Grit, Loss Aversion, and Investor Behavior*

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Abstract

We examine whether grit affects individuals' preferences and trading decisions. Grit is the sustained effort toward a goal despite setbacks. It is malleable and distinct from the Big Five personality traits. Using experiments formalized in prospect theory, we find that grit reduces loss aversion. By diminishing loss aversion, gritty investors exhibit a lower disposition effect since they are more willing to exit losing investments. Consequently, they accumulate about 7% more wealth relative to control participants. Overall, grit affects the quality of investment decisions. Ultimately, our results suggest that interventions cultivating grit could improve households' financial outcomes.

Keywords: Prospect theory, investor preferences, disposition effect, experimental market, personality traits.

JEL classification: G11, G40, G41.

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1 Introduction

The trading decisions of individual investors have important consequences for both their own wealth accumulation and aggregate financial markets. For instance, many investors realize their gains while retaining their losing stock holdings. This behavior, known as the disposition effect, leads to lower portfolio returns and impedes the incorporation of news into stock prices (Shefrin and Statman 1985; Odean 1998; Frazzini 2006; Birru 2015).

One explanation for the disposition effect is loss aversion (e.g., Barberis and Xiong (2009)), the tendency of individuals to be more sensitive to losses than to gains (Kahneman and Tversky 1979; Tversky and Kahneman 1992). Despite loss aversion's prominent role in economic decision-making, its determinants are not fully understood.[1] In this study, we provide evidence that grit, a novel dimension of personality, is related to loss aversion and that it influences the disposition effect.

Grit captures the tendency to sustain effort despite challenges in achieving a goal (Duckworth, Peterson, Matthews, and Kelly 2007). Grit is a unique element of personality that is not subsumed by the Big Five personality traits.[2] Moreover, evidence suggests that having grit is important for individuals' socioeconomic outcomes. For instance, it is linked to greater educational achievements and career success (Duckworth and Quinn 2009; Vallerand, Houlfort, and Forest 2014; Cornaggia, Cornaggia, and Xia 2020). Yet, little is known about how grit influences financial decisions.

To extend the literature, we first examine whether grit is related to individuals' preferences and, second, whether it affects investors' stock trading decisions. In terms of

[1] For example, loss aversion affects households' labor, consumption, and savings decisions (Tversky and Kahneman 1991; Knetsch 1989; Van Dijk and Van Knippenberg 1998). An individual's degree of loss aversion has been linked to demographic characteristics, such as gender and education (e.g., Booij and Van de Kuilen (2009)).

[2] See Duckworth, Peterson, Matthews, and Kelly (2007), Duckworth and Quinn (2009), and Duckworth and Gross (2014), Schmidt, Nagy, Fleckenstein, Möller, and Retelsdorf (2018).

preferences, we conjecture that grit should affect loss aversion because it could diminish one's sensitivity to financial losses, i.e., setbacks to wealth accumulation. In the context of investment portfolio decisions, if grit moderates loss aversion, then gritty investors should be less susceptible to the disposition effect.

We examine our two hypotheses by conducting several experiments. We implement our experiments on Amazon's Mechanical Turk (MTurk) website. The platform is being increasingly adopted by researchers in disciplines that employ experimental techniques, including economics and finance researchers (e.g., Olea and Strzalecki (2014); Kuziemko et al. (2015); and D'Acunto (2018)). Our sample includes 932 people in the United States.

The goal of the experiments is to establish a causal link between grit and preferences as well as grit and decision-making. Therefore, some participants are randomly selected and primed in a way that raises the mental construct of grit. The prime is a writing prompt asking participants to recall and describe a time that they or a family member worked hard to achieve a goal under difficult circumstances. The prime is effective at eliciting grit because treated participants score higher on the Short Grit Scale questionnaire (Duckworth and Quinn 2009). Given the effectiveness of the prime, we can isolate the causal effects of grit by comparing the individuals who engage in the grit prime to those who did not.

In our first experiment, we examine the relationship between grit and preferences. To estimate individuals' preferences, we rely on the prospect theory model of decision-making under uncertainty (Kahneman and Tversky 1979; Tversky and Kahneman 1992). Specifically, we employ a lottery choice task adapted from Tanaka, Camerer, and Nguyen (2010) that allows us to quantify three key preference parameters: loss aversion, risk aversion, and nonlinear probability weighting. We use the prospect theory model since it is a widely accepted framework for decision-making under uncertainly (Barberis 2013).

Consistent with our expectations, we find that participants primed by the grit prompt

are less sensitive to potential financial losses compared to participants in the control group. The effect of grit is not subsumed by a wide range of controls that account for known determinants of financial choices, such as age, education, income, gender, marital status, race, ex ante risk tolerance, employment status, numeracy, financial literacy, perceived financial knowledge, and optimism. We find no evidence that grittiness affects risk tolerance or the structure of their subjective probability weighting schemes.

In our second experiment, we examine if grit affects investment decisions. Our analysis is based on existing evidence that loss aversion is connected to investor behavior. In particular, Barberis and Xiong (2009) show that high levels of loss aversion amplify the disposition effect. Since participants primed with the grit task are less loss averse, we expect them to be less prone to the disposition effect. We test this hypothesis with an experiment that focuses on a portfolio choice task.

In the portfolio choice experiment, we construct a stock market that is similar to the paradigm of Frydman and Rangel (2014) and Bazley, Moore, and Murren Vosse (2019). During the experiment, we ask participants to make stock trading decisions. Before trading, some investors are randomly assigned to complete the grit writing task. The evidence shows that grit influences investors' portfolio choices. In particular, the disposition effect among treated investors is 15% to 24% lower than that of counterfactual participants. The reduction in the disposition effect is driven by gritty investors' willingness to exit their losing stock positions. Moreover, gritty investors earn higher returns, generating about 7% more wealth from trading.

Our priming task seeks to invoke the mental representation of grit on treated participants. However, Yong (2012), Sherman and Rivers (2021), and Albarracin and Dai (2021) point out that primes can activate multiple mechanisms that could influence subsequent behavior. In our setting, recalling a challenging task that was overcome may invoke emo-

tions. Emotions could be a confounding mechanism since they are likely to affect financial decision-making (Loewenstein 2000). We examine the emotions hypothesis by administering the PANAS-X questionnaire, which evaluates emotions along several dimensions (Watson and Clark 1999). We find no significant differences between treatment and control participants' emotions after the priming task. Incorporating controls for both positive and negative emotions into our empirical tests does not subsume the effects of grit.

Another concern is that grit may be closely related to other dimensions of personality, which can also affect economic decision-making. To address this concern, we administer a validated personality assessment, the Ten-item Personality Inventory (e.g., Gosling, Rentfrow, and Swann Jr (2003)), to all participants at the beginning of the experiment. We find no systematic differences across treatment and control participants' personality traits along the traditional Big Five dimensions (e.g., Fiske (1949) and Digman (1990)). Moreover, the influence of grit is unaffected in multivariate regressions that include the participants' personality characteristics as control variables. Overall, the collective evidence indicates that grit influences individuals' preferences and stock trading decisions. Gritty investors tend to be less averse to financial losses, which reduces their propensity to hold onto financial assets that are depreciating in value. As a result, gritty investors are likely to generate higher returns on their investment portfolios.

Our study is related to the literature on how personality affects decision making (Dunn, Mount, Barrick, and Ones 1995; Roberts and Robins 2000; Brown and Taylor 2014). For instance, Lauriola and Levin (2001) connect one's openness to new experiences to variation in risk-taking in the gain and loss domains. We contribute to this literature by showing that grit affects loss aversion, a primitive that underpins a variety of economic choices, such as entrepreneurship (Gächter, Johnson, and Herrmann 2010; Koudstaal, Sloof, and Praag 2016; Arco-Tirado, Bojica, Fernández-Martín, and Hoyle 2019), housing decisions

(Genesove and Mayer 2001), stock market participation (Barberis, Huang, and Thaler 2006; Dimmock and Kouwenberg 2010), and investment portfolio decisions (Rau 2014).

Our evidence also contributes to the behavioral finance literature (Barberis and Thaler 2003; Kaustia 2010; Hirshleifer 2015). This literature finds that most investors do not follow the predictions of canonical portfolio choice models. For example, the disposition effect cannot be rationalized by traditional explanations, such as access to private information (Odean 1998), but rather, by behavioral explanations (Shefrin and Statman 1985; Hirshleifer 2001; Ben-David and Hirshleifer 2012). We complement these studies and show that a personality trait like grittiness influences the disposition effect.

More broadly, our findings suggest potential mechanisms to improve household-level financial outcomes. In particular, personality traits are malleable through time, even through digital interventions.[3] Recent evidence by Alan, Boneva, and Ertac (2019) shows that grit can also be fostered in classroom settings. Bryan, Choi, and Karlan (2021) find that religious guidance initiatives can instill grit and thereby support socioeconomic attainment. Consequently, interventions that target elements of personality may be a way to improve financial decision-making, which can enhance wealth accumulation and alleviate wealth inequality (Saez and Zucman 2016; Benhabib and Bisin 2018).

2 How Could Grit Influence Financial Decisions?

Our empirical analysis revolves around two hypotheses. First, we conjecture that grit is a salient personality trait that should affect one's preferences, particularly loss aversion. To begin with, grit is a personality trait that drives adherence and effort toward an objective despite challenges (Duckworth, Peterson, Matthews, and Kelly 2007). Grit is typically

[3]See Damasio, Grabowski, Frank, Galaburda, and Damasio (1994), Roberts and Chapman (2000), Almlund, Duckworth, Heckman, and Kautz (2011), Hudson and Fraley (2015), Hudson, Fraley, Chopik, and Briley (2020), and Stieger, Flückiger, Rüegger, Kowatsch, Roberts, and Allemand (2021).

associated with achieving long-term goals. However, recent research suggests that grittier people are also better at adjusting their short-term goals and the related attainment strategies in the presence of difficulties and setbacks (Jordan, Ferris, Hochwarter, and Wright 2019; Tang, Wang, Parada, and Salmela-Aro 2021).

Grit is different from the traditional Big Five personality traits even if it seems related to conscientiousness. Specifically, Duckworth, Peterson, Matthews, and Kelly (2007) and Duckworth and Quinn (2009) find that grit has incremental explanatory power over conscientiousness for human behavior. Moreover, Schmidt, Nagy, Fleckenstein, Möller, and Retelsdorf (2018) find that grit better explains perseverance and consistency than conscientiousness. Grit is also distinct from self-control (Duckworth and Gross 2014).

The effects of a gritty disposition are wide-ranging. Grit leads to better educational attainment and professional success.[4] For example, grittier military cadets are more likely to persevere through arduous training initiatives (Duckworth, Peterson, Matthews, and Kelly 2007; Duckworth and Quinn 2009). Teachers with grit are more likely to remain in the profession and be more effective (Duckworth and Quinn 2009; Robertson-Kraft and Duckworth 2014). Gritty individuals are also more likely to repay their debt obligations, like student loans (Cornaggia, Cornaggia, and Xia 2020).

Based on the aforementioned evidence, we conjecture that grit should also directly affect preferences that determine financial decisions. By definition, grit influences how individuals react to setbacks when striving to achieve a goal. In the financial domain, monetary losses are setbacks towards wealth accumulation and gritty individuals may be less sensitive to such losses. But, existing evidence suggests that individuals treat financial losses differently than gains. Specifically, losses have greater behavioral impact than financial gains of the

[4]See Baum and Locke (2004), Duckworth and Quinn (2009), Wrzesniewski (2012), Locke and Latham (2013), Vallerand, Houlfort, and Forest (2014), Alan, Boneva, and Ertac (2019), and Cornaggia, Cornaggia, and Xia (2020).

same magnitude (Kahneman and Tversky 1979; Tversky and Kahneman 1991). This asymmetric effect is loss aversion and, therefore, grit and loss aversion should be related.

If grit is related to loss aversion, it is likely to influence many household-level decisions. For instance, loss aversion affects consumption and savings choices (Kahneman and Tversky 1984; Tversky and Kahneman 1991; Knetsch 1989; Van Dijk and Van Knippenberg 1998; Dimmock and Kouwenberg 2010). In terms of investment decisions, loss aversion is linked to the willingness to trade (Knetsch 1989; Kahneman, Knetsch, and Thaler 1991). Barberis and Xiong (2009) theoretically show that loss-averse investors should be less willing to sell losing stocks. Thus, they are more susceptible to the disposition effect identified by Shefrin and Statman (1985) and Odean (1998). Rau (2014) provides some empirical evidence in support of Barberis and Xiong's (2009) insight. Ultimately, the disposition effect is an important behavioral bias since it reduces portfolio performance and also leads to less efficient asset markets.[5]

Based on this evidence, in our second hypothesis, we conjuncture that grit should affect investors' trading decisions. In particular, we posit that gritty investors will be more likely to realize investment losses. Therefore, gritty investors should be less susceptible to the disposition effect and they should outperform investors that do not exhibit grit.

3 Experimental Methodology

We test our hypotheses with two main experiments. First, we test if grit is related to preferences as suggested by prospect theory. Specifically, we examine individuals' loss aversion, the curvature of the value function (i.e., risk preferences), and the weighting of objective probabilities. Second, we examine whether grit affects stock trading decisions.

[5]See Shefrin and Statman (1985), Odean (1998), Genesove and Mayer (2001), Shumway and Wu (2005), Frazzini (2006), Goetzmann and Massa (2008), Kaustia (2010), and Birru (2015).

We do not combine the experiments in order to keep them relatively short and avoid concerns related to attrition among participants.

We conduct our experiments using the Amazon Mechanical Turk (MTurk) platform. Compared to traditional in-the-laboratory samples, the MTurk platform offers several advantages. First, it supports efficient and cost-effective sampling, while providing data that is similar in quality to that from traditional lab samples (Paolacci, Chandler, and Ipeirotis 2010; Goodman, Cryder, and Cheema 2013; Casler, Bickel, and Hackett 2013; Paolacci and Chandler 2014). Second, traditional samples commonly rely on student participants, but individuals on MTurk exhibit substantial heterogeneity across socioeconomic traits.

Third, MTurk is a double-blind platform, which facilitates the random assignment of individuals to treatment or control groups. Consequently, the potential for demand characteristics, which are common in traditional laboratory settings, is reduced (Orne 1962). Overall, MTurk is a reliable and popular tool among researchers across disciplines, including finance (e.g., Duarte, Siegel, and Young (2012) and D'Acunto (2018)).

We follow Goodman and Paolacci (2017) and use several best practice guidelines for experiments on MTurk. First, we use approval ratings on prior tasks to limit participation. Specifically, we require participants to have a rating of at least 90% on their prior tasks. Second, we prohibit repeat participation in the experiments in order to promote independent sampling across individuals. Finally, we incorporate attention checks into the experiments in order to assess participants' diligence to the task. In particular, we prompt individuals to choose "Asia" from a set of choices that included (in random order): "Asia," "Europe," "North America," and "South America." We subsequently control for individuals who fail the attention check questions in our empirical tests.[6]

[6]Our results are unaffected when omitting individuals who fail the attention checks from the empirical tests.

3.1 Experimental Conditions

We use a priming task designed to activate the mental representation of grit.[7] We implement the prime by randomly assigning participants into one of two conditions at the start of an experiment: (i) the grit condition (i.e., treatment) or (ii) the control group. Individuals in the treatment group perform a short writing task that is designed to elicit grittiness. Specifically, we provide them with the following writing prompt adapted from Hillygus, Holbein, and Snell (2016):

> *We would like you to think about an experience where you, or someone in your family, worked hard to achieve a goal. This experience could be something that happened recently or something that happened a while ago. What did you or your family member do to keep going even when things got difficult?*

We require that individuals spend a minimum of two minutes describing their experience but we place no maximum time limit. Across all our experiments, we find that individuals spend an average of three minutes and forty-six seconds writing about the experience. In our primary experiments, the only difference between the two groups is that individuals in the treatment group engage with the grit writing task.

3.1.1 Manipulation Check

To assess the effectiveness of the writing prompt as a prime, we ask all participants eight questions related to grit towards the end of the experiment. The questions and response scale are obtained from Duckworth and Quinn (2009) and comprise the Short Grit Scale questionnaire. Participants respond to each question on a zero (i.e., Not like me at all) to four (i.e., Very much like me) scale.

[7] Priming is the activation of mental constructs which influence subsequent behavior (Logan 1980; Molden 2014). Priming techniques are utilized by researchers across a wide array of disciplines, including cognitive and social psychology and financial economics (e.g., Fazio et al. (1986), Neely (1991), and D'Acunto (2016)).

We calculate each participant's average rating across the questions and compare the mean responses between treated and control participants. We find that the grit priming is effective. Specifically, across our experiments, treated individuals score on average 6.6% higher on the grit scale compared to the control group participants. In the first experiment related to preference primitives, the average rating among treatment participants is 2.26, whereas it is 2.15 for control individuals. The difference of 0.11 is statistically significant (p-value = 0.050). In the second experiment related to trading, the mean rating for treated individuals is 2.37 while it is 2.19 for control participants; the difference, 0.18, is statistically significant (p-value = 0.002).

4 Grit and Preference Primitives

We begin our empirical analysis with the first experiment that focuses on the relation between grit and preferences.

4.1 Research Design: Modelling Preferences

In the experiment, we focus on three preference parameters. They are the coefficient of loss aversion (λ), a risk preference parameter related to the curvature of the value function (σ), and the degree to which an individual distorts objective probabilities to form subjective probabilities (α). To obtain estimates, we use the parameterization of Liu (2013). Specifically, we assume that individuals' preferences can be described as:

$$U(x,p;y,q) = \begin{cases} v(y) + w(p)(v(x) - v(y)) & x > y > 0 \text{ or } x < y < 0 \\ w(p)v(x) + w(q)v(y) & x < 0 < y \end{cases} \tag{1}$$

In U, the variables x and y are monetary payouts with respective probabilities of p and q. Also, in the formulation of U, the value function v takes the following form:

$$v(x) = \begin{cases} x^{1-\sigma} & \text{for } x > 0 \\ -\lambda(-x)^{1-\sigma} & \text{for } x < 0 \end{cases} \tag{2}$$

Finally, the w function in U is the following probability weighting function:

$$w(p) = \exp[-(-\ln(p))^{\alpha}] \tag{3}$$

In the parameterization, the overall curvature of the value function, v, is captured by the risk preferences parameter, σ. The loss aversion parameter, λ, models the additional aversion to losses. That is, in absolute terms, the utility derived from an $x > 0$ is λ times less than the disutility from an $x < 0$. Loss aversion is increasing in λ and $\lambda \neq 1$ indicates that there is a kink in the value function around zero.

The third preference parameter is the degree to which individuals distort objective probabilities. Liu (2013) follows Prelec (1998) and Gonzalez and Wu (1999) and uses a nonlinear exponential weighting scheme that depends on α. When $\alpha < 1$, the probability weighting function takes an inverted S shape. In this case, individuals underweight (overweight) high (low) probabilities.(Kahneman and Tversky 1979; Tversky and Kahneman 1992).[8] When $\alpha = 1$ and $\lambda = 1$, the model collapses to the expected utility theory.

4.2 Research Design: Estimating Preferences

We estimate the preference primitives using the multiple price lists method. Following Tanaka, Camerer, and Nguyen (2010), we present a series of consecutive paired lotteries to

[8]Mounting evidence documents that human behavior is consistent with this pattern (e.g., Hershey and Schoemaker (1980), Camerer (1989), and Battalio, Kagel, and Jiranyakul (1990)).

participants (i.e., lotteries A and B). Table IA1 in the Internet Appendix includes the series of paired lotteries. While viewing the lottery lists, participants select at which lottery pair they prefer to switch from lottery A to lottery B. Participants can switch between lotteries only once. They also have the options to never switch (i.e., always lottery A) or to switch at row 1 (i.e., always lottery B). The point at which they switch from one lottery to the other enables us to estimate their preference parameters.

Specifically, if a participant switches at row n, we infer that the individual prefers lottery A over lottery B in the previous row. Accordingly, we construct sets of inequalities that provide ranges for σ, α, and λ. For example, switching from lottery A to lottery B at row 7 in both Series 1 and Series 2 of the lotteries would result in parameter values of: $0.27 < \sigma < 0.35$ and $0.67 < \alpha < 0.75$. We adhere to the convention of approximating σ, α, and λ by using the midpoints of the intervals.

In our sample, the unconditional averages for participants' σ, α, and λ are 0.41, 0.56, 2.69, respectively. These estimates are in line with those found by Tanaka, Camerer, and Nguyen (2010) and Liu (2013). The mean of 0.41 for σ indicates that our participants are, on average, risk averse while the mean of 0.56 for α implies they also have a tendency to overweight low probabilities, i.e., consistent with evidence found by Tversky and Kahneman (1992). The mean value of λ shows that individuals are loss averse.

Before making any lottery choices, each experiment participant is randomly assigned to an experimental condition: (i) grit, i.e., the treatment condition or the (ii) control condition. All participants face the same lottery options (in random order), but participants in the treatment group complete the grit prime before making their decisions.

Towards the end of the experiment, participants provide demographic information and are compensated for participating. Participants received fixed compensation of $2.00 and a variable payment that depends on their response to the attention check question and on

their lottery choices. Specifically, to incentivize participants to reveal their true preferences, one lottery was chosen at random to be played for real money. The payout is then based on the participant's choice and the outcome of the lottery. The average total earnings were about $4.10, which is equivalent to about $16.40 per hour.

4.3 Participants' Socioeconomic Characteristics

We use a total of 336 individuals in the primary preferences experiment and present their characteristics in Table 1. We focus on characteristics that influence individual-level preferences and financial decisions (e.g., Barsky, Juster, Kimball, and Shapiro (1997) and Campbell (2016)). They include age, gender, race, income, and marital status. For completeness, we define all variables in Appendix I. Moreover, we collect information on other determinants of financial decisions, such as numeracy, financial literacy, perceived financial knowledge, employment status, ex-ante risk tolerance, and economic outlook.

We find that about 60% of our participants identify as male and 76% are married. The average participant is between 31 to 35 years of age. Consistent with evidence from the field (e.g., Van Rooij, Lusardi, and Alessie (2011)), our participants display moderate levels of financial literacy. In particular, they answer less than two of the three financial literacy questions correctly (Lusardi and Mitchell 2008; Lusardi and Mitchell 2011).

4.4 Grit and Loss Aversion: Regression Results

Next, we formally examine whether grit affects individuals' sensitivity to financial losses. For this analysis, we estimating the following ordinary least squares (OLS) regression:

$$\lambda_j = \alpha_0 + \beta_1 Grit_j + \theta X_j + \epsilon_j, \tag{4}$$

where λ is the loss aversion parameter. *Grit* is an indicator variable that takes a value of one if a participant is assigned to the treatment condition, and zero otherwise. The key coefficient of interest is β_1 and it measures the effect of grit on loss aversion. The regression also includes the control variables, represented by X_j. The controls account for the known determinants of individuals' financial choices and participants' socioeconomic characteristics.

We report the estimates of the the regression analysis in Table 2. Overall, the results show that grit reduces an individual's sensitivity to financial losses. For example, in the univariate regression in column (1), the estimate of β_1 is -1.824 and it is statistically significant (p-value = 0.056). This estimate remains unaffected in column (2) when we add additional control variables (i.e., age, education, income, gender, marital status, racial identity, ex-ante risk tolerance, and employment status).

4.5 Grit and Loss Aversion: Expanded Regressions

In the results reported in columns (3) to (6), we expand the regression analysis to include additional control variables. We do not expect for the estimate of β_1 to materially change in the expanded regressions because there are no systematic differences between the treated and control groups with respect to their characteristics (see Table 1). The lack of differences suggests that the random assignment was effective and lends support to the causal interpretation of the univariate estimate.

Nevertheless, we want to be especially cautious and ensure that our inferences are not biased if a particular group of individuals, who may be less prone to avoiding losses, was over sampled. For instance, Schmidt and Traub (2002) show that women are more loss averse than men while Hjorth and Fosgerau (2011) and Gächter, Johnson, and Herrmann (2010) link greater age and less education to one's tendency to avoid losses. For this reason,

we sequentially expand the control variables in the regressions.

As previously noted, in column (2), we control for the traditional determinants of portfolio decisions and the estimate of β_1 is not materially altered. Moreover, the estimate remains stable, in column (3), when controlling for numeracy, financial literacy, perceived financial knowledge, stock market participation, trust that the stock market is fair, optimism, economic outlook, and performance on the attention check question.

Our prime aims to manifest the mental representation of grit within treated participants. However, recalling a challenging task that was overcome may also invoke emotions. If so, emotions could serve as a confounding mechanism since they are likely to play roles in financial decision-making (Elster 1998; Loewenstein 2000; Heilman, Crişan, Houser, Miclea, and Miu 2010). We examine this "emotions hypothesis" by administering a validated psychological questionnaire to participants towards the end of the experiment. Specifically, we use the PANAS-X since it allows us to evaluate affect and emotions along several dimensions (Watson and Clark 1999).[9]

Using participants' responses to the questionnaire, we create several measures of positive and negative affect and emotions. As reported in Table 1, there are no significant differences across treatment and control participants with respect to the emotion measures. Nevertheless, we expand our regressions to include the measures of emotions as control variables. In column (4) of Table 2, we report results from an expanded regression that includes participants' negative affect and sadness measures. The controls have little impact on the estimate on *Grit*. Controlling for measures of positive affect and happiness, reported in column (5), also does not absorb the influence of grit on loss aversion.[10]

Another concern is that grit may be captured by the traditional Big Five traits. If so,

[9]The PANAS-X has been used in prior financial decision-making research to examine the influence of emotions on risk-taking (e.g., Bassi, Colacito, and Fulghieri (2013)).

[10]The lack of negative affect does not necessarily imply positive engagement (Cohen and Pressman 2006; Bassi, Colacito, and Fulghieri 2013). Therefore, we include measures of both dimensions.

our identified effect may be unsurprising since personality can affect the financial choices that an individual makes (Brown and Taylor 2014). We address this concern by assessing participants' personality traits along the five classic dimensions using the Ten-item Personality Inventory developed by Gosling, Rentfrow, and Swann Jr (2003). In Table 1, we find no systematic differences in the traditional personality characteristics across participants in the treatment and control conditions. We also use these personality measures in our regression analysis and report the results in column (6) of Table 2. The estimate on *Grit* remains negative and statistically significant (p-value = 0.045).

To summarize, the specifications in Table 2 show that the participants in the treatment condition display significantly different preferences over financial losses compared to individuals in the control group. Specifically, grit reduces an individual's sensitivity to financial losses. The effect of grittiness is also robust and not subsumed by various known determinants of preferences.

4.6 Grit and Risk Preferences

One's preference for risk also influences economic decisions and a growing literature examines if risk tolerance is related to personality traits (Lauriola and Levin 2001). Since grit is an element of personality, it could have an impact on the willingness to take on financial risk. If so, the treated participants should have higher σ.

To test this conjecture, we estimate Equation 4 with σ as the dependent variable. The estimation results in Panel A of Table 3 show that participants assigned to the treatment condition do not exhibit greater willingness to take financial risks compared to individuals in the control group. Across all specifications, the coefficients on *Grit* are not statistically significant and near zero. This finding is intuitive because, at its core, grit relates to how one deals with setbacks, which is a distinct concept from risk tolerance.

4.7 Grit and Subjective Probability Weights

Individuals tend to assign subjective probabilities to risky outcomes. In particular, small probabilities are typically overweighted while large probabilities are underweighted (Kahneman and Tversky 1979; Tversky and Kahneman 1992; Wu and Gonzalez 1996; Prelec 1998). For completeness, we therefore examine if grit affects the degree to which individuals distort objective probabilities.

For this analysis, we estimate Equation 4 with α as the dependent variable. We report the estimates from OLS regressions, in Panel B of Table 3. The results show that grit does not affect the probability weighting parameter α. For instance, the estimate on *Grit* from a univariate regression is 0.029 and it is not statistically significant (p-value = 0.524). When including a wide range of control variables in the regressions, presented in columns (2) through (6), the estimates vary minimally and are consistently not statistically significant.

4.8 Robustness Check: Alternative Control Condition

For robustness, we conduct an additional experiment that uses an alternative writing task for participants randomly assigned to the control group. Specifically, we ask counterfactual participants to write about their typical day, a commonly used neutral prime in psychological research (e.g., Garg and Lerner (2013) and Faraji-Rad and Pham (2017)). All other elements of the additional experiment are the same as before. That is, participants in the treatment condition complete the grit writing prime and all individuals face the same lottery options.

We recruit 240 new participants and report the results in Table 4. The evidence is consistent with the findings from the primary experiment. We again find that individuals in the grit condition are less averse to financial losses relative to individuals in the control group. Controlling for various factors like emotions and personality traits, does not sub-

sume the impact of grit on loss aversion. We also do not find grit to influence participants' risk preferences or subjective probabilities.

5 Grit and Investor Trading Behavior

In light of the evidence from the financial preferences experiment, we conduct a portfolio choice experiment to examine whether grit affects indivdiuals' stock trading decisions. In particular, Barberis and Xiong (2009) show that greater loss aversion is associated with a higher likelihood of trading according to the disposition effect. Since grit lowers an individual's aversion to financial losses, we conjecture that gritty investors should be more likely to sell losing stocks and, thus, be less susceptible to the disposition effect.

5.1 Experiment Design: Price Process

For the portfolio choice experiment, we construct a financial market similar to Frydman et al. (2014), Frydman and Rangel (2014), and Bazley, Moore, and Murren Vosse (2019). In the experiment, all participants can trade three stocks, A, B, and C. Each stock's price moves along a two-state (i.e., a "good" state and a "bad" state) Markov chain. If the stock is randomly selected to receive a price update and it is in the good state, the price increases (decreases) with a 70% (30%) probability. If the stock is in the bad state, the probability of a price decreases (increase) is 70% (30%). Each stock's price process is independent of the other stocks' Markov chains. The economic magnitude of the price change is independent of the price direction and is uniformly selected to be either \$5, \$10, or \$15.

A stock's underlying state evolves independently. We randomly assign each stock to a state at the start of the experiment. When a stock receives a price update, then the stock's state in trial t remains the same as in trial $t-1$ with a probability of 80%. The stock switches states with a 20% probability. We do not explicitly inform investors about

the stock's state in each trial. Rather, they can infer the state using the observed price movements. The same set of realized prices are used for all individuals so that the trading performance of participants can be compared.

Our reasoning for using this price process is twofold. First, the structure ensures that the stock returns in our experimental market mimic the return momentum observed in equity markets (Jegadeesh and Titman 1993; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013). Second, as in Frydman and Rangel (2014), the price process suggests that the optimal trading strategy for a risk-neutral Bayesian participant is the opposite of the disposition effect. Specifically, a risk-neutral Bayesian trader should purchase (sell) stocks that have recently performed well (poorly).

5.2 Experiment Design: Trading Setup

In the experiment, participants are initially provided with instructions that describe the market, the price update process of the stocks, and all other details of the experiment.[11] We also endow each individual with $350 in experimental currency. The participant is then required to purchase one share of each stock, which are all priced at $100.

In order for investors to accumulate information about the price process for the stocks, we prohibit trading during the first nine trials. That is, the initial trials consist only of price updates. Following the information accumulation stage, investors have the opportunity to trade each stock three times. In particular, one of the stocks is randomly selected and the investor views the price change for that stock. While viewing the price change information, the investor may then choose to buy or sell the stock. A stock's price only evolves when it is randomly selected to be traded. As a result, investors are aware of the entire price path for each stock throughout the experiment. Figure IA1 in the appendix provides an

[11] The instructions provided to participants are available in the supplementary Internet Appendix.

example of the complete portfolio choice environment.

At any time during the experiment, investors can hold either one or zero shares of each stock in their portfolio. Therefore, when trading a stock, the investor has three options: (i) purchase the stock if it is not currently owned, (ii) sell the stock if it is already a portfolio holding, or (iii) do not trade. When an investor opts to trade, the transaction occurs at the stock's current market price. We negate concerns related to liquidity constraints by allowing participants to carry a negative cash balance. Accordingly, investors may purchase a stock even if they do not have sufficient cash during the trial.[12]

After completing the trading task, participants provide demographic information. We also liquidate their stock holdings and combine the proceeds with any cash balance held in the portfolio. To incentivize diligence during the experiment, we connect participants' compensation to their final portfolio value. Each participant receives a fixed payment of $2.00 and a variable payment, the value of which is linked their final portfolio value and their response to an attention check question. The typical investors' total earnings were equivalent to about $15.03 per hour.

To identify the causal effect of grit, we again randomly assign investors to either the grit (treatment) condition or the control condition. At the start of the experiment, individuals in the treatment condition complete the grit writing task while control participants do not. That is, the only difference between the two conditions is the grit writing prime.

5.3 Participants' Socioeconomic Characteristics

We recruit 356 individuals and provide descriptive statistics for the treatment and control groups in Table 5. About 72% of our participants are married and 68% identify

[12]If an investor concludes the experiment with a negative cash balance, the balance is deducted from the final portfolio value. The initial endowment and restricting investors to holding a maximum of one share of each stock in their portfolio ensures that participants do not complete the experiment with a negative portfolio value.

as male. As in the preferences experiment, individuals in this sample also report having above-average financial literacy but tend to correctly answer less than two of the three objective literacy questions. Importantly, the random assignment of individuals into either the treatment or control condition seems to have been effective. We find no statistically significant differences across participants' observable socioeconomic characteristics.

5.4 The Disposition Effect Measure

We use the trading decisions of the participants and compute the disposition effect measure of Odean (1998). Specifically, we collect the following information for each stock held by each participant: (i) realized gain, (ii) realized loss, (iii) paper gain, or (iv) paper loss. If the market price is above (below) the investor's purchase price and the share is sold, the transaction is identified as a realized gain (loss). If the sale price is above (below) the purchase price but the share is not sold, the trading opportunity is classified as a paper gain (loss). Next, we tabulate the number of realized and unrealized gains and losses over the course of the experiment and calculate the *Proportion of Gains Realized (PGR)*:

$$PGR = \frac{Number\ of\ Realized\ Gains}{Number\ of\ Realized\ Gains + Number\ of\ Paper\ Gains} \tag{5}$$

and the *Proportion of Losses Realized (PLR)*:

$$PLR = \frac{Number\ of\ Realized\ Losses}{Number\ of\ Realized\ Losses + Number\ of\ Paper\ Losses} \tag{6}$$

Finally, we compute the disposition effect measure as the difference between PGR and PLR. The larger the difference, the stronger the disposition effect. If PGR is equal to PLR, then the participant displays no disposition effect.

5.5 Grit and the Disposition Effect

To set the stage for our regression analysis, we graphically compare the disposition effect across the treatment and control conditions. Figure 1 illustrates that participants randomly assigned to the grit condition exhibit lower disposition than control investors. In the grit group, the average of the disposition effect measure is about 0.33. In contrast, its mean is about 0.39 in the control condition. The difference, 0.06, is statistically significant (p-value = 0.086) and represents about a 15% reduction.

If individuals in the treatment group are more prone to the disposition effect for some exogenous reason, then our inference could be biased. For example, if the grit condition over-sampled wealthier individuals, who are less prone to the disposition effect (e.g., Dhar and Zhu (2006)), then our estimates would be confounded. However, this is unlikely because we find no evidence of systematic differences between participants in the treatment and control conditions with respect to demographic characteristics (see Table 5).

Nevertheless, we estimate multivariate OLS regressions where the disposition effect measure is the dependent variable. Panel A of Table 6 presents the estimation results. Consistent with the graphical evidence, the univariate estimate in column (1) suggests that gritty individuals are less likely to trade according to the disposition effect. The estimates in columns (2) to (6) vary between -0.070 and -0.095 when we gradually include various participant-level control variables. In economic terms, our most restrictive specification suggests that grit reduces an investor's disposition effect by about 24% (p-value = 0.010).

5.6 Propensities to Realize Gains and Losses

The evidence in Panel A of Table 6 shows that grit reduces the disposition effect. However, the core element of grit is related to how an individual responds to setbacks. Therefore, grit should be mitigating the disposition effect by primarily affecting the will-

ingness to realize losses as opposed to realizing gains. We test this hypothesis in Figure 2 and in Panels B and C of Table 6.

In Figure 2, we compare *PGR* and *PLR* across investors in the treatment and control groups. Relative to the control group, treated participants do not exhibit differential trading behavior with respect to stocks that have appreciated in price (p-value = 0.689). In contrast, gritty investors realize a greater proportion of their losing stock positions. The average treated investor exhibits a *PLR* of 0.416 while it is 0.365 for the typical control investor. The difference, 0.051, is statistically significant (p-value = 0.021) and corresponds to a 14% increase in the proportion of losses that are realized.

We formally examine whether grit differentially affects investors' propensities to realize gains and losses by estimating regressions where the *PGR* and *PLR* are the dependent variables. We report the results in Panels B and C of Table 6 *PGR* and *PLR*, respectively. As before, we incrementally expand the set of control variables.

The estimate on the *Grit* variable in Panel B is not statistically significant in any of the specifications. Therefore, participants in the grit condition do not significantly differ in their willingness to sell their winning stocks compared to participants in the control group. However, grit influences the willingness to realize investments that are declining in value. Across all specifications in Panel C, we find that the estimates on the *Grit* variable are positive and statistically significant. For instance, in column (6), the estimate from the strictest specification is 0.055 (p-value = 0.006), which suggests that investors with grit realize about 15% more of their financial losses compared to investors in the control group.

5.7 Grit and Portfolio Performance

Investors who trade according to the disposition effect typically have lower performance (Odean 1998; Kaustia 2010). Since gritty individuals are more willing to move on from

losing investment positions, their trading decisions are likely to generate higher returns in asset markets with price momentum. We test this hypothesis by computing their final portfolio value. This value includes both the stock and cash holdings of participants at the end of the experiment. We then estimate regressions where the dependent variable is this final portfolio value. Table 7 shows the results.

The evidence indicates that that gritty investors generate higher returns. For instance, the estimate on the *Grit* variable in the univariate regression, in column (1), shows that treated individuals accumulate about \$2.78 (p-value = 0.032) more than investors in the control group. These incremental gains correspond to about 5.48% more wealth generated from trading. We expand the regression specifications with various control variables and report the results in columns (2) through (6). We find that the estimates on the *Grit* variable vary only slightly and remain statistically significant. For instance, in column (6), the estimate from the strictest specification is 3.46 (p-value = 0.007), which translates to about 6.82% greater wealth creation among gritty investors.

5.8 Grit and Portfolio Diversification

The evidence thus far suggests that grit is a beneficial trait for investors. However, grit raises the propensity to realize losses but not gains, which could lead individuals to hold less-diversified investment portfolios that are concentrated only in winning stocks. Such an investment strategy could be sub-optimal because holding a concentrated portfolio can reduce portfolio performance and increase portfolio risk (e.g., Ivkovic, Sialm, and Weisbenner (2008)). Under-diversification can also have negative long-term wealth implications since the benefits of investing are associated with efficient portfolio construction (Campbell, Ramadorai, and Ranish 2014).

We examine the effects of grit on investors' portfolio diversification by counting each

participant's number of unique stock holdings at the conclusion of the experiment. We then re-estimate Equation 4 with the number of stocks as the dependent variable. We report the results in Panel A of Table 8. We find that the number of stock holdings of treated investors is not significantly different from that of control investors. That is, the OLS estimates on the *Grit* variable in columns (1) through (6) are not statistically significant.

Since the number of stocks variable is censored at zero and three, we also estimate a Tobit regression. We present the result in column (7). In this regression, the estimate on the *Grit* variable is 0.075 and it remains not statistically significant (p-value = 0.541). Finally, we find similar results in unreported estimates from Poisson regressions.

5.9 Grit and Trading Frequency

Because trading behavior is influenced by an investor's inherent traits (e.g., Barber and Odean (2001)), grit may affect the frequency with which an individual buys and sells stocks. To test this hypothesis, we count the number of trades of each participant, which is the total number of purchases and sales executed during the experiment. Participants may engage in a maximum of nine transactions, i.e., trade each stock three times. We find that the average participant executes about 5.11 transactions (standard deviation = 2.36).

We empirically estimate the effect of grit on trading frequency using regressions with the number of trades as the dependent variable. We report the results in Panel B of Table 8. We find that grit does not affect the propensity to trade. In all the OLS regressions, i.e., columns (1) through (6), its estimate is not statistically significant.

Since the range of the number of trades variable is between zero and nine, we also estimate a Tobit regression and report the results in column (7). We again find that grit does not affect investors' total trading activity (p-value = 0.386). We find similar results in unreported estimates from Poisson regressions.

6 Conclusion

Grit, the drive to sustain interest in and effort toward a goal despite setbacks, affects the behavior of individuals across a variety of domains. In this study, we examine whether having a gritty disposition has implications for financial decision-making. First, using a standard lottery choice experiment, we find that grit affects the prospect theoretic preferences of individuals in a unique manner. The results show that grit reduces loss aversion. Grit does not influence the curvature of the value function, i.e., risk preferences, nor does it affect the subjective probabilities that individuals apply to uncertain financial payouts. The relation between grit and loss aversion cannot be explained by traditional determinants of economic choice, emotions, or alternative dimensions of personality.

Second, we find that grit affects investor behavior. In an experimental financial market, grit reduces participants' tendency to trade according to the disposition effect. By increasing their willingness to realize losses, participants treated with the grit prompt tend to earn higher portfolio returns. We find no evidence that grit affects portfolio diversification or the overall frequency of buying and selling stocks.

Overall, our study highlights that heterogeneity in portfolio choices across individuals may be rooted in differences in personality. This finding offers a potential mechanism through which household financial decisions could be improved. Since personality traits are malleable over an individual's lifetime, interventions that target elements of personality, such as grit, may promote better financial decisions throughout the life cycle of investors.

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Figure 1: Grit and the Disposition Effect

The figure reports estimates of the effect of grit on the disposition effect (i.e., the percentage of gains realized minus percentage of losses realized) of the participants in the stock-trading experiment. The bars show the mean disposition effect for the treatment (Grit) and control groups of participants. Error bars show the mean ± one standard error.

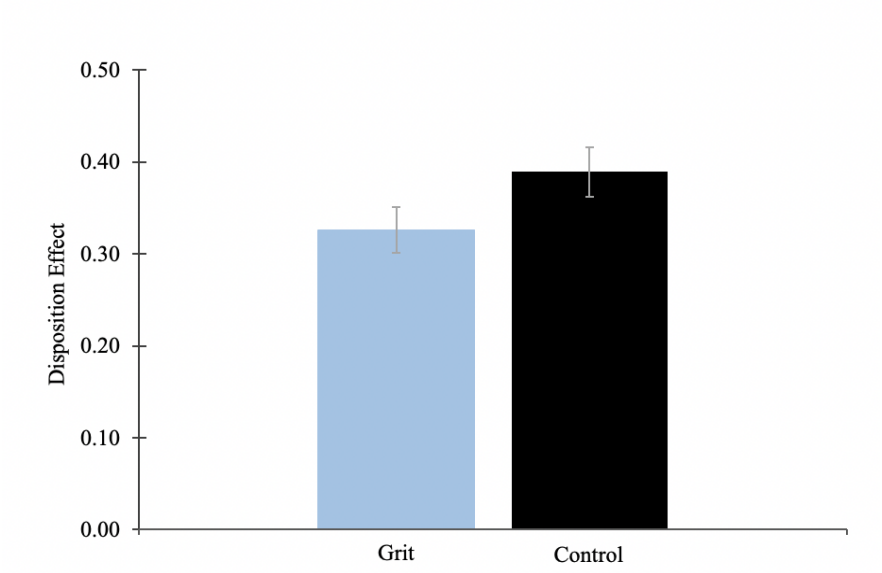

Figure 2: Grit and the Proportions of Gains and Losses Realized

The figure reports estimates of the effect of grit on the tendencies to realize gains and losses of the participants in the stock-trading experiment. The bars show the mean proportion of gains realized (PGR) and the mean proportion of losses realized (PLR) for the treatment (Grit) and control groups of participants. Error bars show the mean ± one standard error.

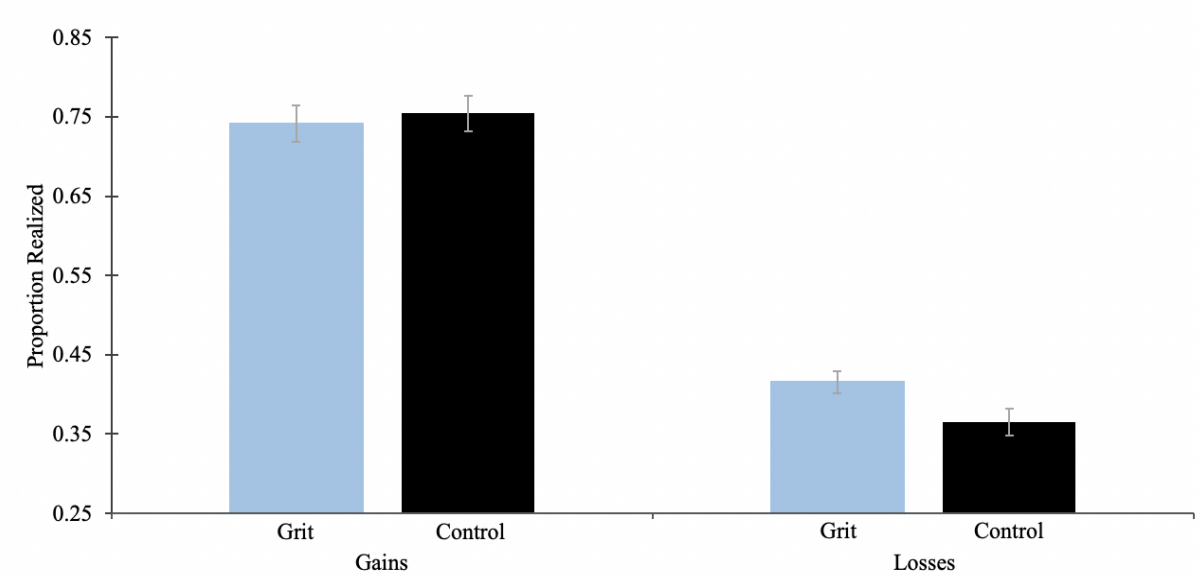

Table 1: Participant Statistics: Financial Preferences Experiment

The table reports participant summary statistics, means and standard deviations, across the treatment (Grit) and control conditions for individuals who participated in the financial preferences experiment. Panel A reports estimates for individuals who were randomly assigned to the treatment condition. Panel B shows estimates for individuals who were assigned to the control condition. The final column reports p-values from two-sample t-tests which compare the means for each variable across the treatment and control conditions. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively. All variables are defined in Appendix I.

	Grit			Control			
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	p-value
Age	4.619	2.104	168	4.690	2.290	168	(0.766)
Education	5.321	1.282	168	5.232	1.179	168	(0.507)
Income	81.452	46.470	168	77.708	46.736	168	(0.462)
Male	0.607	0.490	168	0.655	0.477	168	(0.367)
Married	0.762	0.427	168	0.762	0.427	168	(1.000)
White	0.744	0.438	168	0.673	0.471	168	(0.151)
Risk Tolerance	3.126	0.621	168	3.196	0.606	168	(0.297)
Employment Status	2.875	0.560	168	2.839	0.660	168	(0.593)
Numeracy	1.768	1.892	168	1.625	2.305	168	(0.535)
Financial Literacy	1.351	1.033	168	1.363	0.938	168	(0.912)
Perceived Financial Know.	2.655	0.948	168	2.685	0.923	168	(0.771)
Optimism	1.565	1.141	168	1.554	1.076	168	(0.922)
Economic Outlook	1.452	1.104	168	1.452	1.071	168	(1.000)
Stock Market Investor	0.655	0.477	168	0.696	0.461	168	(0.416)
Trust Stock Market	1.256	1.406	168	1.363	1.206	168	(0.454)
Attention Incorrect	0.190	0.394	168	0.220	0.416	168	(0.501)
Negative Affect	1.921	1.046	168	2.096	1.001	168	(0.118)
Sadness	1.768	1.285	168	1.863	1.271	168	(0.495)
Positive Affect	2.569	0.765	168	2.656	0.761	168	(0.297)
Happiness	2.631	1.114	168	2.780	1.052	168	(0.209)
Extraversion	-0.158	1.037	168	-0.143	0.935	168	(0.890)
Agreeableness	0.446	0.990	168	0.292	0.905	168	(0.136)
Conscientiousness	0.500	1.079	168	0.345	0.977	168	(0.169)
Emotional Stability	0.432	1.030	168	0.271	0.879	168	(0.125)
Openness to Experience	0.268	1.029	168	0.235	0.880	168	(0.754)

Table 2: Grit and Loss Aversion

The table reports estimates from OLS regressions of the effects of grit on loss aversion. The dependent variable is λ, which is the loss aversion parameter derived from the lottery choices of each experiment participant. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. Column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes a set of traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Grit	-1.824*	-1.878*	-1.944**	-1.990**	-2.043**	-1.950**
	(-1.92)	(-1.95)	(-2.00)	(-2.05)	(-2.10)	(-2.01)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	336	336	336	336	336	336
R-sq.	0.011	0.017	0.030	0.031	0.035	0.058

Table 3: Grit, Risk Preferences, and Probability Weighting

The table reports estimates from OLS regression models of the effects of grit on risk preferences and probability weighting. In Panel A, the dependent variable is σ, which is the coefficient of risk preferences derived from the lottery choices of each participant. In Panel B, α is the dependent variable, which is the nonlinear probability weighting parameter derived from the lottery choices of each participant. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. In each panel, column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes a set of traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Panel A: Risk Preferences						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	0.023	0.028	0.024	0.018	0.020	0.021
	(0.38)	(0.46)	(0.39)	(0.28)	(0.31)	(0.33)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	336	336	336	336	336	336
R-sq.	0.000	0.019	0.030	0.041	0.054	0.062
Panel B: Probability Weighting						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	0.029	0.030	0.023	0.030	0.036	0.032
	(0.64)	(0.65)	(0.50)	(0.66)	(0.79)	(0.70)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	336	336	336	336	336	336
R-sq.	0.001	0.009	0.040	0.047	0.061	0.077

Table 4: Grit and Alternative Control Condition

The table reports estimates from OLS regression models of the effects of grit on individuals' financial preferences. In Panel A, the dependent variable is λ, which is the loss aversion parameter. In Panel B, the dependent variable is σ, which is the coefficient of risk preferences and in Panel C, α is the dependent variable and is the nonlinear probability weighting parameter. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. The alternative grit condition is described in Section 4.6. In each panel, column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes the traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Panel A: Loss Aversion						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	-2.572**	-2.461**	-2.262**	-2.066*	-2.033*	-1.956*
	(-2.46)	(-2.31)	(-2.08)	(-1.92)	(-1.89)	(-1.80)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	240	238	238	238	238	238
R-sq.	0.025	0.060	0.112	0.119	0.121	0.134
Panel B: Risk Preferences						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	0.007	0.006	-0.011	-0.020	-0.017	-0.026
	(0.09)	(0.08)	(-0.15)	(-0.28)	(-0.24)	(-0.35)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	240	238	238	238	238	238
R-sq.	0.000	0.007	0.063	0.067	0.071	0.098
Panel C: Probability Weighting						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	0.041	0.043	0.040	0.046	0.044	0.040
	(0.76)	(0.78)	(0.71)	(0.78)	(0.74)	(0.67)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	240	238	238	238	238	238
R-sq.	0.002	0.019	0.051	0.053	0.055	0.079

Table 5: Participant Statistics: Stock Trading Experiment

The table reports participant summary statistics, means and standard deviations, across the treatment (Grit) and control conditions for individuals who participated in the stock trading experiment. Panel A reports estimates for individuals who were randomly assigned to the treatment condition. Panel B shows estimates for individuals who were assigned to the control condition. The final column reports p-values from two-sample t-tests which compare the means for each variable across the treatment and control conditions. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively. All variables are defined in Appendix I.

	Grit			Control			
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	p-value
Age	4.551	2.277	178	4.871	2.319	178	(0.190)
Education	5.270	1.321	178	5.264	1.264	178	(0.967)
Income	98.124	67.713	178	94.680	65.804	178	(0.627)
Male	0.669	0.472	178	0.685	0.466	178	(0.735)
Married	0.736	0.442	178	0.708	0.456	178	(0.556)
White	0.736	0.442	178	0.792	0.407	178	(0.213)
Risk Tolerance	3.127	0.657	178	3.152	0.660	178	(0.725)
Employment Status	2.893	0.547	178	2.837	0.673	178	(0.388)
Numeracy	1.815	2.236	178	2.051	2.363	178	(0.334)
Financial Literacy	1.292	1.102	178	1.410	1.060	178	(0.304)
Perceived Financial Know.	2.669	0.868	178	2.618	0.968	178	(0.604)
Optimism	1.702	0.995	178	1.528	1.170	178	(0.131)
Economic Outlook	1.466	1.015	178	1.551	1.068	178	(0.446)
Stock Market Investor	0.742	0.439	178	0.742	0.439	178	(1.000)
Trust Stock Market	1.331	1.322	178	1.343	1.366	178	(0.937)
Attention Incorrect	0.185	0.390	178	0.202	0.403	178	(0.689)
Negative Affect	1.887	1.181	178	1.844	1.134	178	(0.722)
Sadness	1.646	1.346	178	1.697	1.377	178	(0.726)
Positive Affect	2.649	0.724	178	2.517	0.845	178	(0.116)
Happiness	2.618	1.094	178	2.663	1.169	178	(0.708)
Extraversion	-0.081	1.067	178	-0.242	1.105	178	(0.165)
Agreeableness	0.472	1.052	178	0.362	1.043	178	(0.324)
Conscientiousness	0.542	1.088	178	0.514	1.048	178	(0.804)
Emotional Stability	0.449	1.158	178	0.421	0.970	178	(0.804)
Openness to Experiences	0.208	1.040	178	0.272	1.097	178	(0.569)

Table 6: Evidence on Grit and Investors' Disposition

The table reports estimates from OLS regression models of the effects of grit on participants' disposition. In Panel A, *Disposition Effect* is the dependent variable and is calculated as the proportion of gains realized less the proportion of losses realized. In Panel B, the dependent variable is *Proportion of Gains Realized (PGR)*, as measured in Equation 5. In Panel C, the dependent variable is *Proportion of Losses Realized (PLR)*, as measured in Equation 6. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. In each panel, column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes a set of traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Panel A: Disposition Effect						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	-0.063*	-0.070*	-0.088**	-0.088**	-0.095***	-0.095***
	(-1.72)	(-1.93)	(-2.42)	(-2.40)	(-2.65)	(-2.61)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	356	356	356	356	356	356
R-sq.	0.008	0.099	0.140	0.143	0.152	0.157
Panel B: Proportion of Gains Realized						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	-0.013	-0.015	-0.030	-0.031	-0.035	-0.039
	(-0.40)	(-0.52)	(-1.05)	(-1.08)	(-1.25)	(-1.40)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	356	356	356	356	356	356
R-sq.	0.000	0.216	0.291	0.301	0.304	0.324
Panel C: Proportion of Losses Realized						
	(1)	(2)	(3)	(4)	(5)	(6)
Grit	0.051**	0.055***	0.058***	0.057***	0.060***	0.055***
	(2.32)	(2.63)	(2.87)	(2.82)	(2.99)	(2.75)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	356	356	356	356	356	356
R-sq.	0.015	0.147	0.211	0.218	0.224	0.238

Table 7: Evidence on Grit and Investors' Trading Performance

The table reports estimates from OLS regression models of the effects of grit on participants' trading performance. The dependent variable is *Portfolio Value*, which is the participant's total cash value, in dollars, at the conclusion of the experiment after liquidating all portfolio holdings. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. Column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes a set of traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeable, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Grit	2.781**	2.995**	3.284**	3.247**	3.756***	3.456***
	(2.16)	(2.34)	(2.56)	(2.54)	(2.96)	(2.71)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes
Personality Controls	No	No	No	No	No	Yes
N	356	356	356	356	356	356
R-sq.	0.013	0.063	0.093	0.095	0.121	0.141

Table 8: Evidence on Grit, Portfolio Concentration, and Trading Activity

The table reports estimates from OLS regressions in columns (1) through (6). Column (7) includes estimates from a Tobit model. In Panel A, *Number of Stocks* is the dependent variable, which is a participant's number of unique stock holdings at the conclusion of the experiment. In Panel B, the dependent variable is *Number of Trades*, the total number of buys and sells each participant implemented during the experiment. *Grit* is an indicator variable that takes the value of one if the individual was randomly assigned to the treatment condition, and zero otherwise. In each panel, column (1) reports a univariate estimate while column (2) reports an estimate from the model which includes a set of traditional control variables: age, education, income, male, married, white, risk tolerance, and employment status. Column (3) reports estimates from an expanded model which includes traditional controls as well as additional controls: numeracy, financial literacy, perceived financial knowledge, stock market investor, trust stock market, optimism, economic outlook, and attention incorrect. In column (4), we expand the regression model to incorporate controls for participants' negative emotions: negative affect and sadness. In column (5), we include positive affect and happiness control variables. In column (6), we include controls for participants' personality characteristics: extraversion, agreeable, conscientiousness, emotional stability, and openness to experience. All variables are defined in Appendix I. Standard errors are White (1980) heteroskedasticity-robust and t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Panel A: Number of Stocks							
	(1)	(2)	(3)	(4)	(5)	(6)	(7) Tobit
Grit	0.045	0.044	0.047	0.052	0.086	0.063	0.075
	(0.48)	(0.47)	(0.51)	(0.56)	(0.93)	(0.67)	(0.61)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes	Yes
Personality Controls	No	No	No	No	No	Yes	Yes
N	356	356	356	356	356	356	356
R-sq.	0.001	0.053	0.087	0.097	0.118	0.143	0.053
Panel B: Number of Trades							
	(1)	(2)	(3)	(4)	(5)	(6)	(7) Tobit
Grit	0.287	0.300	0.269	0.267	0.284	0.199	0.196
	(1.14)	(1.42)	(1.30)	(1.31)	(1.39)	(0.97)	(0.87)
Traditional Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	Yes	Yes	Yes	Yes	Yes
Negative Emotion Controls	No	No	No	Yes	Yes	Yes	Yes
Positive Emotion Controls	No	No	No	No	Yes	Yes	Yes
Personality Controls	No	No	No	No	No	Yes	Yes
N	356	356	356	356	356	356	356
R-sq.	0.004	0.298	0.361	0.375	0.376	0.405	0.110

Appendix I: Variable Definitions

This table describes the variables used in the experimental analyses.

Panel A: Experimental Variables	
Key Variables	Definition
α	Participant's nonlinear probability weighting parameter.
λ	Participant's loss aversion parameter.
σ	Participant's risk preference parameter.
Disposition Effect	The propensity to realize gains versus losses. Calculated as PGR less PLR.
Grit	One if the participant is randomly assigned to the grit (treatment) condition, zero otherwise.
PGR	Participant's number of realized gains scaled by the total number of winning portfolio holdings.
PLR	Participant's number of realized losses scaled by the total number of losing portfolio holdings.
Portfolio Value	Participant's final portfolio value in dollars.
Number of Stocks	Number of unique stock holdings at the end of the experiment.
Number of Trades	Participant's total number of buys and sells during the experiment.
Explanatory Variables	Definition
Age	Categorical age group of the participant: 1. 18 - 20; 2. 21 - 25; 3. 26 - 30; 4. 31 - 35; 5. 36 - 40; 6. 41 - 45; 7. 46 - 50; 8. 51 - 55; 9. 56 - 60; 10. 61 - 65; 11. Above 65 years old.
Agreeableness	Score, from -3 (Disagree strongly) to 3 (Agree strongly) on the Agreeableness dimension of the Ten-item Personality Inventory.
Attention Incorrect	Indicator equal to one if the individual incorrectly answered the attention check question "Please select Asia from the list," and zero otherwise.
Conscientiousness	Score, from -3 (Disagree strongly) to 3 (Agree strongly) on the Conscientiousness dimension of the Ten-item Personality Inventory.
Economic Outlook	Response on a one (much worse) to seven (much better) Likert scale to "Five years from now, my household's economic status will be:"
Education	The level of highest education attained. Categorical variable: 1. Some high school; 2. High school graduate; 3. Some college; 4. Undergraduate degree; 5. Professional degree; 6. Master's degree; 7. Doctoral degree.
Emotional Stability	Score, from -3 (Disagree strongly) to 3 (Agree strongly) on the Emotional Stability dimension of the Ten-item Personality Inventory.
Employment Status	Equal to 1 if participant is a student, 2 if a homemaker, 3 if employed part-time or full-time, zero otherwise.
Extraversion	Score, from -3 (Disagree strongly) to 3 (Agree strongly) on the Extraversion dimension of the Ten-item Personality Inventory.
Financial Literacy	Zero (low literacy) to three (high literacy) index based on the three literacy questions in Lusardi and Mitchell (2008, 2011).
Happiness	Participant's score from zero (Very slightly or not at all) to four (Extremely) on the happiness dimension of the PANAS-X.

Variable Definitions – *Continued*

Explanatory Variables	Definition
Income	Participant's income in thousands of dollars.
Male	Equal to one if male, zero otherwise.
Married	Equal to one if the participant is married, zero otherwise.
Negative Affect	Participant's score from zero (Very slightly or not at all) to four (Extremely) on the PANAS-X Negative Affect Scale.
Numeracy	Number of correct answers, from zero to eleven, on a sixty second numeracy questionnaire adapted from Lipkus, Samsa, and Rimer (2001).
Openness to Experiences	Score, from -3 (Disagree strongly) to 3 (Agree strongly) on the Openness to Experiences dimension of the Ten-item Personality Inventory.
Optimism	Response on a one (strongly disagree) to seven (strongly agree) Likert scale to "I am optimistic about my future."
Perceived Financial Knowledge	Rating from zero (No knowledge at all) to four (A great deal of knowledge) to "How would you rate your level of knowledge about personal finance?"
Positive Affect	Participant's score from zero (Very slightly or not at all) to four (Extremely) on the PANAS-X Positive Affect Scale.
Risk Tolerance	Index composed of the gambling and investing risk assessment questions from Weber, Blais, and Betz (2002).
Sadness	Participant's score from zero (Very slightly or not at all) to four (Extremely) on the sadness dimension of the PANAS-X.
Stock Market Investor	One if the participant invests in the stock market, and zero otherwise.
Trust Stock Market	Response on a one (strongly disagree) to seven (strongly agree) Likert scale to the question "Are you confident that the stock market is fair and that you will not be cheated when investing?"
White	Equal to one if the participant is White, zero otherwise.

Internet Appendix

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Table IA1: Estimating Financial Preferences

This table shows the series of lottery pairs used to elicit participants' financial preferences.

Panel A: Series 1		
Pair #	Lottery A	Lottery B
1	30% chance of $2.00; 70% chance of $0.50	10% chance of $3.40; 90% chance of $0.25
2	30% chance of $2.00; 70% chance of $0.50	10% chance of $3.75; 90% chance of $0.25
3	30% chance of $2.00; 70% chance of $0.50	10% chance of $4.15; 90% chance of $0.25
4	30% chance of $2.00; 70% chance of $0.50	10% chance of $4.65; 90% chance of $0.25
5	30% chance of $2.00; 70% chance of $0.50	10% chance of $5.30; 90% chance of $0.25
6	30% chance of $2.00; 70% chance of $0.50	10% chance of $6.25; 90% chance of $0.25
7	30% chance of $2.00; 70% chance of $0.50	10% chance of $7.50; 90% chance of $0.25
8	30% chance of $2.00; 70% chance of $0.50	10% chance of $9.25; 90% chance of $0.25
9	30% chance of $2.00; 70% chance of $0.50	10% chance of $11.00; 90% chance of $0.25
10	30% chance of $2.00; 70% chance of $0.50	10% chance of $15.00; 90% chance of $0.25
11	30% chance of $2.00; 70% chance of $0.50	10% chance of $20.00; 90% chance of $0.25
12	30% chance of $2.00; 70% chance of $0.50	10% chance of $30.00; 90% chance of $0.25
13	30% chance of $2.00; 70% chance of $0.50	10% chance of $50.00; 90% chance of $0.25
14	30% chance of $2.00; 70% chance of $0.50	10% chance of $85.00; 90% chance of $0.25
Panel B: Series 2		
Pair #	Lottery A	Lottery B
1	90% chance of $2.00; 10% chance of $1.50	70% chance of $2.70; 30% chance of $0.25
2	90% chance of $2.00; 10% chance of $1.50	70% chance of $2.80; 30% chance of $0.25
3	90% chance of $2.00; 10% chance of $1.50	70% chance of $2.90; 30% chance of $0.25
4	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.00; 30% chance of $0.25
5	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.10; 30% chance of $0.25
6	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.25; 30% chance of $0.25
7	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.40; 30% chance of $0.25
8	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.60; 30% chance of $0.25
9	90% chance of $2.00; 10% chance of $1.50	70% chance of $3.85; 30% chance of $0.25
10	90% chance of $2.00; 10% chance of $1.50	70% chance of $4.15; 30% chance of $0.25
11	90% chance of $2.00; 10% chance of $1.50	70% chance of $4.50; 30% chance of $0.25
12	90% chance of $2.00; 10% chance of $1.50	70% chance of $5.00; 30% chance of $0.25
13	90% chance of $2.00; 10% chance of $1.50	70% chance of $5.50; 30% chance of $0.25
14	90% chance of $2.00; 10% chance of $1.50	70% chance of $6.50; 30% chance of $0.25
Panel C: Series 3		
Pair #	Lottery A	Lottery B
1	50% chance of $1.25; 50% chance of -$0.20	50% chance of $1.50; 50% chance of -$1.00
2	50% chance of $0.20; 50% chance of -$0.20	50% chance of $1.50; 50% chance of -$1.00
3	50% chance of $0.05; 50% chance of -$0.20	50% chance of $1.50; 50% chance of -$1.00
4	50% chance of $0.05; 50% chance of -$0.20	50% chance of $1.50; 50% chance of -$0.80
5	50% chance of $0.05; 50% chance of -$0.40	50% chance of $1.50; 50% chance of -$0.80
6	50% chance of $0.05; 50% chance of -$0.40	50% chance of $1.50; 50% chance of -$0.70
7	50% chance of $0.05; 50% chance of -$0.40	50% chance of $1.50; 50% chance of -$0.55

Trading Experiment: Participant Instructions

You will be given 350 experimental dollars to invest in three different stocks. Your job is to choose when to buy and sell each stock, so that you earn the most money by the end of the experiment. Throughout the experiment, you will see the stock prices change and you can use this information to decide when to buy and sell.

You will start the experiment with 1 share of Stock A, 1 share of Stock B, and 1 share of Stock C. Each share is worth $100. You will also start with $50 in cash. For the remainder of the experiment, you are only allowed to hold either 1 share or 0 shares of each stock, and the rest of your portfolio is held in cash. The cash balance can be positive or negative. Either way, the cash balance earns a 0% return.

Structure of the Market

The experiment will begin by showing you information about the price history for Stock A, Stock B, and Stock C over the past nine periods. Then, you will have nine trading sessions where you decide whether to buy or sell one of the three stocks.

In each trading session, you will be given a price update for either Stock A, Stock B, or Stock C. One of the three stocks will be randomly selected and you will see if the selected stock price has gone up or down, and by how much.

Then, you will be asked whether you would like to trade the stock and you have to answer "yes" or "no." You will see whether you currently own 1 or 0 shares of the stock. If you choose "yes" and you own 1 share, you will sell it. If you choose "yes" and you own 0 shares, you will buy 1 share. If you choose "no," then you will keep your current position of 0 or 1 shares.

How Stock Prices Change

The prices of Stock A, Stock B, and Stock C all change over time according to the

same rule. At any time, each stock is either in a "good state" or a "bad state." A stock in the good state has a 70% chance of going up and a 30% chance of going down in the next period. A stock in the bad state has a 30% chance of going up and a 70% chance of going down in the next period. In either state, the size of the stock price change is equally likely to be \$5, \$10, or \$15. After each time period, there is a 20% chance that the stock switches state.

Figure IA1: Stock Trading Environment

The figure illustrates the trading environment used in portfolio choice experiment. The environment provides participants' with information on the current market price for the stock, their portfolio holding details, as well as their contemporaneous cash position.