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ON THE LINKAGE BETWEEN FINANCIAL RISK TOLERANCE AND RISK AVERSION

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Abstract

We explore the linkage between financial risk tolerance (FRT) and risk aversion. To do this, we obtain FRT scores from a psychometrically validated survey and conduct a battery of online lottery choice experiments involving the same non-student participants. We contrast: real and hypothetical payoffs, low and high stakes, decisions involving gains and losses, and order effects. Our key finding is that the two approaches to analyzing decision making under uncertainty are strongly aligned. We present evidence that this is particularly the case for the female participants in our sample and when high-stake gambles are employed.

JEL Classification: D81, G19

I. Introduction

This article bridges two literatures on the attitude to economic/financial risk—financial risk tolerance (FRT) and risk aversion (RA)—in an attempt to see how well they complement and reinforce each other. Integration of FRT and RA has never been done and it offers the realistic prospect of unique insights into both literatures.[1] FRT refers to an investor's attitude toward risk—the amount of uncertainty

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[1] We are extremely grateful to the referee, John List, for suggesting this unique focus.

or investment return volatility that an investor is willing to accept when making a financial decision (Grable 2000). In concept, FRT is inversely related to the economists' notion of RA. That is, individuals who are more (less) risk averse will have a lower (higher) tolerance for financial risk.

The literature includes three methods for measuring FRT and RA: observing actual investment behavior, assessing choices in an experimental setting, and creating scores from survey questionnaires. For example, Cohen and Einav (2005) structurally estimate RA using car insurance data. There is also a growing body of literature that analyzes contestant behavior on game shows (e.g., *Deal or No Deal;* Post et al. Forthcoming). In assessing choices in an experimental setting, researchers consider either hypothetical scenarios or where decisions have financial consequences (e.g., Holt and Laury 2002, 2005). Finally, researchers such as Hallahan, Faff, and McKenzie (2004) investigate demographic patterns in FRT scores.

With regard to the FRT literature, there is considerable interest in the demographic determinants and attention is particularly focused on age, gender, education, income and wealth, and marital status. Specifically, although debate remains on some issues, a range of common findings are generally observed. First, FRT decreases with age (e.g, Morin and Suarez 1983). Second, females have a lower preference for risk than males (e.g., Grable 2000).[2] Third, FRT increases with education (e.g., Haliassos and Bertaut 1995). Fourth, FRT increases with income and wealth (e.g., Cohn et al. 1975; Bernheim, Skinner, and Weinberg 2001). Fifth, single (i.e., unmarried) investors are more risk tolerant (e.g., Roszkowski, Snelbecker, and Leimberg 1993).

Holt and Laury (2002) investigate RA in the context of lottery choice decisions. Specifically, they address the incentive effects issue by having their experimental group of participants (students) engage in both hypothetical and real lottery games. That is, with real games, the participants receive actual (rather than hypothetical) monetary payoffs. They examine the effects of payoff magnitudes in an experiment where people have to choose between a range of matched pairs of safe and risky gambles.[3] Holt and Laury find that the size of the payoff matters, with RA increasing as the stakes grow. They also find that people exhibit higher levels of RA in hypothetical choices than in choices involving real monetary stakes. A key implication is that a hypothetical scenario is not a good substitute for one that involves real monetary consequences.

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[2]Other recent studies with a gender focus in the financial markets setting include Atkinson, Baird, and Frye (2003) and Barber and Odean (2001).

[3]In the smallest base case, 1x, the safe (risky) lottery game's payoffs are $2 and $1.60 ($3.85 and $0.10), with varying probabilities. In the largest lottery game, 90x, the safe (risky) payoffs are $180 and $144 ($346.50 and $9). The expression 90x refers to the same lottery experiment except that all payoffs are scaled up by 90 times the base game.

As outlined, two related literatures (FRT and RA), which have not been compared, provide an opportunity for a unique methodological contribution to the literature. The primary goal of our article is to perform such an integration. Specifically, we select a group of experimental participants who follow a two-stage process. In the first stage, they complete a full psychometrically based FRT survey that produces a risk tolerance score for each individual. In the second stage, they play a range of lottery choice games with both hypothetical and real payoffs (modeled on the Holt and Laury 2002 design).

Our experimental setup produces a range of key elements relative to the existing literature. First, our analysis gives important insights into whether and to what extent the FRT and RA approaches are compatible. Second, compared to Holt and Laury (2002) we have higher stakes and engage more participants in such games. Third, we include some rounds of play in which negative outcomes (loss making) occur, thereby allowing us to draw inferences regarding loss aversion and prospect theory. Fourth, unlike other similar studies, we do not use students as participants. This has the major advantage of giving a more representative sample of society, including a broader range of education levels, age, and wealth. A final feature is that we implement our lottery experiment using an online Web-based delivery.

Our central result is that an FRT score obtained from a psychometrically validated survey and the RA type of information deduced from lottery choice experiments are indeed strongly correlated. Our evidence suggests that this is particularly the case for females. There is also some suggestion that the FRT–RA linkage is strengthened when high-stake gambles are employed.

II. Research Design and Implementation

There are two key elements to our basic research design. First, all participants completed a full psychometrically validated FRT survey, which produced a risk tolerance score for each of them. Second, all participants played a range of lottery choice games with both hypothetical and real payoffs. Details of each element and how they relate to each other are presented in the following sections.

FRT Survey Element

The use of subjective survey questionnaires is a widely accepted method for assessing FRT. Because of the complexity of the attitudinal construct, a sophisticated psychological testing instrument is required (Callan and Johnson 2003). A good attitudinal test meets accepted psychological standards for both face validity (perceived relevance of the questions) and predictive validity (prediction of later performance or behavior). It also has reliability (consistency in results for repeated tests of the same person), as well as appropriate test norms so that participants' test scores can be interpreted against an appropriate reference group. FinaMetrica Ltd. is an Australian company that uses such an approach to measure the preferred level of risk of an individual. The FinaMetrica Personal Financial Profiling system is a proprietary, commercial FRT metric (www.riskprofiling.com). It is a psychometrically validated attitude test comprising 25 questions that generate a standardized FRT score (1 to 100), in which a higher score indicates higher risk tolerance.[4] It has been available commercially to the Australian financial planning industry since 1998 and was introduced in the United States in 2002. It can be completed in hardcopy form or accessed through the Internet. Accompanying the risk tolerance test is a set of eight demographic questions dealing with age, gender, postcode (zip code), education, income, marital status, financial dependents, and net assets. Our project uses a database of these FRT scores and associated demographic data.

We contacted FinaMetrica in early 2005 seeking its assistance in obtaining a sample of participants for our experiment. FinaMetrica initially identified a pool exceeding 1,000 people who had recently completed its FRT survey (and a range of demographic questions).[5] From this group, a subset of approximately 600 participants answered "yes" to a question administered with the original survey asking whether they would be willing to participate in follow-up surveys relating to FRT and attitudes to investing. Our contact at FinaMetrica kindly agreed to e-mail these 600 people asking if they would be specifically interested in taking part in our experiment (see the Appendix for a transcript of the email communication). From this group, 250 individuals indicated that they would be willing to participate; thus, this subset became the target for our stage 2 lottery experiment.

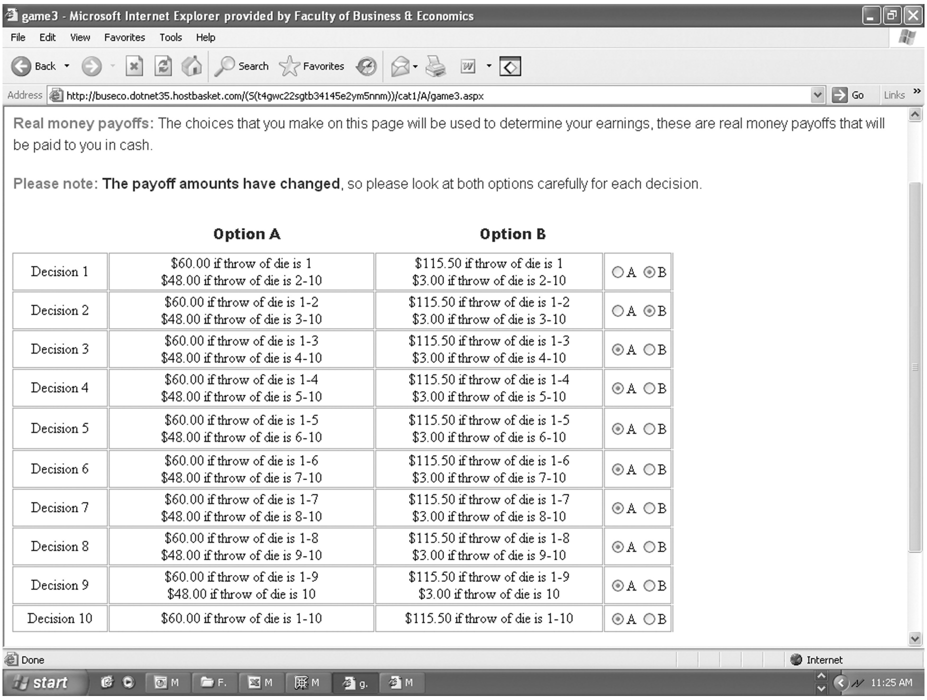
Lottery Choice Experiment

From the potential pool of 250, 162 people completed the lottery experiment. The major advantage of this sample compared to other studies (e.g., Holt and Laury 2002) is that we do not rely on students. The participants in our experiment represent a much broader spectrum of society along many dimensions including age, wealth, and life experience. Although we applied Holt and Laury's (2002) basic lottery choice design, unlike them we created a completely Web-based online experiment.[6]

[4]The scale is normally distributed with a mean of 50 and a standard deviation of 10. The metric has been subject to usability, reliability and norming trials by the University of New South Wales, exceeding international psychometric standards (Web site: http://www.risk-profiling.com).

[5]We followed a lengthy process to obtain full and proper ethical clearance for our project from the ethics committee at our university. As part of that process we agreed to fully respect the confidentiality of all participants.

[6]Full details of how we implemented the online experiment are suppressed to conserve space. Suffice it to say, several difficulties were encountered and resolved. For example, we needed to design the experiment such that participants could not "cheat." As a result, two important features were that we assigned unique IDs to each player (password protected) and we ensured that a real-time permanent record of each completed


game3 - Microsoft Internet Explorer provided by Faculty of Business & Economics

Real money payoffs: The choices that you make on this page will be used to determine your earnings, these are real money payoffs that will be paid to you in cash.

Please note: **The payoff amounts have changed**, so please look at both options carefully for each decision.

	Option A	Option B	
Decision 1	$60.00 if throw of die is 1 $48.00 if throw of die is 2-10	$115.50 if throw of die is 1 $3.00 if throw of die is 2-10	○A ⊙B
Decision 2	$60.00 if throw of die is 1-2 $48.00 if throw of die is 3-10	$115.50 if throw of die is 1-2 $3.00 if throw of die is 3-10	○A ⊙B
Decision 3	$60.00 if throw of die is 1-3 $48.00 if throw of die is 4-10	$115.50 if throw of die is 1-3 $3.00 if throw of die is 4-10	⊙A ○B
Decision 4	$60.00 if throw of die is 1-4 $48.00 if throw of die is 5-10	$115.50 if throw of die is 1-4 $3.00 if throw of die is 5-10	⊙A ○B
Decision 5	$60.00 if throw of die is 1-5 $48.00 if throw of die is 6-10	$115.50 if throw of die is 1-5 $3.00 if throw of die is 6-10	⊙A ○B
Decision 6	$60.00 if throw of die is 1-6 $48.00 if throw of die is 7-10	$115.50 if throw of die is 1-6 $3.00 if throw of die is 7-10	⊙A ○B
Decision 7	$60.00 if throw of die is 1-7 $48.00 if throw of die is 8-10	$115.50 if throw of die is 1-7 $3.00 if throw of die is 8-10	⊙A ○B
Decision 8	$60.00 if throw of die is 1-8 $48.00 if throw of die is 9-10	$115.50 if throw of die is 1-8 $3.00 if throw of die is 9-10	⊙A ○B
Decision 9	$60.00 if throw of die is 1-9 $48.00 if throw of die is 10	$115.50 if throw of die is 1-9 $3.00 if throw of die is 10	⊙A ○B
Decision 10	$60.00 if throw of die is 1-10	$115.50 if throw of die is 1-10	⊙A ○B

Figure I. Computer Screen View of an Illustrative Round of Play in the Online Lottery Choice Experiment.

The experiment comprises a series of rounds, with each round involving 10 choices between separate pair-wise lotteries. An example of an illustrative round is presented in Figure I as a computer screen view in the Web-based format that confronts the participants. As shown in the figure, Option A represents the safer gamble with a high payoff of $60 and a low payoff of $48,[7] whereas Option B represents the riskier gamble with a high payoff of $115.50 and a low payoff of $3. Decision 1 in this case gives a 10% (90%) chance of the high (low) payoff. For each successive increment on the list, the chance of the high (low) payoff increases (decreases) by 10% until Decision 10 is reached, in which case the high payoff is fully certain.

After the participant recorded his or her choices for a complete round of 10 decisions, that round is completed and the lottery choice program moves on to ascertain the outcome for that participant. The outcome for each round (revealed to

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round was made in the database such that a participant could not try to replay a round in the hope of being luckier and winning a larger prize. Holt and Laury (2005) use a computer interface (unlike Holt and Laury 2002); however, the researcher was present during the experiment and conducted the dice throw by hand.

[7] All amounts are paid in Australian dollars. At the time of the experiment, the exchange rate was approximately, AU$1 = US$0.75.

each player at the end of each round before starting the next round) is determined by a two-stage process. In step 1 a notional 10-sided die is rolled and the number revealed identifies which decision is alive. For example, if the electronic die roll reveals a 7, it is Decision 7 that is alive. Step 2 involves a second roll of the notional die, and the number that comes up identifies whether a high or low win has occurred. For example, if the second die roll for Decision 7 comes up a 2 (9), the participant has won either $60 ($48) if Option A was chosen or $115.50 ($3) if Option B was chosen.

Each participant plays between three and six rounds depending on the scenarios encountered, which will be explained shortly. We designed rounds to vary along a range of dimensions. The first is stakes—there are low and high case scenarios. In the low case scenario winnings range between $0.10 and $3.85, and in the high case scenario winnings range between $3 and $577.50. The second dimension is real versus hypothetical rounds. Each round is clearly designated as being either real (and therefore affecting actual money the participant will receive) or hypothetical (which has no bearing on actual winnings). The third dimension is gain versus loss rounds. A gain round involves a choice between two positive payoffs, whereas a loss round involves choice between two negative payoffs. Thus, if it is a real loss round the participants' actual winnings will necessarily decline. We designed the experiment so that every participant completes it with positive winnings—no one can lose money. We assured participants of this fact before they played the lottery game (see the Appendix).

Participants can play a maximum of six rounds—the sequence of the rounds is listed in Panel A of Table 1. Round 1 is a low payoff (1x), gain, and real round. Rounds 2–5 are high payoff: 2 and 3 are gain rounds, whereas 4 and 5 are loss rounds (both are hypothetical–real pairs). The final round (Round 6) reverts to the identical scenario of Round 1. Panel B of Table 1 shows the payoff schedule for the two low rounds (Rounds 1 and 6). The risky (safe) option produces a "good" outcome of $3.85 ($2) and a "bad" outcome of $0.10 ($1.60).

The reality of conducting experiments such as ours is the existence of a binding (relatively low) budget constraint, and the challenge is to balance the myriad of competing issues to arrive at what is seen as the optimal research design. With this in mind, we decided to stream participants into three different high payoff rounds. The highest payoff we were able to justify was $577.50, but because of budget constraints we could not allow this to be available to any more than about 40 players. Panel C of Table 1 outlines the three streams used. For the gain rounds, Stream 1 corresponds to a 30x game, Stream 2 is a 78x game, and Stream 3 a 150x game. As revealed in this table, we need to ensure that the high-loss rounds (Rounds 4 and 5) appropriately matched their high-gain round counterparts so that the possibility of "bankruptcy" is eliminated. Indeed, participants who won the lowest amount in Round 3 automatically bypass Rounds 4 and 5; they are instead directed straight to Round 6. We summarize the four possible sequences of play

TABLE 1. Lottery Choice Experimental Design Summary.

Panel A. Sequence of Rounds

		Dimension	
Round Number	Scale	Gain/Loss	Real/Hypothetical
1	Low payoff	Gain	Real
2	High payoff	Gain	Hypothetical
3	High payoff	Gain	Real
4	High payoff	Loss	Hypothetical
5	High payoff	Loss	Real
6	Low payoff	Gain	Real

Panel B. Low Payoff Rounds (Rounds 1 & 6: 1x)

	Risky Option	Safe Option
Bad outcome	$0.10	$1.60
Good outcome	$3.85	$2.00

Panel C. Streaming on Varying Size of High-Payoff Rounds (Rounds 2–5)

		High-Gain Rounds (2 & 3)		High-Loss Rounds (4 & 5, if played)	
Stream	Outcome	Risky Option	Safe Option	Risky Option	Safe Option
Stream 1	Bad	$3.00	$48.00	−$1.20	−$19.20
(Low: 30x)	Good	$115.50	$60.00	−$46.20	−$24.00
Stream 2	Bad	$7.80	$125.00	−$3.20	−$51.20
(Medium: 78x)	Good	$300.00	$156.00	−$123.00	−$64.00
Stream 3	Bad	$15.00	$240.00	−$6.00	−$96.00
(High: 150x)	Good	$577.50	$300.00	−$231.00	−$120.00

Panel D. Four Possible Sequences of Play

	Round 3 Outcome	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6
One half	> $15	Yes	Yes	Yes	Yes	Yes	Yes
participants	≤ $15	Yes	Yes	Yes	No	No	Yes
Other half	> $15	No	Yes	Yes	Yes	Yes	Yes
participants	≤ $15	No	Yes	Yes	No	No	Yes

Note: This table exhibits several features of the online lottery experiment design. Panel A displays the sequence of the six rounds in terms of several defining dimensional characteristics, namely: scale of stakes, whether a gain or loss round, and whether a real or hypothetical round. Panel B defines the bad and good outcomes for the risky and safe options confronting participants in the Low Rounds 1 and 6. Panel C defines the payoffs for three streams of risky and safe options confronting participants in the High Rounds 2–5. Panel D identifies the four sequences of play that participants may encounter in the game.

in Panel D of Table 1—note that three (six) rounds are the minimum (maximum) played.

The literature addresses the potential confounding of order effects (e.g., Harrison, Johnson, et al. 2005; Holt and Laury 2005). We implement two forms of control to counterbalance order effects in our experiment. Half of the participants start in Round 1 (with a real, low-payoff scenario) and the other half skip Round 1 and start in Round 2 (with a hypothetical, high-payoff scenario). We also ensure that half of the participants are presented with Option A as the risky option and the other half are presented with Option B as the risky option (Option A is always listed first).

III. Discussion of Experimental Issues

Harrison and List (2004) propose a taxonomy of experiments that includes: conventional lab experiments, artefactual lab experiments, framed field experiments, and natural field experiments. Artefactual field experiments differ from conventional lab experiments in that they use a nonstandard participant pool. A framed field experiment is an artefactual experiment with a field context in either the commodity task or information set that contestants can use. Finally, a natural field experiment is the same as a framed field experiment except the environment is one where participants naturally undertake the tasks that are the subject of the experiment and the participants do not know they are in an experiment.

In terms of the parameters of the taxonomy set out previously, our experiment differs from traditional lab experiments in two important respects. First, we use nonstudents. According to Harrison and List (2004), this would be a sufficient innovation to move it into the artefactual field experiment category. Second, our experiment is conducted online. Although still an artificial environment in some respects, it reflects a setting in which many people regularly undertake commercial transactions today. This is likely to be true for at least some of the people in our sample, who were informed about the experiment and volunteered for it online. Our experiment would not fall within the definition of a natural field experiment as set out by Harrison and List because our participants were aware they were taking part in an experiment, but it is nonetheless important to note that the environment in which they made their decisions was not the same as a conventional lab experiment.

Artefactual Field Experiments

Laboratory experiments in economics are often criticized for relying almost exclusively on students as participants. One of the key issues in this debate is whether students are somehow unrepresentative of the broader population or whether they are representative but simply exhibit less variance in certain demographic characteristics such as age and income. If the latter is true, it may be possible (though difficult) to extrapolate from findings about students by using whatever variance exists (e.g., Andersen et al. 2006). If the former is true, it may be necessary to take account of selection bias in some other fashion.

Potential Selection Bias

Selection bias could arise in at least two ways. First, people might self-select into being a student. This could be observed through a comparison of relevant demographic traits across the overall population and the student population. Second, a bias might arise in the type of students who are most likely to respond to advertisements that ask people to participate in experiments. Some field experiments avoid the second type of bias (e.g., natural experiments). In such instances, the only bias is selection into the group being studied in its natural environment. Camerer (1998), who studies bookmakers in their natural environment, is one example of such an experiment.

Our experiment, even though arguably conducted in a field setting, certainly has both biases. Our participants self-select into the pool from which we draw our sample by becoming connected in some way with FinaMetrica. Among other things, one would expect them to be wealthier, better educated, more interested in wealth creation, and more knowledgeable about financial transactions than the average person. Participants in our experiment, like student participants in conventional laboratory experiments, also self-select via the volunteering process. As in conventional laboratory experiments, we do not correct for this potential bias.

Because our experiment was conducted online, we find it difficult to control the information flow and, as a result, we have to rely on highly detailed instructions to make sure we cover the most likely areas of confusion. However, we are fortunate in that there was almost no attrition in our experiment. Of those who volunteered to take part and e-mailed us requesting a login identity, all but a very small number fully completed the experiment.

A final issue relating to selection bias runs in the opposite direction. Specifically, certain tasks in the real world may be performed by a very narrow set of people, making it difficult to extrapolate how such people will behave based on people randomly chosen for an experiment (e.g., Harrison 2005). For example, there may be certain tasks that are subject to extreme self-selection in the real world, such as risk-loving people being attracted to becoming traders. This may be reinforced as people without the necessary aptitude or preferences are subjected to attrition over time. Moreover, people involved in certain real-world tasks may develop skills and behavioral characteristics over time through experience: a process that is difficult to replicate in time-constrained experiments. These are important considerations when extrapolating from an experiment to the broader world. However, we believe that the tasks being performed in this experiment are sufficiently generic and straightforward so that this type of bias should not be a problem.

Are Students Different?

Several studies examine nonstudents (e.g., for studies focusing on Chicago Board of Trade traders, see Haigh and List 2005; Alevy, Haigh, and List 2007), and some contrast student samples with nonstudent samples. For example, Harrison and Lesley (1996) explore whether it is possible to obtain similar results in a survey of students at the University of South Carolina to those collected using a major national survey. They find that the student survey, when reweighted to reflect the U.S. population, produces accurate estimates of damage valuations. This study suggests that it is the limited variance in the demographic characteristics of students (which can usually be corrected for, at least to some degree), rather than something inherent in the nature of students per se, that makes students different from the overall population.

Nature of the Task

Another important question is whether the nature of the task is too abstract or lacking in field references for the participants to fully comprehend what is being asked of them. This could be particularly problematic in our setting given that the experiment is conducted online and there is relatively little opportunity for contestants to ask questions.[8] However, the nature of our experiment is such that we are confident participants have adequate reference points. The instructions are detailed and include several trial runs. In particular, the choices people make are over dollars rather than an abstract unit of measurement such as tickets or points. Moreover, we attempt to make the randomization process as transparent as possible and use examples and trials before the experiment to increase participants' understanding.

Size of the Stakes

Many argue that the behavior of participants in laboratory experiments involving small stakes may not reflect their behavior in real-world situations involving much higher stakes. One response to this criticism has been to raise the dollar value of the stakes (Holt and Laury 2002). This is the approach we adopt.

Hypothetical Stakes

A large experimental literature demonstrates there are differences in the decisions people make when real financial consequences as opposed to decisions of a hypothetical nature are involved (for a survey of this literature, see Harrison 2006). Holt and Laury (2002) find that participants in a lottery choice experiment display lower levels of RA where the choices are hypothetical, as opposed to choices with real monetary consequences. Similarly, Cameron (1999) finds that proposer behavior displays greater variance and responders are significantly more likely to reject offers when games involved hypothetical stakes. Our experiment contrasts lottery choices with both real and hypothetical stakes, broadly supporting the findings of these earlier studies.

The Environment of the Field Study

Most laboratory experiments seek to create an environment that controls for all external stimuli other than the subject under study. Given that we conducted our

[8]Participants could submit queries via e-mail, and in some cases they did so.

experiment online, we effectively had no control over the environment in which our participants participated. This need not be a problem. In fact, it could be an advantage. Harrison and List (2004) and Levitt and List (2006) summarize an extensive literature examining the potential for the artificiality and formality of the laboratory environment to affect people's decision making. In addition to the laboratory setting itself being an issue, the mere knowledge of being observed may also affect participant behavior (see Harrison and List 2004; Levitt and List 2006, especially pp. 15–18).

In our experiment, many participants were aware they were being observed. Some e-mailed us after the experiment indicating what they thought our expectations were and whether they felt that they had behaved consistently with those expectations. Some indicated that they had tried to answer questions "properly"—even though our instructions clearly stated that there was no correct answer.

We believe that the environment in which our participants made their choices reduced these effects. It is, for many of the participants, an environment in which they ordinarily undertake commercial transactions—that is, on their home or work computer. As such, the environment may have reduced some participants' feeling of being observed while they made their choices.

IV. Empirical Analysis

Sample Descriptives

As indicated earlier, our final sample includes 162 participants, which represents a response rate of about 65% from the group that had initially indicated they were willing to play the lottery game. Table 2 provides summary information about our sample. Panel A provides overall figures; several observations are worthy of note. First, our sample is dominated by males (83%); only 28 of the 162 participants are female. Second, the vast majority of the survey respondents are married (98%). Third, the average age in our sample is 50 years, with a minimum age of 20 and a maximum age of 73. As such, although our sample is slightly skewed toward older people, it is more "age representative" than many other previous lottery choice experiments. Fourth, the sample is highly educated with an average score of 3.58 (where 4 is the maximum education category and indicates that the person has completed a university degree or higher qualification).

Fifth, we observe that the average wealth (income) per person of our sample is approximately $400,000 ($30,000). Notably, we have a wide divergence of financial well-being, with some respondents claiming wealth exceeding $2 million and others claiming wealth to 0. Sixth, the average FRT score is 65, with a minimum of 38 and a maximum of 89. This diversity in assessed risk tolerance is important because it gives confidence that our testing has good power. Finally, the average

TABLE 2. Basic Descriptive Statistics.

Panel A. Overall Statistics

	Mean	Median	Maximum	Minimum	Std. Dev.
DFem	0.17	0	1	0	0.38
DMarr	0.98	1	1	0	0.11
NDep	1.64	1	5	0	1.27
Age (years)	50.66	52	73	20	11.51
Edu	3.58	4	4	1	0.78
Income (per person)	$30,513	$25,000.00	$125,000	$3,000	$19,819
Wealth (per person)	$405,367	$291,667	$2,000,000	$2,500	$386,495
FRT	65.52	66	89	38	9.90
Prize won	$133.92	$84.53	$579.20	$4.60	$149.05

Panel B. By Type of Game

Game Type	Stream 1: Low	Stream 2: Medium	Stream 3: High
Number of players	88	34	40
Number of rounds	465	183	212
Average winnings	$54.14	$145.39	$315.12

Note: This table reports basic descriptive statistics for our sample. The variables are defined as follows: *DFem* is a dummy variable that equals 1 if female and 0 if male; *DMarr* is a dummy variable that equals 1 if the participant is married (legally or de facto), and 0 otherwise; *NDep* is the number of people in the family who are financially dependent on the respondent; *Age* is the age of the participant in years; *Edu* is an ordered categorical variable representing the educational background of the participant where 1 (4) represents the minimum (maximum) education level; *Income* is the income per person; *Wealth* is the wealth per person; and *FRT* is the financial risk tolerance score provided by FinaMetrica Ltd based on the answers to their Risk Tolerance Questionnaire (value ranges between 0 and 100—a higher score indicates greater risk tolerance). Panel A exhibits mean, median, maximum, minimum, and standard deviation for several variables used in later analysis. Panel B presents additional summary figures by type of game—characterized according to the three streams of play: low, medium, and high (as defined in Panel C of Table 1).

prize won is $134, with a maximum of $579.20 and a minimum of $4.60. Indeed, the total (real) dollar prize pool for our experiment is approximately $22,000.[9]

In Panel B of Table 2 we report further summary statistics classified by type of game, in which we partition games into "low" (Stream 1, as characterized in Table 1), "medium" (Stream 2), and "high" (Stream 3). First, a little more than half of the participants played the low game type, and the remaining people are evenly split between the medium and high game types. Second, 860 total rounds were played, with more than half coming from the low game type. Finally, the average winnings in the high game type scenario were almost 6 times the average for the low game type.

[9] Although we recognize that our sample is not fully representative of the population, it is much closer to this ideal than studies that rely exclusively on student participants. Moreover, we argue that it represents those in society who are likely to seek professional investment and personal financial planning advice.

Preliminary Univariate Analysis

By way of preliminary analysis we first consider whether any basic unconditional patterns exist. Specifically, we analyze the number of safe option choices selected by each player in each round (*NSafe*) and calculate mean values per round. *NSafe* is taken to be a simple and intuitive "index" of RA. In Table 3 we report the outcome of such univariate comparisons in which games are classified into low, medium, and high cases. Panel A shows overall results, and we observe three main things.

First, there appear to be scale effects between rounds but not across streams. The mean number of safe choices in Rounds 1 and 6 are virtually identical both in the overall sample and within each stream. The number of safe choices in Rounds 2 and 3 (hypothetical and real high rounds, respectively) are higher. In the overall sample, the mean number of safe choices in Round 3 is statistically higher than the mean number of safe choices in Round 6 (p-value = .013).[10] Moreover, the mean number of safe choices in Rounds 2 and 3 are higher than in either Round 1 or Round 6 for each individual stream. Given the small sample sizes, most of these differences are not statistically significant (although for Stream 3, the difference between Round 3 and Round 6 has a p-value of .059). This corroborates Holt and Laury's (2002) finding that moving from a low-payoff to a high-payoff round of play increases people's RA.

In contrast, we do not find a difference across streams. The mean number of safe choices in Round 3 is approximately equal in Streams 1 and 3 (and, surprising, higher in Stream 2). In Round 2 (hypothetical high stakes) the mean number of safe choices declines between Streams 1 and 2.

Together, these two results suggest that people behave differently in a gamble with an expected value of $2 versus a gamble with an expected value of $50 to $300 (i.e., small vs. high stakes gambles). However, people do not see a material difference between the various high stakes gambles. The first finding is not surprising and accords with both hypothetical and real stakes experiments that have been conducted (e.g., Holt and Laury 2002). The second finding may attributable to the fact that we are not using students as participants. Adults may notice the difference between a trivial gamble of $2 to $5 and a more substantial gamble of $50 or more. But someone with higher income or wealth and more life experience may not distinguish between $50 and $300 to the same extent that a typical student would.

A second observation from Panel A is that there is no compelling evidence of a loss aversion effect based on the overall univariate results—comparisons between gain and loss rounds reveal nothing statistically significant. Third, comparisons between real and hypothetical lotteries also show no signs of statistical

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[10] We compare Rounds 3 and 6 because only half of the participants took part in Round 1 (Rounds 1 and 6 are substitutes because they both involved low real choices).

TABLE 3. Mean of the Number of Safe Choices per Lottery Round.

		Game Type		
	All	Stream 1: Low	Stream 2: Medium	Stream 3: High
Panel A. Overall				
All rounds	5.36 (860)	5.37 (465)	5.32 (183)	5.37 (212)
R1: Low-gain real	5.04 (82)	5.04 (49)	4.80 (15)	5.22 (18)
R2: High-gain hypothetical	5.29 (162)	5.22 (88)	5.08 (34)	5.63 (40)
R3: High-gain real	5.49 (162)	5.48 (88)	5.62 (34)	5.40 (40)
R4: High-loss hypothetical	5.71 (146)	5.78 (76)	5.94 (33)	5.38 (37)
R5: High-loss real	5.49 (146)	5.49 (76)	5.48 (33)	5.51 (37)
R6: Low-gain real	5.01 (162)	5.13 (88)	4.71 (34)	5.00 (40)
Panel B. By Gender				
All rounds				
Male	5.29 (707)	5.31 (405)	5.30 (135)	5.22 (167)
Female	5.67** (153)	5.77* (60)	5.35 (48)	5.89** (45)
R1: Low-gain real				
Male	5.00 (67)	4.93 (42)	5.17 (12)	5.08 (13)
Female	5.20 (15)	5.71 (7)	3.33 (3)	5.60 (5)
R2: High-gain hypothetical				
Male	5.16 (134)	5.14 (77)	4.92 (25)	5.38 (32)
Female	5.93** (28)	5.73 (11)	5.56 (9)	6.63* (8)
R3: High-gain real				
Male	5.38 (134)	5.42 (77)	5.56 (25)	5.16 (32)
Female	6.04* (28)	6.00 (11)	5.78 (9)	6.38 (8)
R4: High-loss hypothetical				
Male	5.71 (119)	5.77 (66)	5.92 (24)	5.38 (29)
Female	5.74 (27)	5.80 (10)	6.00 (9)	5.38 (8)
R5: High-loss real				
Male	5.45 (119)	5.44 (66)	5.38 (24)	5.55 (29)
Female	5.67 (27)	5.80 (10)	5.78 (9)	5.38 (9)
R6: Low-gain real				
Male	4.96 (134)	5.08 (77)	4.84 (25)	4.78 (32)
Female	5.25 (28)	5.55 (11)	4.33 (9)	5.88 (8)

Note: This table reports the sample mean value of safe choice options (on a per round basis) chosen by participants in the lottery experiment. Panel A exhibits overall means for all rounds and round by round. Panel B shows a breakdown of the means between male and female participants. The numbers in parentheses indicate the numbers of observations for the cell in question. Although there are 10 games per round, the maximum rational score of safe choices is 9 because Decision 10 is always a choice between two certain outcomes (refer to Figure I) and in that setting the option designated as risky, having the higher (certain) payoff, is preferred.

**Significant at the 5% level.

*Significant at the 10% level.

difference (although, in the overall sample and two of the three streams, participants make more safe choices, on average, in the real rounds than in the hypothetical rounds).

In Panel B of Table 3 we report the same univariate information partitioned by gender. These results suggest that a gender effect exists: generally, females are more risk averse, showing a tendency to take a higher number of safe options on average. Specifically, females choose more safe options overall (5.67 vs. 5.29), which seems to be largely driven by the high stream subsample, suggesting that the females in our sample are more susceptible to a scale effect. Indeed, when we consider the round-by-round analysis, it is the high (gain) rounds (Rounds 2 and 3) in which some further significant gender differences are revealed.[11] For example, in the high stream of Round 2, females choose an average of 6.63 safe lotteries whereas the counterpart males choose only 5.38. Similarly, in the high real gain round (Round 3), females average 6.04 safe choices versus 5.38 for males. Finally, 14 of 18 cases in the disaggregated rounds analysis show a higher average safe choice by females. Such a ratio is statistically significant based on a nonparametric sign test.

Multivariate Analysis of Demographic Factors: Number of Safe Choices in Lottery Games Versus FRT

As outlined earlier, there is a considerable literature that tests the determinants of risk tolerance in terms of different demographic data. Accordingly, we begin our main analysis by estimating a model specified as:

$$\begin{aligned} FRT = {} & \alpha_0 + \alpha_1 DFem + \alpha_2 Age + \alpha_3 Age^2 + \alpha_4 Wealth + \alpha_5 Income + \alpha_6 DMarr \\ & + \alpha_7 NDep + \alpha_8 Edu + \varepsilon, \end{aligned} \tag{1}$$

where *FRT* is the financial risk tolerance score provided by FinaMetrica Ltd. based on the answers to their Risk Tolerance Questionnaire (value ranges between 0 and 100—a higher score indicates greater risk tolerance); *DFem* is a dummy variable that equals 1 if female and 0 if male; *Age* is the age of the participant in years and Age^2 is the square of *Age* (e.g., Riley and Chow 1992; Bajtelsmit and VanDerhai 1997); *Wealth* is the wealth per person; *Income* is the income per person;[12] *DMarr* is a dummy variable that equals 1 if the participant is married (legally or de facto), and 0 otherwise; *NDep* is the number of people in the family who are financially dependent

[11] Although several of the subgroup means appear divergent, small sample size creates weak power, making statistical significance a high hurdle.

[12] The original income and wealth data recorded by FinaMetrica provided for ranges of values rather than specific values. The specific question in relation to income is: "Having in mind income from all sources—work, investment, family and government—my personal before-tax income is . . . ," with 5 answer categories available. The specific question in relation to wealth is: "Think of your net assets as being what you own, including your family home and other personal-use assets, minus what you owe. Into which bracket does the value of your net assets fall? (If you are married or have a de facto partner, include your share of jointly owned assets)", with 10 answer categories available. We converted these ranges to specific values by taking the midpoint and dividing through by the number of family dependents. In the case of the maximum categories of income (> $200,000) and net assets (> $2 million), we arbitrarily apply $250,000 and $4 million, respectively.

on the respondent; and *Edu* is an ordered categorical variable representing the educational background of the participant where 1 (4) represents the minimum (maximum) education level.[13]

We report the estimated regression results in Panel A of Table 4. Several features are noteworthy. First, every estimated coefficient is statistically significant except for wealth and education. Hence, the specification is generally well supported. Second, women are less tolerant to risk than men, as is well documented in other studies. For our sample, all other things equal, on average women have an *FRT* that is 6.5 units lower than men. Such a difference constitutes a significant difference in the context of the FinaMetrica risk tolerance metric. This gender finding confirms earlier work in the literature (e.g., Jianakoplos and Bernasek 1998; Grable 2000). Third, *Age* produces a nonlinear effect—the linear term is negative and the quadratic term is positive. This indicates a convex linkage, suggesting that both younger and older people tend to be more risk tolerant, whereas people in the middle age bracket are less risk tolerant (i.e., more risk averse). This finding is in line with the nonlinear role of age reported by Riley and Chow (1992) and Bajtelsmit and VanDerhai (1997).

Fourth, the coefficient on income is positive, suggesting that higher income people are more willing to bear financial risk (e.g., Cohn et al. 1975; Riley and Chow 1992). Fifth, being married tends to reduce *FRT;* however, given the overwhelming dominance of married people in our sample, this result needs to be treated with caution. Sixth, *NDep* has a positive coefficient, indicating that a respondent with more family dependents will have a higher tolerance for risk. In sum, the strength of the collective results for this *FRT* regression gives us great confidence to examine our main research question.

The primary focus of this article is to examine how well the *FRT* score produced from a psychometric validated attitude test aligns with indications of RA inferred from a lottery experimental framework. Accordingly, to allow an initial assessment of this research question, we also conduct regressions with *NSafe* (the number of safe choices made in each round by each participant in the lottery choice experiment) as the dependent variable:

$$\begin{aligned} NSafe = \alpha_0 + \alpha_1 DFem + \alpha_2 Age + \alpha_3 Age^2 + \alpha_4 Wealth + \alpha_5 Income \\ + \alpha_6 DMarr + \alpha_7 NDep + \alpha_8 Edu + \varepsilon. \end{aligned} \quad (2)$$

In the event that *FRT* and *NSAfe* are compatible measures, we would expect the same explanatory variables to produce statistically significant coefficients but of opposite sign (given their reciprocal nature).

[13]The four education categories are: 1—did not complete high school, 2—completed high school, 3—completed a trade or diploma qualification, and 4—completed a university degree or higher qualification.

TABLE 4. Basic Regression Results: Demographic Determinants of Financial Risk Tolerance Score and Number of Safe Choices in Lottery Experiment.

		Panel A. Dependent Variable = *FRT*		Panel B. Dependent Variable = *NSafe*					
				Low-Gain Rounds		High Gain Rounds		Loss Rounds	
Variable	Parameter	Est. Coefficient	*t*-statistic	Est. Coefficient	*t*-statistic	Est. Coefficient	*t*-statistic	Est. Coefficient	*t*-statistic
Constant	α_0	93.5501***	8.08	5.1627	1.57	−0.4376	−0.28	6.6156***	3.65
DFem	α_1	−6.4697***	−2.99	0.3103	0.82	0.7049***	2.74	0.0580	0.24
Age	α_2	−0.9961*	−1.80	−0.0358	−0.26	0.1786**	2.56	−0.0245	−0.30
Age^2	α_3	0.0097*	1.73	0.0004	0.27	−0.0016**	−2.22	0.0002	0.19
Wealth	α_4	−0.0037	−1.33	−0.0003	−0.64	−0.0010***	−2.76	0.0002	0.52
Income	α_5	0.1120***	2.96	0.0071	0.86	0.0173***	3.13	−0.0101*	−1.83
DMarr	α_6	−4.6363***	−2.76	0.4980	1.35	0.9618***	3.22	−1.0357***	−3.50
NDep	α_7	1.3545**	2.15	0.1268	0.99	−0.0299	−0.37	−0.0466	−0.59
Edu	α_8	−0.6424	−0.71	−0.0436	−0.20	0.0095	0.06	0.3172**	2.22
Adjusted R^2		0.1300		−0.0202		0.0578		0.0127	
Sample size		162		244		324		292	

Note: Panel A reports regression results in which the dependent variable is the participant's financial risk tolerance score, *FRT,* as provided by FinaMetrica Ltd. based on the answers to their Risk Tolerance Questionnaire (value ranges between 0 and 100—a higher score indicates greater risk tolerance). Observations in this regression are defined on each participant. The independent variables are: *DFem,* a dummy variable that equals 1 if the participant is female and 0 if male; *Age,* the participant's age in years; *Age*^{2}, age squared; *Wealth,* net assets of the participant including the family home and other personal-use assets, minus any amounts owed adjusted for number of dependents; *Income,* average income per person; *DMarr,* a dummy variable that equals 1 if the respondent is married and 0 if unmarried; *NDep,* the number of people in the family whom are financially dependent on the participant; and *Edu,* an ordered categorical variable representing the educational background of the participant (1—did not complete high school, 2—completed high school, 3—completed a trade or diploma qualification, and 4—completed a university degree or higher qualification). Panel B reports a similar regression to Panel A except that the dependent variable is now *NSafe,* the number of safe options chosen by the participant in each round of the lottery choice experiment. The independent variables are identical to those used in the Panel A regression. Panel B has three variations of its regression in which observations are partitioned based on the type of round as follows: (1) low-gain rounds (Rounds 1 and 6), (2) high-gain rounds (Rounds 2 and 3), and (3) loss rounds (Rounds 4 and 5). White's heteroskedasticity-consistent standard errors and covariance are used. Note that the reported coefficients on the *Wealth* and *Income* variables are scaled up by a factor of 1,000 to aid readability.

***Significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

We outline the results of these regressions in Panel B of Table 4. We conduct three sets of regressions: for the low-gain rounds, for the high-gain rounds, and for the loss rounds. The most notable finding is that statistically significant results occur for most of the demographic determinants in the high-gain rounds but not for the low-gain rounds or the loss rounds. Moreover, for the high-gain rounds regression the sign of the coefficients on *DFem, Age,* Age^2*,* and *DMarr* are as expected and consistent with the counterpart *FRT* regression of Panel A. Furthermore, for the regression with the high-gain rounds, the coefficients are of opposite sign to the results in the *FRT* regression, as expected. The only variable whose coefficient remains significant yet does not change sign is income. It seems that the demographic determinants of RA are difficult to ascertain with very low stakes gambles, at least where the participants are adults earning moderate to high incomes. Taken together, our Table 4 results suggest that *FRT* and *NSafe* are particularly compatible when the stakes of the lottery experiment are high.

Direct Assessment of the Linkage Between NSafe and FRT

As a final set of analysis to explore the robustness of our key finding, we perform a series of regressions between *NSafe* and *FRT.* As a baseline case we estimate the simple regression as follows:

$$NSafe = \alpha + \beta * FRT + error. \tag{3}$$

The basic prediction is that the slope coefficient will be negative and significant.

In addition, we extend the model in equation (3) to incorporate a range of conditional versions. Specifically, we adjust the model in a simple way: interaction terms are created that involve the *FRT* variable. Four versions of this interaction approach are investigated, involving the following dimensions: gender, education, stake size, and separate rounds. The specifications for each of these cases are as follows:

$$\begin{aligned} NSafe = \alpha_{Fem} * DFem + \alpha_{Male} * (1 - DFem) + \beta_{Fem} * DFem * FRT \\ + \beta_{Male} * (1 - DFem) * FRT + error \end{aligned} \tag{4}$$

$$\begin{aligned} NSafe = \alpha_{Uni} * DUni + \alpha_{NUni} * (1 - DUni) + \beta_{Uni} * DUni * FRT \\ + \beta_{NUni} * (1 - DUni) * FRT + error \end{aligned} \tag{5}$$

$$\begin{aligned} NSafe = \alpha_{Low} * DLow + \alpha_{High} * DHigh + \alpha_{Loss} * DLoss + \beta_{Low} * DLow * FRT \\ + \beta_{High} * DHigh * FRT + \beta_{Loss} * DLoss * FRT + error \end{aligned} \tag{6}$$

$$NSafe = \sum_{i=R1}^{R6} \alpha_i Di + \sum_{i=R1}^{R6} \beta_i * Di * FRT + error, \tag{7}$$

where *DUni* is a dummy variable that equals 1 if the participant has a university or higher degree qualification, and 0 otherwise; *DLow* (*DHigh*) is a dummy variable that equals 1 if the round is a low (high) stakes round, i.e., Rounds 1 or 6 (Rounds 2 to 5), and 0 otherwise; and *Di* ($i = R1, R2, R3, R4, R5, R6$) is a dummy variable that equals 1 if the round is Round *j,* and 0 otherwise. Our primary focus in these equations is on the sign and significance of the coefficient associated with each interaction term; they are all predicted to be negative.

We present the results for the estimated beta coefficient in equation (3) and for the interaction terms in the remaining models, in Panels A to E of Table 5. The salient points arising from these estimations are as follows. First, in Panel A, as expected, the overall (unconditional) relation between *NSafe* and *FRT* is negative and significant (at the 1% level). As such, we have immediate confirming evidence of our central hypothesis. Second, in Panel B, the female *FRT* coefficient is considerably more negative than its male counterpart: –0.0545 versus –0.0193. Indeed, the Wald test of equality is rejected (at the 5% level). This finding suggests that the females in our sample exhibit a much tighter correspondence between the *NSafe* and *FRT* indicators of risk attitude.

Third, Panel C reveals that participants with a university education are much more likely to produce a consistency between *NSafe* and *FRT*. Although the formal Wald test fails to reinforce this conclusion, it is interesting nevertheless. Fourth, Panel D shows that high-stakes rounds dominate with a strongly negative estimated coefficient (at the 1% level). Although the low-stakes and loss rounds also produce negative coefficient estimates, it is only the latter that achieves significance (at the 10% level). Despite observing differences in the individual estimated coefficients, the Wald test fails to reject equality for the high, low, and loss round coefficients. Fifth, Panel E shows that Rounds 2, 3, and 4 are the drivers of the negative *NSafe–FRT* relation, particularly, the first high-stakes case of Round 2 (which is individually significant at the 1% level). However, once more the overall joint test of equality across rounds cannot be rejected.

Finally, Panel F reports a range of pair-wise tests of equality relating to the estimated version of equation (7) reported in Panel E. In every case we are unable to reject the hypothesis of joint equality. Specifically, these tests involve low versus high stakes (two cases: Round 1 vs. Round 3, and Round 6 vs. Round 3) and real versus hypothetical stakes (two cases: Round 2 vs. Round 3, and Round 4 vs. Round 5). In addition, these tests relate to gains versus losses (two cases: Round 2 vs. Round 4, and Round 3 vs. Round 5) and early rounds versus late rounds (Round 1 vs. Round 6). Overall, the analysis confirms that when it comes to exploring the linkage between *NSafe* and *FRT,* specific round effects are generally not statistically

TABLE 5. Testing the Linkage Between the Number of Safe Choices in the Lottery Choice Experiment and the Financial Risk Tolerance Score.

	Parameter	Est. Coefficient	Std. Error	t-statistic	p-value	Wald Test of Equality (p-value)
Panel A. Unconditional						
	β	−0.0278***	0.0072	−3.87	.0001	NA
Panel B. Males Versus Females						
Female	β_{Fem}	−0.0545***	0.015	−3.54	.000	4.057**
Male	β_{Male}	−0.0193**	0.008	−2.35	.019	(.044)
Panel C. University Education versus Nonuniversity Education						
University	β_{Uni}	−0.0306***	0.008	−3.73	.000	0.267
Nonuniversity	β_{NUni}	−0.0222	0.014	−1.56	.119	(.605)
Panel D. Low stakes versus High Stakes versus Losses						
Low stakes	β_{Low}	−0.0174	0.016	−1.12	.263	
High stakes	β_{High}	−0.0433***	0.011	−3.86	.000	3.104
Losses	β_{Loss}	−0.0187*	0.010	−1.78	.075	(.212)
Panel E. Round by Round						
Round 1	β_{R1}	−0.0134	0.021	−0.63	.527	
Round 2	β_{R2}	−0.0561***	0.013	−4.21	.000	
Round 3	β_{R3}	−0.0305*	0.018	−1.73	.084	6.451
Round 4	β_{R4}	−0.0265*	0.015	−1.75	.081	(.265)
Round 5	β_{R5}	−0.0110	0.014	−0.76	.448	
Round 6	β_{R6}	−0.0196	0.021	−0.93	.353	

Panel F. Round-by-Round Pair-wise Tests of Equality

Specific Test	Control Conditions	Round vs. Round		Absolute Difference	Wald Test of Equality
Low vs. high stakes	Real gains	R1	R3	0.0171	0.387 (0.534)
Low vs. high stakes	Real gains	R6	R3	0.0109	0.158 (0.691)
Real vs. hypothetical	High gains	R2	R3	0.0255	1.337 (0.248)
Real vs. hypothetical	High losses	R4	R5	0.0155	0.547 (0.460)
Gains vs. losses	High hypothetical	R2	R4	0.0296	2.154 (0.142)
Gains vs. losses	High real	R3	R5	0.0195	0.735 (0.391)
Early vs. late	Real low gains	R1	R6	0.0062	0.0430 (0.836)

Note: This table explores the linkage between *NSafe* (the number of safe choices in each round of a lottery experiment) and *FRT* (financial risk tolerance score as provided by FinaMetrica Ltd. based on the answers to their Risk Tolerance Questionnaire in which value ranges between 0 and 100—a higher score indicates greater risk tolerance). This is achieved by examining the correlation between *NSafe* and *FRT* in a simple regression framework in which *NSafe* is (arbitrarily) chosen as the dependent variable. In Panel A, the estimated coefficient on *FRT* is reported unconditionally. In each remaining panel, the results represent cases in which *FRT* is interacted with different sets of dummy variables: (B) male versus female participant, (C) university versus nonuniversity education, (D) low (Rounds 1 and 6) versus high (Rounds 2 and 3) versus loss (Rounds 4 and 5) rounds, and (E) each round separately. The table reports the estimated coefficients on these interaction terms and tests joint equality across each set based on Wald tests (final column). In Panel F, specific pair-wise tests of equality are reported relating to the Panel E results. White's heteroskedasticity-consistent standard errors and covariance are used.

***Significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

significant. However, as shown previously there is some evidence of a gender effect (Panel B), an education effect (Panel C), and a scale effect (Panel D).

V. Conclusion

The FRT and RA literatures study similar, although potentially distinguishable, aspects of decision making under uncertainty. By conducting a lottery choice experiment composed of people who had previously completed a psychometrically validated FRT survey, we are able to link these literatures.

We find that FRT and RA are indeed closely aligned. A person's FRT score is an important predictor of his or her behavior in the lottery choice experiment. Moreover, we are able to identify and confirm important demographic determinants of both FRT and RA, and we present evidence that these demographic determinants are largely consistent across the two measures. We also document some evidence that the *NSafe–FRT* linkage is stronger for females, for larger stakes, and for more highly educated participants.

Consistent with earlier studies, we find that women tend to be more risk averse (and less tolerant of financial risk) than males. In addition, we observe that RA and FRT have a nonlinear relation with age, with FRT (RA) decreasing (increasing) to a certain point and then increasing (decreasing) again. Furthermore, wealth and income tend to act in opposite directions, and FRT increases (and RA decreases) as the number of dependents rises. Overall, our study provides much encouragement for future research efforts that seek to positively exploit potential synergies emanating from the FRT–RA nexus.

Appendix

E-mail Sent to Potential Participants in the Lottery Choice Experiment

E-mail Subject Line: Lottery Experiment on Willingness to Bear Risk

Dear . . . . ,

I am writing to gauge your interest in a potential follow up to the Personal Investor/FinaMetrica survey that you completed earlier this year. As you had indicated in that survey your willingness to be contacted in relation to any follow up work, we are very hopeful that you will find this opportunity worthwhile.

The follow up survey is part of an important research program being conducted by a small group of researchers at XXX University, under the direction of XXX. The research will focus on people's willingness to bear risk. If you agree to participate in this experiment, you will be asked to make a series of simple choices between lotteries on a Website specifically designed for this purpose. It is estimated that this will take about 30 minutes of your time to complete. Participants who fully complete the experiment will win real monetary prizes on average exceeding $50. Importantly, no participant will be financially disadvantaged and some will do considerably better than the average. You should also note that one important condition for you to take part in the experiment would be your agreement that data previously collected in the PI survey will be cross-referenced by the XXX researchers against your decisions in the experiment. Your privacy will be guaranteed at every stage and all results will only ever refer to sample averages.

We would greatly appreciate you replying to this email at your earliest convenience informing us of your willingness or otherwise to participate in this research experiment. Specifically, please simply reply with the word "YES" or "NO" in the subject line of the email.

Thanking you in advance for your serious consideration of the above.

References

Alevy, J., M. Haigh, and J. List, 2007, Information cascades: Evidence from a field experiment with financial market professionals, *Journal of Finance* 62, 151–80.

Andersen, S., G. Harrison, M. Lau, and E. Rutstrom, 2006, Preference heterogeneity in experiments: Comparing the field and lab, Mimeo, Centre for Economic and Business Research, Copenhagen.

Atkinson, S., S. Baird, and M. Frye, 2003, Do female mutual fund manages manage differently? *Journal of Financial Research* 26, 1–18.

Bajtelsmit, V. and J. VanDerhei, 1997, Risk aversion and pension investment choices, in O. S. Mitchell, ed.: *Positioning Pensions for the Year 2000* (University of Pennsylvania Press, Philadelphia), 45–66.

Barber, B. and T. Odean, 2001, Boys will be boys: Gender, overconfidence, and common stock investment, *Quarterly Journal of Economics* 116, 261–92.

Bernheim, B., J. Skinner, and S. Weinberg, 2001, What accounts for the variation in retirement wealth among U.S. households? *American Economic Review* 91, 832–57.

Callan, V. and M. Johnson, 2003, Some guidelines for financial planners in measuring and advising clients about their levels of risk tolerance, *Journal of Personal Finance* 1, 31–44.

Camerer, C., 1998, Can asset markets manipulated? A field experiment with racetrack betting, *Journal of Political Economy* 106, 457–82.

Cameron, L., 1999, Raising the stakes in the ultimatum game: Experimental evidence from Indonesia, *Economic Inquiry* 37, 47–59.

Cohen, A. and L. Einav, 2005, Estimating risk preferences from deductible choice, Mimeo, Stanford University.

Cohn, R., W. Lewellen, R. Lease, and G. Schlarbaum, 1975, Individual investor risk aversion and investment portfolio composition, *Journal of Finance* 30, 605–20.

Grable, J., 2000, Financial risk tolerance and additional factors that affect risk taking in everyday money matters, *Journal of Business and Psychology* 14, 625–30.

Haigh, J. and J. List, 2005, Do professional traders exhibit myopic loss aversion? An experimental analysis, *Journal of Finance* 60, 523–34.

Haliassos, M. and C. Bertaut, 1995, Why do so few hold stocks? *Economic Journal* 105, 1110–29.

Hallahan, T., R. Faff, and M. McKenzie, 2004, An empirical investigation of personal financial risk tolerance, *Financial Services Review* 13, 57–78.

Harrison, G., 2005, Field experiments and control, *Research in Experimental Economics* 10, 17–50.

Harrison, G., 2006, Hypothetical bias over uncertain outcomes, in J. A. List, ed.: *Using Experimental Methods in Environmental and Resource Economics* (Edward Elgar Publishing, Northhampton, MA), 41–69.

Harrison, G., E. Johnson, M. McInnes, and E. Rutstrom, 2005, Risk aversion and incentive effects: Comment, *American Economic Review* 95, 897–901.

Harrison, G., M. Lau, E. Rutstrom, and M. Sullivan, 2005, Eliciting risk and time preferences using field experiments: Some methodological issues, *Research in Experimental Economics* 10, 125–218.

Harrison, G. and J. Lesley, 1996, Must contingent valuation surveys cost so much? *Journal of Environmental Economics and Management* 31, 79–95.

Harrison, G. and J. List, 2004, Field experiments, *Journal of Economic Literature* 42, 1009–55.

Holt, C. and S. Laury, 2002, Risk aversion and incentive effects, *American Economic Review* 92, 1644–55.

Holt, C. and S. Laury, 2005, Risk aversion and incentive effects: New data without order effects, *American Economic Review* 95, 902–40.

Jianakoplos, N. and A. Bernasek, 1998, Are women more risk averse?, *Economic Inquiry* 36, 620–30.

Levitt, S. and J. List, 2006, What do laboratory experiments tell us about the real world? Mimeo, University of Chicago.

Morin, R. and A. Suarez, 1983, Risk aversion revisited, *Journal of Finance* 38, 1201–16.

Post, T., M. Van Den Assem, G. Baltussen, and R. Thaler, Forthcoming, Deal or no deal? Decision making under risk in a large-payoff game show, *American Economic Review*.

Riley, W. and K. Chow,1992, Asset allocation and individual risk aversion, *Financial Analysts Journal* 48, 32–37.

Roszkowski, M., G. Snelbecker, and S. Leimberg, 1993, Risk tolerance and risk aversion, in S. R. Leimberg, M. J. Satinsky, and R. T. Leclair, eds.: *The Tools and Techniques of Financial Planning* (National Underwriter, Cincinnati, OH.), 213–25.