tells them earning for the current trial (“current”) and for all trials leading up to the present one (“total”). Then, they are shown the Market screen, where they see the values of all three assets.
Figure 6. Amount bet on the coin flip as a function of self-control and induction condition. Increased bet size indicates increased confidence in predictive accuracy.
Figure 7

**Risk-averse errors on BIAS in IOC induction**

![Risk-averse errors on BIAS in IOC induction](image)

**Figure 7.** Number of risk-averse errors committed as a function of self-control and IOC induction.
Figure 8

Optimal choices on BIAS in affect induction

Figure 8. Number of optimal choices in BIAS task, as a function of self-control and affect induction.
Figure 9

Risk-seeking errors on BIAS in affect induction

Figure 9. Number of risk-seeking errors in BIAS task, as a function of self-control and affect induction.
Figure 10

Self-control induction effects

Figure 10. Self-reports of self-control, as function of baseline self-control and self-control induction.
Figure 11

Optimal choices on BIAS in self-control induction

![Bar chart showing the number of optimal choices in BIAS task, as a function of baseline self-control and self-control induction.]

**Figure 11.** Number of optimal choices in BIAS task, as a function of baseline self-control and self-control induction.
Figure 12. Affect mediation analysis for optimal choices on the BIAS task in Study 5. Regression coefficients are shown adjacent to the arrows. The coefficient labeled “after” indicates the results for the relation between condition and risk-taking after the mediators, anxiety and confidence, were added to the equation.
**Figure 13.** Affect mediation analysis for optimal choices on the BIAS task for pooled data, Study 3, 4, and 5. Regression coefficients are shown adjacent to the arrows. The coefficient labeled “after” indicates the results for the relation between condition and risk-taking after the mediators, anxiety and confidence, were added to the equation.