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DISCUSSION PAPER SERIES

IZA DP No. 15536

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ABSTRACT

How Do Humans Respond to Huge Financial Losses?*

In a controlled field setting, in which the majority of people in our sample lose more than £90,000 ($120,000), we examine how human beings respond to major financial losses. University ethics boards would not allow this kind of huge-loss phenomenon to be studied with normal social-science experiments. Yet the scientific and practical issues at stake are unusually important ones. In our setting, individuals are handed £100,000 in cash. They then have to make risky decisions. Facing a sequence of seven questions, individuals are required to distribute their cash endowment over a set of possible answers. Participants lose any cash placed on a wrong answer. We find evidence of risk reduction after people suffer a loss in the previous decision round. A prior financial loss of £10,000 is estimated to increase the propensity to fully diversify by 6 percentage points. In terms of proportional losses, a loss of 50% or more of the remaining cash endowment increases diversification rates by approximately 13 percentage points. The fixed-effects panel data estimates are robust to the remaining cash endowment, previous diversification strategy, relative difficulty of questions, the ability level of participants, and other personal traits. The findings support a prospect theory-based model with a coefficient of loss aversion that is increasing in past losses. Our study appears to be the first to be able to calculate systematically how human beings react to enormous and unrecoverable financial losses.

JEL Classification: D81, G11, G40, G41

Keywords: risk taking, prior losses, diversification, large stakes, field evidence

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I. Introduction

How do people approach risky choice immediately after having suffered a massive loss? For instance, how do managers respond to a major drop in product sales? Or how do army generals react to a substantial loss of soldiers' lives on the battlefield? Do they typically engage in risk reduction strategies to minimise the likelihood and severity of future losses? Or do they take on even more risk than before? To what extent are their risk attitudes dependent on the size of prior losses? What if previous losses are not only large, but also irrecuperable? These are difficult questions to address empirically, but they seem essential to understanding how past performance influences people's preferences and ability to manage future risks.

This study offers evidence that after suffering huge and unrecoverable financial losses, people become more averse to potential future losses. The larger the prior loss, the more painful subsequent losses appear to be. We document such growing aversion to monetary losses in a controlled, and previously unexplored, field setting in which the majority of people lose more than £90,000 ($120,000). The special nature of the data means that we are able to provide a test that could not be done by previous researchers using normal social-science experiments. Our findings provide new support for a prospect theory-based model in which an individual's degree of loss aversion is not constant, but rather varies over time with the size of past losses.

The idea that prior outcomes may affect subsequent risk-taking behaviour has been of interest to psychologists, economists, behavioural scientists, and other decision researchers for at least the last forty years (Kahneman and Tversky 1979, Shefrin and Statman 1985, Thaler and Johnson 1990, Gneezy and Potters 1997, Weber and Camerer 1998, Barberis et al. 2001, Coval and Shumway 2005, Imas 2016, Meyer and Pagel 2021). Among the laboratory and field studies that have examined risk taking after individuals experience monetary losses, the results have largely been mixed. For example, while some studies have found people to take on more risk following a prior loss (Gneezy and Potters 1997, Coval and Shumway 2005, Weber and

Zuchel 2005, Langer and Weber 2008, Andrade and Iyer 2009, Smith et al. 2009), others have found the opposite (Thaler and Johnson 1990, Shiv et al. 2005, Liu at al. 2010, Suhonen and Saastamoinen 2018).[1] Such an apparent divide in the empirical literature is scientifically unattractive and requires further unpacking of the potential drivers and explanations.

In their seminal work on prospect theory involving one-shot gambles, Kahneman and Tversky (1979) provide evidence of *risk-seeking* in the domain of losses: someone who is facing the possibility of a loss will take on more risk to try and avoid the loss. Motivated by experimental evidence of Thaler and Johnston (1990) in the context of sequential gambles, Barberis et al. (2001) propose a model of investor preferences in which people become more, not less, *risk averse* after experiencing a financial loss. The authors argue that the emotional pain of having already suffered and accepted a loss leads investors to become more wary of further losses and hence more risk averse in subsequent periods. While both of these ideas suggest that people dislike entering the loss domain, they also point to an important difference in how individuals may react to the *possibility* of a loss versus an *already taken* loss.

Imas (2016) formalises and tests the above view for risk taking in dynamic contexts. He attempts to reconcile the conflicting findings in existing theoretical and empirical studies by appealing to differences in people's psychological response to *paper* versus *realised* losses. In the former case, the monetary value of an asset only drops on paper as the asset has not been sold yet. On the other hand, a loss is realised when a physical transfer of money takes place and decision makers part with their losses by 'cashing out' and settling their mental accounts (Shefrin and Statman 1985, Read et al. 1999, Barberis and Xiong 2012). Consequently, after a burst of negative utility from a realised loss, people are predicted to stop chasing their previous losses. In a series of laboratory experiments, Imas (2016) finds that subjects initially endowed

[1] See Suhonen and Saastamoinen (2018) and Flepp et al. (2021) for recent overviews of the literature on prior outcomes and subsequent risk taking. For surveys of the growing literature on estimating risk preferences in the field, see Charness et al. (2013) and Barseghyan et al. (2018).

with $8 take on more risk after they suffer paper losses. But the same subjects tend to engage in risk reduction following realised losses, which is when they must settle their accounts by handing the money back to the experimenter just before the final gamble is played out. A small but growing literature has started to examine such differential effects of paper *versus* realised outcomes on risk attitudes across different choice contexts (e.g., Imas 2016, Nielsen 2019, Flepp et al. 2021, Merkle et al. 2021, Meyer and Pagel 2021).

Another potential explanation for the mixed findings in the literature comes from the hypothesis that prior losses affect people's preferences differently depending on whether or not they are able to recover and offset these financial amounts. Early choice experiments by Thaler and Johnson (1990) and Heath (1995) demonstrate that gambles offering the decision maker a chance to recover a prior loss, and return to their starting or reference point, are particularly desirable. By contrast, if there exists no opportunity to exactly 'break even', then prior losses are likely to trigger risk aversion. As a result, people are more likely to opt for a risk reduction strategy in order to avoid the psychological pain that comes with further potential losses. While a critical feature of almost all previously examined decision contexts is the opportunity to erase an earlier loss if the gamble or investment is successful, much less attention has been paid to the study of risk attitudes when offsetting a prior loss is transparently not possible. Sunk costs are a prime example of such unrecoverable losses (Thaler 1980, Arkes and Blumer 1985).

A further constraint in much of the existing empirical evidence on the sequential effects of past outcomes on risky decisions is that the financial losses suffered by the studied subjects tend to be relatively small – ranging from a few dollars inside the lab (e.g., Gneezy and Potters 1997, Imas 2016, Merkle et al. 2021) to a few hundred dollars in the field (e.g., Suhonen and Saastamoinen 2018, Flepp et al. 2021). Given these somewhat restricted loss sizes, the extent to which the previously documented findings can be generalised to situations involving much greater losses, or even life-changing stakes, remains poorly understood.[2]

In this paper, we offer a different approach and decision environment that enables us to simultaneously address the three main understudied elements in the empirical literature above: i) paper vs. *realised* losses; ii) recuperable vs. *irrecuperable* losses; and iii) low vs. *high-stake* losses. We are primarily interested in how people respond to unusually large financial losses that – unlike in most financial markets and other naturally-occurring settings – they can never recover. Specifically, we collect and analyse data from the laboratory-like British television game show: *The £100k Drop*. In this closely controlled field setting, two participants – playing as a 'couple' – are handed a large cash endowment of £100,000 (approx. $136,000), which comes in forty £2,500 bundles at the start of the show. In each of the seven question rounds, the host asks each couple to distribute their entire cash endowment across four possible answers in the first three rounds, three possible answers in the next three rounds, and two possible answers in the final round. It is then up to each couple to decide how they would like to spread their cash endowment across the possible answers. Given that there is only one correct answer per decision round, all bundles of cash placed on any of the incorrect answers are physically dropped down a set of trap doors as the correct answer is revealed. The participants get to take home the remaining cash endowment, which they hold, at the end of the seventh and final decision round. Since cash placed on any of the wrong answers vanishes immediately, and participants have no opportunity to get this money back, we are able to purely focus on financial losses that are realised and finalised in some way.

[2] Recent field studies on prior monetary losses and subsequent risk taking in racetrack betting (Suhonen and Saastamoinen 2018) and casino gambling (Flepp et al. 2021) document average loss amounts of around $10 and $30 per customer, respectively. Smith et al. (2009) is one possible exception, in which the authors analyse the aggregate behaviour of 346 experienced online poker players. Overall, about 50 percent of the observed players won or lost more than $200,000, while around 10 percent of players won or lost more than $1 million in total. A key difference in these decision contexts is that a successful gamble or investment can erase prior losses. The same is true for empirical studies using data from financial markets, where people also stand to lose a lot of money. In the current field setting, individuals can *only* experience financial losses that they can never recover.

Unlike many other types of risky decisions observed in the field including stock market investments (Weber and Camerer 1998, Coval and Shumway 2005, Liu et al. 2010, Meyer and Pagel 2021), racetrack and sports betting (Thaler and Ziemba 1988, Suhonen and Saastamoinen 2018, Andrikogiannopoulou and Papakonstantinou 2020), or casino gambling (Barberis 2012, Smith et al. 2009, Eil and Lien 2014, Flepp et al. 2021), the *£100k Drop* is a finite game with a fixed number of possible decision rounds. Following a loss in the previous round, participants can then gamble to leave with the least amount of loss or otherwise leave with nothing. This controlled laboratory-like setting, with multiple decision periods, makes it ideal to empirically test for path-dependence, and changing risk aversion, in risky choice with participants being well aware when the final gamble – should they get that far – takes place.

With an average loss size across all decision rounds of £19,000 (see Table 1), we are able to examine potential losses that are much bigger than the typical amounts investigated in the empirical literature so far. The considerable range and variation in the observed financial loss amounts – spanning from £2,500 to just below £100,000 – allows us to directly examine how sensitive risk attitudes are to different sizes of past losses. Empirically, very little is known on this topic.

The current field setting offers the researcher a unique kind of natural experiment to examine how human beings react to large potential losses that come on the heels of prior losses. It allows us to test whether the degree of risk aversion is simply a fixed dose that is independent of one's past performance. Or, alternatively, whether this dosage *changes* within individuals over time and hence increases with the size of recently experienced losses. Such a story of changing risk aversion has previously been conceptualised (Barberis et al. 2001), but rarely ever tested.

Barberis et al. (2001) develop a conceptual framework of investor preferences in which people derive utility not only from their overall consumption but also from *changes* in the value of their financial holdings. The authors assume that losses on the heels of prior losses are more painful than usual by specifying a *loss aversion coefficient* that changes over time based on the investor's past performance. The model predicts that after being burnt by an initial loss, an investor will be more sensitive to any further losses and hence more risk averse. Moreover, the larger the prior loss, the more painful subsequent losses will be – with the coefficient of loss aversion increasing in past losses: $\lambda'(\textit{size of prior loss}) > 0$.

Contrary to the theoretical predictions derived by Nicholas Barberis and colleagues, Merkle et al. (2021) depart from the assumption of higher loss aversion after a prior loss and instead propose a loss aversion coefficient that is constant and hence independent of past losses. They base their arguments on a lack of existing empirical support for lower risk tolerance after people go through a series of monetary losses.

So far, there is hardly any direct lab or field evidence on how human beings respond to different magnitudes of prior losses. A recent study by Flepp et al. (2021), on slot machine gambling inside a Swiss casino, is a possible exception. The authors document average loss amounts of CHF 30 ($30) per customer. They estimate that cumulative losses above CHF 800 ($800), which are settled between casino visits, lead to reduced risk-taking in later sessions.

We add to the literature on the dynamics of risk taking by providing some of the first evidence on how *huge* and *unrecoverable* losses are linked to future risk appetites. We find that people engage in risk reduction by diversifying more after big financial losses. We further show that risk taking is strongly influenced by the size of a recent loss. The estimated effects are substantial. A prior loss of £10,000 is estimated to increase the average propensity to fully diversify by about 6 percentage points. In terms of proportional losses, a loss of 50% or more of the remaining endowment is estimated to boost diversification rates by 13 percentage points. Our empirical results are robust to conditioning on participant fixed effects, which difference out any unobserved heterogeneity in ability levels and other time-invariant personal traits across participants, and round fixed effects, which control for the relative difficulty level of the presented questions that increases with each progressing round. Our findings are consistent with the Barberis et al. (2001) model of investor preferences: *the larger the prior loss, the more painful subsequent losses appear to be*. Overall, the study documents one of the first systematic patterns of risk-reducing behaviour after people realise major financial losses that they can never recover.

II. Data and Rules of the Game

We collected data from recordings of the nationally televised game show in Great Britain: *The £100k Drop*. While not all recordings of episodes were available at the start of our data collection, we ended up collecting *N*=851 observations from 177 pairs of participants in the show's first and third seasons.[3] There were at least two or three participating couples per episode, with each couple taking turns playing the game in succession. In each game, couples received £100,000 (approximately $136,000) in cash – in the form of forty bundles of £2,500 – as their initial endowment. At the start of play, the host made the following verbal announcement to each set of players: "*You have one-hundred thousand pounds, and I have seven questions*", making it clear that the money is theirs to lose.

The rules of the game are as follows. Participants had to face seven rounds of multiple-choice questions that started easy before getting increasingly harder with each progressing round. There were four possible answers to a question in each of the first three rounds, three possible answers in each of the following three rounds, and two possible answers in the final round. Couples had 60 seconds to answer each question by distributing their cash endowment over the set of available answers.

[3] Each recording of an episode was only available online for 30 days, before getting taken off from the official broadcaster's (Channel 4) website: https://www.channel4.com/programmes/the-100k-drop. Our data consists of Series 1: Episodes 14-60, and Series 3: Episodes 1-30. The data and the .do file used for our statistical analysis can be downloaded from GitHub at the following website: https://github.com/npowdthavee/priorlossriskychoice.

Out of the four possible answers in the first three rounds, participants had to place all of their endowment on at least one answer. They could distribute the money how they wanted across three of the answers. However, they always had to leave at least one answer completely blank. For example, let us say there are four possible answers (A, B, C, and D) in the first round, participants could either put their entire cash endowment (£100,000) on A, or they could put £25,000 on A, £42,500 on B, and £32,500 on D, leaving C blank. If the correct answer is A, then the decision to put the entire £100,000 on A means that the couple gets to keep all of the initial endowment for the next round. By contrast, the decision to spread and diversify the risk would have meant that the couple got to keep only £25,000 as their endowment for the next round. Because couples always had to leave one answer blank, they could only distribute their money across two out of three possible answers in Rounds 4-6 and had to put their entire stake on one answer in the seventh and final round. Unlike other previously analysed television game shows, such as *Who Wants to Be a Millionaire* (Hartley et al. 2014) and *Deal or No Deal* (Post et al. 2008), which allow contestants to choose when it is best to leave the game with some money, players in the *£100k Drop* were required to answer all of the seven questions correctly before they could leave with any money at all. As a result of this rule, the probability of people leaving the game with at least £2,500 – even if they did not know any of the correct answers – from adopting a strategy that distributes the risk equally across all available choices is equal to $0.75\times3+0.66\times3+0.5\times1\approx5\%$.

We are primarily interested in people's risk preferences at each stage of the game, which we believe can be adequately captured by the following diversification or dispersion index, based on a simple variance-to-mean ratio formula (see Hoel 1943, Cox and Lewis 1966):

$$Diversification\ index = \frac{k(N^2-\sum f^2)}{N^2(k-1)} \qquad (1)$$

where the *Diversification index* has a continuous value ranging from 0 to 1; k is the number of possible answers in the round (including the answer that must be left blank); N represents the starting cash endowment amount in that round; f denotes the allocation of N across all available choices in that round. Higher values of the diversification index imply greater diversification in a participating couple's choices. For example, the diversification index from a couple putting down £35,000 on *A*, £25,000 on *B*, and £40,000 on *D*, while leaving *C* blank, in the first round is $\frac{4(100{,}000^2-(35{,}000^2+25{,}000^2+0^2+40{,}000^2)}{100^2(4-1)} = 0.873$. Compare this to the diversification index obtained from a couple putting down their entire cash endowment on only one answer, i.e., $Diversification\ index = \frac{4(100{,}000^2-(100{,}000^2+0^2+0^2+0^2)}{100^2(4-1)} = 0$. As a result, the diversification index is an appropriate risk measure as it captures the propensity to reduce risk.

Our diversification index can be broadly related to the Herfindahl index, which is well known to economists, and is based on the Simpson index that measures diversity in ecology (see Simpson 1949). The Herfindahl index captures the relative size and concentration of firms within an industry: with values close to 1 indicating a single monopolistic producer, and values close to 0 capturing a diverse and equal spread of many small producers. Therefore, observing participants place their entire monetary endowment on one possible answer is analogous to a single big firm supplying the market. While, having participants allocate their cash endowment equally across all possible answers is equivalent to many small firms supplying the market. We note that the Herfindahl index is reverse coded relative to our diversification measure.

Of the 177 pairs of participants, 29 (or 16%) left with some money at the end of the game. The average monetary amount won by participants who answered all seven questions correctly was £8,448, with a standard deviation of £13,333. The average number of rounds played across all couples was 3.26 rounds, with a standard deviation of 1.81. In addition to this, 46 couples (*n*=225) were both males, 42 couples (*n*=193) were both females, and 89 couples

(n=430) were of mixed gender. In total, 86% of the sample were white British, and 39% were spouses or romantic partners. As reported in Table 2, the average diversification index is equal to 0.42 across all decision rounds. Examining by decision round: the average diversification index equals 0.37 in Round 1, 0.50 in Round 2, 0.52 in Round 3, 0.41 in Round 4, 0.44 in Round 5, 0.47 in Round 6, and 0 in Round 7.

A. Pros and Cons of the Natural Experiment

Before turning to our empirical strategy, it is important to note some of the key advantages and disadvantages associated with using this type of data to draw inferences. As is the case with any empirical method or setting, using laboratory-like game show data to study individual preferences has both its pros and cons. Some of these have already been discussed at length in other well-known and related studies (e.g., List 2006, Post et al. 2008, van den Assem et al. 2012, van Dolder et al. 2015). However, a few specific elements of the *100k Drop* are still worth mentioning here.

First, the televised game show provides a unique field setting outside of the traditional university laboratory, with non-student subjects facing the prospect of winning or losing vast amounts of money. To this end, if we were to conduct such an experiment in the lab, the cost to gather the data would be well into the hundreds of thousands, or even millions, of British pounds. To achieve this in a normal university-led experiment would not be possible because research ethics boards and committees would not allow scientific investigators to run such an experiment.[4]

Second, our setting is atypical to most previously studied field contexts involving risky choice as the decision makers are physically handed the maximum payoff *upfront*, making it their money to lose. This incentive structure differs from other gameshow formats and naturally

[4] See, for example, Hertwig and Ortmann (2001) for a discussion of stake effects in social-science experiments.

occurring settings, including *Card Sharks* (Gertner 1993), *Jeopardy!* (Metrick 1995), *Lingo* (Beetsma and Schotman 2001), *Golden Balls* (van den Assem et al., 2012; van Dolder et al., 2015; Turmunkh et al., 2019), *Hoosier Millionaire* (Fullenkamp et al. 2003), *Deal or No Deal* (Blavatskyy and Pogrebna 2008, Deck et al. 2008, Post et al. 2008), and *Who Wants to Be a Millionaire?* (Hartley et al. 2014), as well as sporting contests such as professional golf and tennis tournaments (e.g., Pope and Schweitzer 2011). In these settings, contestants usually receive the ultimate monetary prize at the end, with gradual increments being made towards some portion of this total payoff. The upfront and salient nature of the payoffs in the present setting may then also stimulate participants to evaluate their losses in relative rather than absolute terms (see Garland and Newport 1991). We test this possibility later on.

Third, the simple and closely controlled field setting of the *£100k Drop* allows us to isolate and examine almost immediate changes in risk tolerance after prior losses. Such swift emotional adjustments to changes in financial position are rarely captured in the field. In most previously examined non-laboratory contexts, including stock market trading (Coval and Shumway 2005, Liu et al. 2010), racetrack and sports betting (Thaler and Ziemba 1988, Andrikogiannopoulou and Papakonstantinou 2020), casino gambling (Flepp et al. 2021), and natural disaster events (Page et al. 2014, Hanaoka et al. 2018), there is a much longer passage of time – ranging from days to weeks, and even years – before the next risky choice in the same sequence is observed or measured.

Fourth, the relatively fast and uninterrupted series of outcomes helps to minimise the influence of other external and unobservable factors on the studied behaviour of interest. This includes relevant life events and financial shocks experienced by subjects that are not observed by the researcher but occur just before or, even more critically, in-between the actual sequence of choices analysed. For example, a casino or racetrack gambler who is recorded by the analyst for the first time may already be carrying losses from earlier visits. If such prior losses impact the individual's discretionary spending income and consumption patterns, then this person might be more cautious the next time around. Similarly, a stock market investor can sleep on recent losses before selling or acquiring new stocks. And natural disaster survivors are often surveyed about their risk attitudes long after having suffered through the event.[5]

Such prolonged periods between decisions enable people to mentally adapt to their past outcomes (Frederick and Loewenstein 1999), leading to a possible closure of the relevant mental account. This time factor then results in the same psychological response as predicted by the *realisation effect* (Imas 2016), whereby people become more risk averse after a realised loss. From an empirical point of view, the latter point makes it difficult to disentangle the direct influence of past outcomes on risk attitudes from other non-standard factors in the field, such as the amount of time elapsed since the last decision. Hsu and Chow (2013) and Cárdenas et al. (2014) show that risk-seeking behaviour diminishes over time as subjects eventually update their reference points and realise their financial outcomes. The relatively fast choices observed on the *£100k Drop* help to minimise this possible confounding issue, allowing us to isolate the role of past losses that we would not be able to do otherwise.

In terms of potential shortcomings, even though the sample of selected contestants clearly differs from the typical WEIRD subject pool found inside any university laboratory (e.g., Henrich et al. 2010), the studied individuals are still not representative of the general population. Some researchers may nonetheless argue that the average game show contestant portrays the average citizen in Western society much more closely than a young college student does, but this is still up for debate (van den Assem et al. 2012, van Dolder et al. 2015).

Since the game show takes place in front of a large television and studio audience, this kind of public scrutiny may additionally provoke other psychological factors and emotions

[5] See, for example, Ungemach et al. (2011) for experimental evidence on how recent everyday experiences can affect and alter subsequent risk preferences.

including feelings of anxiety and stress. Such limelight and human emotions have previously been shown to influence risk attitudes (e.g., Loewenstein et al. 2001, Baltussen et al. 2016). Some psychological studies have also demonstrated that people tend to take on less risk when they feel anxious or overly stressed (Raghunathan and Pham 1999, Maner et al. 2007, Kuhnen and Knutson 2011). And that these basic emotions tend to be more prevalent in high-stake decision situations (see Beilock 2010).

Yet, these potential limitations do not make the current setting any less interesting or less predictive of human behaviour than any other research approach or context, including randomised controlled trials (see Deaton and Cartwright 2018). The current unique field setting should instead be viewed as being complementary to the wide array of existing environments previously used in the study of risky choice, whereby, as noted by Thaler and Johnson (1990, p.660) … "*perhaps the most important conclusion to be reached from this research is that making generalizations about risk-taking preferences in difficult*."

III. Empirical Strategy

We estimate the following diversification index equation for contestant pair p in round r:

$$Diversification\ index_{pr} = \alpha + \beta_1 Loss\ size_{pr-1} + \beta_2 Endowment_{pr} + \beta_3 Diversification\ index_{pr-1} + x'_{pr}\delta + u_p + q_r + \varepsilon_{pr} \quad (2)$$

where $Disversification\ index_{pr}$ is the value of the diversification index for couple p in round r (ranging continuously from 0 to 1); $Endowment_{pr}$ is the remaining endowment amount; $Loss\ size_{pr-1}$ is the monetary amount lost in the previous round *r-1*; x'_{pr} is a vector of control variables that includes binary indicators for whether or not participants had lower than the minimum amount to fully diversify, i.e., less than £7,500 in rounds 1-3 and less than £2,500 in rounds 4-7; u_p captures couple fixed effects; q_r accounts for round fixed effects; and ε_{pr} is a random error term. We use a fixed-effects regression model to estimate this equation. We also allow for heteroskedasticity within each decision-making unit by clustering the standard errors at the 'couple' level.

Here, the coefficient of interest is β_1, which represents the partial correlation coefficient between the prior loss amount and the propensity to fully diversify in the current round, while holding the cash endowment at the start of the current round and the previous diversification index constant, among other factors. A positive and statistically significant estimate of β_1 would be consistent with risk aversion after prior losses.

A. Proportional losses

Our initial empirical model assumes that prior losses have an absolute rather than relative effect on subsequent risk-taking behaviour. However, it is quite likely that a £10k loss will have a different impact on people's risk appetites when they hold £100k compared to £50k. In other words, individuals might also evaluate their financial losses in a proportional sense.

To test for the importance of proportional losses on later diversification decisions, we re-write Equation (2) as follows:

$$Diversification\ index_{pr} = \alpha + \beta_1 \frac{Loss\ size_{pr-1}}{Endowment_{pr-1}} + \beta_2 Endowment_{pr} + \beta_3 Diversification\ index_{pr-1} + x'_{pr}\delta + u_p + q_r + \varepsilon_{pr} \quad (3)$$

where a *proportional prior loss* is expressed as the ratio of the loss amount in the previous round *r-1* to the endowment amount in the same round *r-1* (ranging from 0 to 1). Such a relative measure has previously been used by Garland and Newport (1991) to examine risk preferences in hypothetical situations. The authors find that relative, rather than absolute, magnitudes of sunk costs matter most for the decision to commit additional funds to a given action.

B. Additional risk-taking measures and robustness checks

We also test alternative functional forms of the *prior loss* independent variable by considering a non-linear, logarithmic, categorical, as well as a higher-order lag transformation. We further undertake subsample analyses by cutting the data along various participant characteristics, and the different stages of the game. Finally, we examine additional measures of risk taking. This includes (i) a binary indicator that takes on a value of 1 if the participating couple placed their entire endowment on only one answer in the current round, and 0 otherwise. And (ii) the highest cash amount placed on a single answer in the current round, as similarly defined and used in related empirical studies (Haigh and List 2005, Suhonen and Saastamoinen 2018, Flepp et al. 2021). Overall, both of these dependent variables capture the willingness of participants to risk the majority of their cash holdings on one possible answer, which may reflect how confident they are in their responses.

IV. Results

What is the effect of prior financial losses on risk-taking behaviour in the current context? Figure 1 is a simple visual illustration of the study's key result. It is derived from Table 3 which reports the estimated relationship between the amount of money lost in the previous round and subsequent changes in people's tendency to diversify. We estimate fixed-effects regression equations. In model 1, we focus on the linear relationship between the *prior loss size* and diversification rates in the current round. Model 2 adds a squared term to the *prior loss size* variable from model 1. Model 3, as shown in Figure 1, replaces the same prior loss variable with four binary dummies that capture different magnitudes or categories of prior losses, with the ‘less than £25k’ loss amount being the omitted reference category. Finally, model 4 uses a logarithmic transformation of the *prior loss* explanatory variable.

The formal regression estimates in Table 3 show that the larger a contestant’s prior loss, the more risk averse she is in her behaviour in the next round. The estimated relationship is statistically significant and economically sizeable even after controlling for the remaining endowment amount, past diversification strategy, rapidly diminished stakes, as well as couple and round fixed effects. From the coefficient estimates in model 1, a prior loss of £10,000 is associated with an increase in the diversification index of 6 percentage points [$p = 0.000$]. While there is little statistical evidence of a quadratic relationship between prior loss size and subsequent diversification rates (model 2), cautious play appears to rise in a monotonic way as the size of the prior loss increases (model 3 and Figure 1). Finally, the logarithmic scale in model 4 implies that a 1% increase in the amount of money lost in the previous round is associated with a 18 percentage point increase in the current diversification index [$p = 0.000$]. We note, however, that model 4 in Table 3 has a smaller number of data points because all observations with a zero ‘prior loss amount’ were automatically dropped in the process of converting this variable from level to logarithmic form.[6]

The other regression results in Table 3 are also interesting. Ceteris paribus, we find the tendency to fully diversify to be positively correlated with the remaining cash endowment amount. Perhaps, when holding large amounts of cash in their hands, the salient nature of the potential rewards makes individuals become more wary and cautious. Moreover, participating

[6] Figure A1 in Appendix A presents a raw scatterplot of the (uncorrected) relationship between the diversification index in round r and the size of the prior loss in round r-1. Each dot in the figure represents the average diversification index in round r for each couple. Figure A2 does the same but with proportional losses on the horizontal axis. Figure A1 shows that the ‘within-couple’ diversification index increases at a decreasing rate with the monetary amount lost in the previous round. This positive relation is somewhat more striking in Figure A2 which plots proportional losses on the horizontal axis. Interestingly, there is also some evidence of a slight drop in risk reduction for couples who had just lost more than 60% of their endowment, which would suggest that people become more risk prone after losing a major share of their financial holdings. However, this result might be there by design as couples who had recently suffered an extreme financial loss are unlikely to have enough cash to diversify further even if they had wanted to in the next round.

couples with a cash endowment lower than £7,500 in Rounds 1-3, and lower than £5,000 in Rounds 4-6, are significantly less likely to diversify compared to those with more than these specified amounts. This could be either because these couples did not have enough cash to diversify in the first place, or that they felt they now had nothing to lose and wanted to risk it all. The latter type of inclination would be consistent with 'escalation of commitment' (Staw 1976): whereby the level of risk-taking increases after prior losses. However, to properly examine such individual responses, we would need more observations at the extreme end as the size of prior losses approaches £100,000. Finally, there is evidence of a monotonic increase in diversification rates by round number. As illustrated in Figure 2, the lowest diversification rates are estimated in the early rounds – possibly because the initial questions tend to be the easiest – and highest in Round 6, which is one round before the final round.[7] Thus, as the end approaches, participants also appear to become more careful.

In Table 4, we estimate similar fixed-effects regression equations but with proportional, instead of absolute, prior losses on the right-hand side. The same empirical patterns continue to hold. Estimates from model 1 in Table 4 imply that losing an extra 1% of the current endowment is associated with a 0.5 percentage point increase in the diversification index [$p = 0.000$].[8] Moreover, there continues to be little statistical evidence of a non-linear quadratic effect for prior losses on risk taking. Lastly, model 3 in Table 4 shows that losing more than 50% of the current endowment increases the propensity to fully diversify by approximately 13 percentage points.

We next undertake several robustness checks. In Table 5, we find some evidence of a long-run relation between the amount of money lost two rounds ago on current risk reduction; with the estimated coefficient on the past loss size in round *r-2* equal to 0.004 [$p = 0.000$].

[7] The diversification index is always equal to zero in Round 7 (the final round). This is because there are only two possible answers in this last round, and participants are required to leave at least one answer blank.
[8] This value is derived from the point estimate that a unit increase in the proportional loss in the previous round is associated with a 50-percentage point increase in the diversification index in the current round.

But this lagged relationship becomes statistically insignificant once we add proportional losses as the main explanatory variable. Still, the more immediate prior loss variables (in round *r-1*) continue to be positive, sizeable, and statistically significant in both regression models.

Subsample analyses are reported in Tables 6 and 7. In Table 6, we split the total sample into different gender pairings, as well as by romantic *versus* non-romantic status. In Table 7, the division is done for early *versus* later decision rounds. We see that the absolute amount of money lost in the previous round continues to have a positive and statistically significant influence on later diversification rates. The estimated coefficients are of similar size across all subsamples.

Lastly, Table 8 reports fixed-effects regression estimates using the two alternative risk-taking measures. These are (i) a binary indicator representing whether or not the couple risked their entire cash endowment on a single answer in the current round, and (ii) the highest cash amount placed on one possible answer. Consistent with the earlier results, we find that as the size of the previous loss rises, couples become less likely to risk their entire endowment on a single answer. Similarly, there is evidence that the highest monetary amount placed on any answer falls as the loss in the previous round increases.

V. Conclusion

Empirical research in the social sciences has previously shown that people tend to adjust their risk attitudes after experiencing negative life shocks such as conflict or violence (Jakiela and Ozier 2019), natural disasters (Hanaoka et al. 2018), loss of social status (Ager et al. 2021), and aggregate falls in wealth levels (Malmendier and Nagel 2011). This study considered a different kind of natural experiment by examining changes in people's willingness to reduce risk after they are handed life-changing sums of money. The special nature of the data means that we are able to provide a test that could not be done by previous researchers.

While there is growing empirical evidence showing that humans tend to integrate their past financial performances when making risky choices going forward (Thaler and Johnston 1990, Imas 2016, Andrikogiannopoulou and Papakonstantinou 2020, Meyer and Pagel 2021), evidence on how individuals respond to past losses of varying magnitudes has been almost completely absent.

Our results show that people become more risk-averse after they experience unusually large and unrecoverable financial losses. We find the relationship between the size of a prior loss and risk-reducing behaviour to be of a 'dose-response' kind: the greater the prior loss, the more strongly people tend to diversify their monetary holdings in the next period. These findings support a prospect theory-based model in which the loss aversion coefficient increases with the size of past losses, as first specified by Barberis et al. (2001). This kind of response behaviour is potentially driven by a loss-sensitisation mechanism whereby, the bigger the prior loss, the more sensitive an individual becomes to future losses (Barberis et al. 2001, Thaler and Johnson 1990). Such rising levels of caution may also be explained by a diminished capacity for dealing with bad news (Kőszegi and Rabin 2009, Pagel 2017): after suffering large losses, individuals may feel mentally shaken up, and hence less able to deal with additional bad news that follows in the upcoming rounds.

Because of the upfront and salient nature of the monetary payoffs, we were also able to test how people respond to relative or proportional losses, i.e., after they lose large portions of their financial holdings. This empirical question has rarely been examined in the past. Garland and Newport (1991) provide an early test using hypothetical choice surveys. More recently, Barberis (2013) makes the intuitive argument that: *"An individual facing a loss that represents a large fraction of wealth will be very sensitive, not insensitive, to any additional losses"*. We find evidence consistent with the latter prediction: larger proportional losses – expressed as the ratio of the prior monetary loss amount to the remaining endowment amount – lead to higher subsequent diversification rates.

More broadly, our analysis adds to the emerging literature on the relevance of upfront financial rewards and the consequent changes in human behaviour attributed to loss aversion (Hossain and List 2012, Fryer et al. 2012, Imas et al. 2016). In the present field setting, we uncover a steady monotonic increase in risk-reducing behaviour as more of the initial cash endowment is lost. The findings suggest that such 'clawback' incentives, or loss contracts, could potentially curb loss-chasing and other risky behaviours (see List and Momeni 2020), even in situations when the financial stakes and personal rewards are extremely high.

This paper raises a number of questions for further investigation. One direction for future work is to focus more closely on the role of decision-maker characteristics and emotions (see, e.g., Meier 2022) in such high-stake sequential choices. Under the glare of camera lights and in front of a national audience, people may undergo emotions that may otherwise not be present. It would hence be useful to examine how such human feelings and personal traits interact with the size of recent losses, especially when people lose a large fraction of their financial resources. Lastly, the upfront nature of monetary payoffs and its implications for risk taking in real-life settings, such as financial trading institutions, demands further attention.

References

Ager, P., Bursztyn, L., Leucht, L., & Voth, H. J. (2021). Killer incentives: Rivalry, performance and risk-taking among German fighter pilots, 1939–45. *Review of Economic Studies*, forthcoming.

Andrade, E. B., & Iyer, G. (2009). Planned versus actual betting in sequential gambles. *Journal of Marketing Research*, 46(3), 372-383.

Andrikogiannopoulou, A., & Papakonstantinou, F. (2020). History-dependent risk preferences: Evidence from individual choices and implications for the disposition effect. *Review of Financial Studies*, 33(8), 3674-3718.

Arkes, H. R., & Blumer, C. (1985). The psychology of sunk cost. *Organizational Behavior and Human Decision Processes*, 35(1), 124-140.

Baltussen, G., van den Assem, M. J., & van Dolder, D. (2016). Risky choice in the limelight. *Review of Economics and Statistics*, *98*(2), 318-332.

Barberis, N. (2012). A model of casino gambling. *Management Science*, 58(1), 35-51.

Barberis, N. (2013). Thirty years of prospect theory in economics: A review and assessment. *Journal of Economic Perspectives*, 27(1), 173-96.

Barberis, N., Huang, M., & Santos, T. (2001). Prospect theory and asset prices. *Quarterly Journal of Economics*, 116(1), 1-53.

Barberis, N., & Xiong, W. (2012). Realization utility. *Journal of Financial Economics*, 104(2), 251-271.

Barseghyan, L., Molinari, F., O'Donoghue, T., & Teitelbaum, J. C. (2018). Estimating risk preferences in the field. *Journal of Economic Literature*, 56(2), 501-64.

Beetsma, R. M., & Schotman, P. C. (2001). Measuring risk attitudes in a natural experiment: data from the television game show Lingo. *Economic Journal*, 111(474), 821-848.

Beilock, S. (2010). *Choke: What the secrets of the brain reveal about getting it right when you have to*. Simon and Schuster.

Blavatskyy, P., & Pogrebna, G. (2008). Risk aversion when gains are likely and unlikely: Evidence from a natural experiment with large stakes. *Theory and Decision*, 64(2-3), 395-420.

Cárdenas, J. C., De Roux, N., Jaramillo, C. R., & Martinez, L. R. (2014). Is it my money or not? An experiment on risk aversion and the house-money effect. *Experimental Economics*, 17(1), 47-60.

Charness, G., Gneezy, U., & Imas, A. (2013). Experimental methods: Eliciting risk preferences. *Journal of Economic Behavior & Organization*, 87, 43-51.

Coval, J. D., & Shumway, T. (2005). Do behavioral biases affect prices?. *Journal of Finance*, 60(1), 1-34.

Cox, D. R., & Lewis, P. A. W. (1966). The statistical analysis of series of events, Methuen.

Deaton, A., & Cartwright, N. (2018). Understanding and misunderstanding randomized controlled trials. *Social Science & Medicine*, 210, 2-21.

Deck, C., Lee, J., & Reyes, J. (2008). Risk attitudes in large stake gambles: evidence from a game show. Applied Economics, 40(1), 41-52.

Eil, D., & Lien, J. W. (2014). Staying ahead and getting even: Risk attitudes of experienced poker players. *Games and Economic Behavior*, 87, 50-69.

Flepp, R., Meier, P., & Franck, E. (2021). The effect of paper outcomes versus realized outcomes on subsequent risk-taking: Field evidence from casino gambling. *Organizational Behavior and Human Decision Processes*, 165, 45-55.

Frederick, S., & Loewenstein, G. (1999). Hedonic adaptation*. Well-Being. The foundations of Hedonic Psychology*, Eds. D. Kahneman, E. Diener, N. Schwarz. NY: Russell Sage, 302-329.

Fryer, R. G., Levitt, S. D., List, J., & Sadoff, S. (2012). Enhancing the efficacy of teacher incentives through loss aversion: A field experiment. *NBER Working Paper w18237*.

Fullenkamp, C., Tenorio, R., & Battalio, R. (2003). Assessing individual risk attitudes using field data from lottery games. *Review of Economics and Statistics*, 85(1), 218-226.

Garland, H., & Newport, S. (1991). Effects of absolute and relative sunk costs on the decision to persist with a course of action. *Organizational Behavior and Human Decision Processes*, 48(1), 55-69.

Gertner, R. (1993). Game shows and economic behavior: risk-taking on "Card Sharks". *Quarterly Journal of Economics*, 108(2), 507-521.

Gneezy, U., & Potters, J. (1997). An experiment on risk taking and evaluation periods. *Quarterly Journal of Economics*, 112(2), 631-645.

Haigh, M. S., & List, J. A. (2005). Do professional traders exhibit myopic loss aversion? An experimental analysis. *Journal of Finance*, 60(1), 523-534.

Hanaoka, C., Shigeoka, H., & Watanabe, Y. (2018). Do risk preferences change? evidence from the great east Japan earthquake. *American Economic Journal: Applied Economics*, 10(2), 298-330.

Hartley, R., Lanot, G., & Walker, I. (2014). Who really wants to be a millionaire? Estimates of risk aversion from gameshow data. *Journal of Applied Econometrics*, 29(6), 861-879.

Heath, C. (1995). Escalation and de-escalation of commitment in response to sunk costs: The role of budgeting in mental accounting. *Organizational Behavior and Human Decision Processes*, 62(1), 38-54.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world?. *Behavioral and Brain Sciences*, 33(2-3), 61-83.

Hertwig, R., & Ortmann, A. (2001). Experimental practices in economics: A methodological challenge for psychologists?. *Behavioral and Brain Sciences*, 24(3), 383-403.

Hoel, P. G. (1943). On indices of dispersion. *Annals of Mathematical Statistics*, 14(2), 155-162.

Hossain, T., & List, J. A. (2012). The behavioralist visits the factory: Increasing productivity using simple framing manipulations. *Management Science*, 58(12), 2151-2167.

Hsu, Y. L., & Chow, E. H. (2013). The house money effect on investment risk taking: Evidence from Taiwan. *Pacific-Basin Finance Journal*, 21(1), 1102-1115.

Imas, A. (2016). The realization effect: Risk-taking after realized versus paper losses. *American Economic Review*, 106(8), 2086-2109.

Imas, A., Sadoff, S., & Samek, A. (2017). Do people anticipate loss aversion? *Management Science*, *63*(5), 1271-1284.

Jakiela, P., & Ozier, O. (2019). The impact of violence on individual risk preferences: evidence from a natural experiment. *Review of Economics and Statistics*, 101(3), 547-559.

Kahneman, D., & Tversky, A. (1979). Prospect theory: an analysis of decision under risk. *Econometrica*, 47(2), 263-292.

Kőszegi, B., & Rabin, M. (2009). Reference-dependent consumption plans. *American Economic Review*, 99(3), 909-36.

Kuhnen, C., & Knutson, B. (2011). The influence of affect on beliefs, preferences, and financial decisions. *Journal of Financial and Quantitative Analysis*, *46*(3), 605-626.

Langer, T., & Weber, M. (2008). Does commitment or feedback influence myopic loss aversion? An experimental analysis. *Journal of Economic Behavior & Organization*, 67(3-4), 810-819.

List, J. A. (2006). Friend or foe? A natural experiment of the prisoner's dilemma. *Review of Economics and Statistics*, 88(3), 463-471.

List, J. A., & Momeni, F. (2020). Leveraging upfront payments to curb employee misbehavior: Evidence from a natural field experiment. *European Economic Review*, *130*, 103601.

Liu, Y. J., Tsai, C. L., Wang, M. C., & Zhu, N. (2010). Prior consequences and subsequent risk taking: New field evidence from the Taiwan Futures Exchange. *Management Science*, 56(4), 606-620.

Loewenstein, G., Weber, E., Hsee, C., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*(2), 267-286.

Malmendier, U., & Nagel, S. (2011). Depression babies: do macroeconomic experiences affect risk taking?. *Quarterly Journal of Economics*, 126(1), 373-416.

Maner, J., Richey, J. A., Cromer, K., Mallott, M., Lejuez, C., Joiner, T., & Schmidt, N. (2007). Dispositional anxiety and risk-avoidant decision-making. *Personality and Individual Differences*, *42*(4), 665-675.

Meier, A. N. (2022). Emotions and risk attitudes. *American Economic Journal: Applied Economics*, 14(3), 527-58.

Merkle, C., Müller-Dethard, J., & Weber, M. (2021). Closing a mental account: The realization effect for gains and losses. *Experimental Economics*, 24(1), 303-329.

Metrick, A. (1995). A natural experiment in "Jeopardy!". *American Economic Review*, 240-253.

Meyer, S., & Pagel, M. (2021). Individual responses to realized gains and losses. *Journal of Finance*, forthcoming.

Nielsen, K. (2019). Dynamic risk preferences under realized and paper outcomes. *Journal of Economic Behavior & Organization*, 161, 68-78.

Page, L., Savage, D. A., & Torgler, B. (2014). Variation in risk seeking behaviour following large losses: A natural experiment. *European Economic Review*, 71, 121-131.

Pagel, M. (2017). Expectations-based reference-dependent life-cycle consumption. *Review of Economic Studies*, 84(2), 885-934.

Pope, D., & Schweitzer, M. (2011). Is Tiger Woods loss averse? Persistent bias in the face of experience, competition, and high stakes. *American Economic Review*, 101(1), 129-57.

Post, T., van den Assem, M. J., Baltussen, G., & Thaler, R. H. (2008). Deal or no deal? Decision making under risk in a large-payoff game show. *American Economic Review*, 98(1), 38-71.

Raghunathan, R., & Pham, M. (1999). All negative moods are not equal: Motivational influences of anxiety and sadness on decision making. *Organizational Behavior and Human Decision Processes*, *79*(1), 56-77.

Read, D., Loewenstein, G., & Rabin, M. (1999). Choice Bracketing. *Journal of Risk and Uncertainty*, 19(1-3), 171-197.

Shefrin, H., & Statman, M. (1985). The disposition to sell winners too early and ride losers too long: Theory and evidence. *Journal of Finance*, 40(3), 777-790.

Shiv, B., Loewenstein, G., Bechara, A., Damasio, H., & Damasio, A. R. (2005). Investment behavior and the negative side of emotion. *Psychological Science*, 16(6), 435-439.

Simpson, E. H. (1949). Measurement of diversity. *Nature*, 163(4148), 688-688.

Smith, G., Levere, M., & Kurtzman, R. (2009). Poker player behavior after big wins and big losses. *Management Science*, 55(9), 1547-1555

Staw, B. M. (1976). Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action. *Organizational Behavior and Human Performance*, 16(1), 27-44.

Suhonen, N., & Saastamoinen, J. (2018). How do prior gains and losses affect subsequent risk taking? New evidence from individual-level horse race bets. *Management Science*, 64(6), 2797-2808.

Thaler, R. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior & Organization*, 1(1), 39-60.

Thaler, R., & Johnson, E. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science*, 36(6), 643-660.

Thaler, R., & Ziemba, W. (1988). Anomalies: Parimutuel betting markets: Racetracks and lotteries. *Journal of Economic Perspectives*, 2(2), 161-174.

Turmunkh, U., Van den Assem, M., & Van Dolder, D. (2019). Malleable lies: Communication and cooperation in a high stakes TV game show. *Management Science*, *65*(10), 4795-4812.

Ungemach, C., Stewart, N., & Reimers, S. (2011). How incidental values from the environment affect decisions about money, risk, and delay. *Psychological Science*, 22(2), 253-260.

van den Assem, M. J., van Dolder, D., & Thaler, R. H. (2012). Split or steal? Cooperative behavior when the stakes are large. *Management Science*, 58(1), 2-20.

van Dolder, D., van den Assem, M. J., Camerer, C. F., & Thaler, R. H. (2015). Standing united or falling divided? High stakes bargaining in a TV game show. *American Economic Review P&P*, 105(5), 402-07.

Weber, M., & Camerer, C. F. (1998). The disposition effect in securities trading: An experimental analysis. *Journal of Economic Behavior & Organization*, 33(2), 167-184.

Weber, M., & Zuchel, H. (2005). How do prior outcomes affect risk attitude? Comparing escalation of commitment and the house-money effect. *Decision Analysis*, 2(1), 30-43.

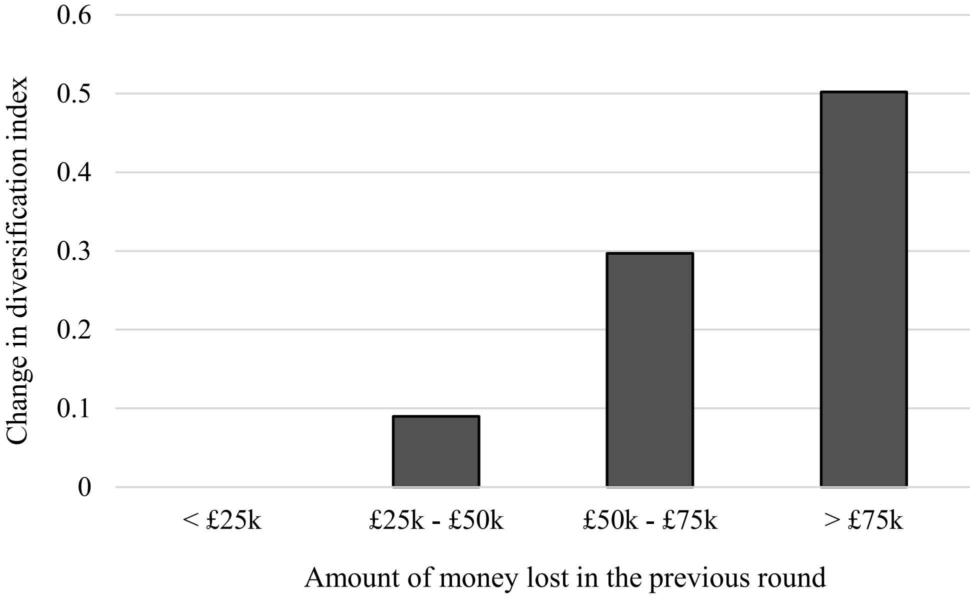

Figure 1. Change in propensity to diversify and prior loss size

Notes: Fixed-effects regression equation of changes in the diversification index in current round as a function of four different financial loss size categories in the previous round. The diversification index is a continuous variable ranging from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. The vertical bars represent the estimated coefficients from regression model 3 in Table 3. The estimated 'within-couple' regression equation controls for other variables including the remaining endowment amount, previous diversification strategy, and round fixed effects. 'Lost less than £25k' is the omitted reference category.

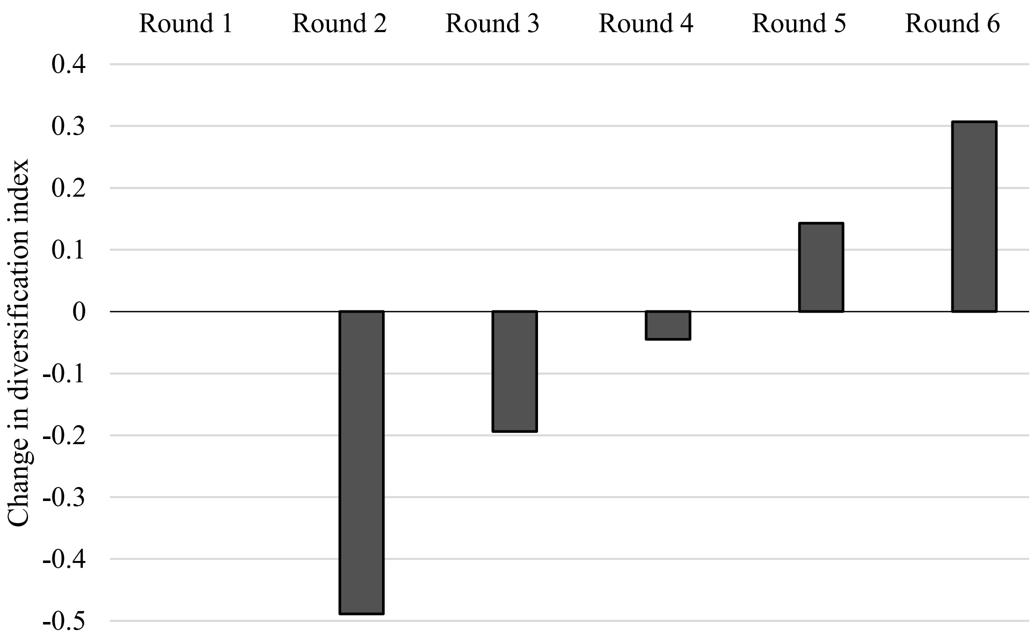

Figure 2. Change in propensity to diversify and decision round

Notes: Fixed-effects regression equation of changes in the diversification index as a function of round number. The diversification index is a continuous variable ranging from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. The vertical bars represent the estimated coefficients from regression model 3 in Table 3. The estimated 'within-couple' regression equation controls for other variables including the amount of money lost in the previous round, remaining endowment amount, and previous diversification strategy. The diversification index is always equal to zero in Round 7 (the final round) as there are only two possible answers in this last round, and participants are required to leave at least one answer blank. 'Round 1' is the omitted reference category.

Table 1. Average prior loss size, by decision round

	Absolute prior loss		Proportional prior loss		
Round	*Mean*	*Std Dev*	*Mean*	*Std Dev*	*n*
2	25.33	27.76	0.25	0.28	169
3	27.93	25.01	0.38	0.29	156
4	21.40	21.55	0.42	0.29	123
5	9.04	11.43	0.30	0.26	104
6	7.43	9.13	0.33	0.25	75
7	6.22	8.37	0.42	0.25	47
Total	19.38	22.93	0.34	0.28	674

Notes: Means and standard deviations are measured in £1,000s. The average numbers capture the monetary amounts lost by participating couples in the previous round before having to make the allocation decision in the current round. *Absolute prior loss* is the absolute amount of the cash endowment lost in the previous round, ranging from £0 to £100k. *Proportional prior loss* is the fraction of the endowment held in the previous round that is lost in the same round, ranging from 0 to 1. *n* denotes the number of decisions observed across all participating couples.

Table 2. Average diversification index, by decision round

Round	Mean	Std Dev	*n*
1	0.37	0.35	177
2	0.50	0.31	168
3	0.52	0.32	154
4	0.41	0.33	123
5	0.44	0.32	104
6	0.47	0.33	75
7	0	0	47
Total	0.43	0.34	848

Notes: The diversification index is a continuous variable ranging from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. The diversification index always equals zero in round 7 as there are only two choices in this final round. Participants are required to leave at least one answer blank in each decision round. *n* denotes the number of decisions observed across all participating couples.

Table 3. Effect of prior financial losses on the propensity to diversify

Dependent variable: *Diversification index in current round r*	Model 1	Model 2	Model 3	Model 4
Amount (£) lost in round *r*-1	0.006**	0.006		
	(0.001)	(0.003)		
Amount (£) lost in round *r*-1 – squared		0.000		
		(0.004)		
Lost between £25k and £50k			0.090*	
			(0.041)	
Lost between £50k and £75k			0.297**	
			(0.050)	
Lost more than £75k			0.502**	
			(0.080)	
Log of lost amount (£) in round *r*-1				0.183**
				(0.021)
Remaining endowment (£) in round *r*	0.009**	0.009**	0.009**	0.009**
	(0.001)	(0.001)	(0.001)	(0.002)
Diversification index in round *r*-1	-0.181**	-0.174*	-0.059	-0.346**
	(0.055)	(0.076)	(0.057)	(0.117)
Have lower than £7.5k to play (rounds 1-3)	-0.093	-0.091	-0.077	-0.195
	(0.116)	(0.117)	(0.115)	(0.109)
Have lower than £5k to play (rounds 4-7)	-0.363**	-0.364**	-0.379**	-0.301**
	(0.051)	(0.053)	(0.050)	(0.059)
Round 2	-0.533**	-0.533**	-0.489**	-0.631**
	(0.076)	(0.076)	(0.071)	(0.123)
Round 3	-0.244**	-0.243**	-0.194**	-0.374**
	(0.061)	(0.060)	(0.058)	(0.088)
Round 4	-0.080	-0.080	-0.045	-0.203**
	(0.048)	(0.047)	(0.047)	(0.066)
Round 5	0.123**	0.123**	0.143**	0.097
	(0.044)	(0.043)	(0.044)	(0.055)
Round 6	0.295**	0.296**	0.307**	0.287**
	(0.037)	(0.037)	(0.038)	(0.047)
Constant	0.244**	0.243**	0.219**	0.116
	(0.053)	(0.054)	(0.055)	(0.096)
Couple fixed effects	Yes	Yes	Yes	Yes
Observations	669	669	669	473
Within R-squared	0.389	0.389	0.390	0.460
Unique pairs	168	168	168	161

Notes: The dependent variable is the diversification index in the current round *r*, with values ranging continuously from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. All money variables are measured in £1,000s. 'Lost less than £25k' is the omitted reference category. Standard errors are clustered at the couple level and are reported in parentheses. ∗ and ∗∗ indicate statistical significance at the 5% and 1% levels, respectively.

Table 4. Effect of proportional prior losses on the propensity to diversify

Dependent variable: *Diversification index in round r*	Model 1	Model 2	Model 3
Ratio of amount lost to endowment (£) in round *r*-1	0.502**	-0.852	
	(0.108)	(0.523)	
Ratio of amount lost to endowment (£) in round *r*-1 – squared		1.273**	
		(0.477)	
Ratio of amount lost to endowment (£) in round *r*-1 between 25% and 50%			-0.055
			(0.055)
Ratio of amount lost to endowment (£) in round *r*-1 of more than 50%			0.133*
			(0.064)
Remaining endowment (£) in round *r*	0.009**	0.009**	0.010**
	(0.001)	(0.001)	(0.001)
Diversification index in round *r*-1	-0.270**	0.181	0.074
	(0.081)	(0.193)	(0.092)
Have lower than £7.5k to play (rounds 1-3)	-0.327**	-0.329**	-0.086
	(0.115)	(0.108)	(0.183)
Have lower than £5k to play (rounds 4-7)	-0.480**	-0.468**	-0.412**
	(0.048)	(0.049)	(0.052)
Couple fixed effects	Yes	Yes	Yes
Round fixed effects	Yes	Yes	Yes
Observations	669	669	614
Within R-squared	0.361	0.370	0.395
Unique pairs	168	168	167

Notes: The dependent variable is the diversification index in the current round *r*, with values ranging continuously from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. All money variables are measured in £1,000s. 'Ratio of amount lost to endowment (£) in round *r*-1 of less than 25%' is the omitted reference category. Standard errors are clustered at the couple level and are reported in parentheses. $*$ and $**$ indicate statistical significance at the 5% and 1% levels, respectively.

Table 5. Effect of accumulated prior losses on the propensity to diversify

Dependent variable: *Diversification index in round r*	Model 1	Model 2
Amount lost (£) in round *r*-1	0.009**	
	(0.001)	
Amount lost (£) in round *r*-2	0.004**	
	(0.001)	
Ratio of amount lost to endowment (£) in round *r*-1		0.328*
		(0.143)
Ratio of amount lost to endowment (£) in round *r*-2		-0.103
		(0.066)
Remaining endowment (£) in round *r*	0.014**	0.007**
	(0.002)	(0.002)
Diversification index in round *r*-1	-0.228**	-0.307**
	(0.060)	(0.099)
Round fixed effects	Yes	Yes
Couple fixed effects	Yes	Yes
Observations	501	501
Within R-squared	0.450	0.406
Unique pairs	154	154

Notes: The dependent variable is the diversification index in the current round *r*, with values ranging continuously from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. All money variables are measured in £1,000s. Standard errors are clustered at the couple level and are reported in parentheses. Additional control variables include dummy variables capturing low remaining endowment amounts at the start of the current round. ∗ and ∗∗ indicate statistical significance at the 5% and 1% levels, respectively.

Table 6. Effect of prior financial losses on propensity to diversify, by couple characteristics

Dependent variable: *Diversification index in round r*	Both females	Mixed gender	Both males	Romantic couple	Non-romantic couple
Amount lost (£) in round *r*-1	0.006**	0.006**	0.007**	0.005**	0.006**
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Remaining endowment (£) in round *r*	0.013**	0.010**	0.008**	0.009**	0.010**
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Diversification index in round *r*-1	-0.153	-0.205**	-0.051	-0.193*	-0.152*
	(0.123)	(0.077)	(0.109)	(0.088)	(0.076)
Round fixed effects	Yes	Yes	Yes	Yes	Yes
Couple fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	150	340	179	261	408
Within R-squared	0.450	0.413	0.423	0.391	0.397
Unique pairs	40	83	45	63	105

Notes: The dependent variable is the diversification index in the current round *r*, with values ranging continuously from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. All money variables are measured in £1,000s. Standard errors are clustered at the couple level and are reported in parentheses. Additional control variables include dummy variables capturing low remaining endowment amounts at the start of the current round. ∗ and ∗∗ indicate statistical significance at the 5% and 1% levels, respectively.

Table 7. Effect of prior financial losses on propensity to diversify, by decision round

Dependent variable: *Diversification index in round r*	Early rounds (1-3)	Later rounds (4-6)
Amount lost (£) in round *r*-1	0.011**	0.007**
	(0.001)	(0.001)
Remaining endowment (£) in round *r*	0.016**	0.009**
	(0.002)	(0.003)
Diversification index in round *r*-1	-0.667**	-0.328**
	(0.092)	(0.087)
Round fixed effects	Yes	Yes
Couple fixed effects	Yes	Yes
Observations	321	301
Within R-squared	0.549	0.271
Unique pairs	168	123

Notes: The dependent variable is the diversification index in the current round *r*, with values ranging continuously from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers. All money variables are measured in £1,000s. Standard errors are clustered at the couple level and are reported in parentheses. Additional control variables include dummy variables capturing low remaining endowment amounts at the start of the current round. * and ** indicate statistical significance at the 5% and 1% levels, respectively.

Table 8. Effect of prior financial losses on alternative measures of risk taking

	Dependent variable	
	Risked the entire endowment on one answer in round *r* (FE Logit)	Highest monetary amount placed on an answer in round *r*
Amount lost (£) in round *r*-1	-0.051**	-0.189**
	(0.009)	(0.028)
Remaining endowment (£) in round *r*	-0.098**	0.307**
	(0.016)	(0.037)
Diversification index in round *r*-1	0.998	3.966*
	(0.545)	(1.855)
Round fixed effects	Yes	Yes
Couple fixed effects	561	672
Observations	561	672
Within R-squared		0.824
Log likelihood	-112.573	
Unique pairs	119	169

Notes: The first dependent variable is a binary indicator that takes on a value of 1 if the participating couple placed their entire cash endowment on only one possible answer in the current round *r*, and 0 otherwise. A fixed-effects logit model is used to estimate this regression equation. The second dependent variable is a continuous variable measuring the highest monetary amount placed on an answer in the current round *r*. All money variables are measured in £1,000s. Standard errors are clustered at the couple level and are reported in parentheses. Additional control variables include dummy variables capturing low remaining endowment amounts at the start of the current round.

$*$ and $**$ indicate statistical significance at the 5% and 1% levels, respectively.

Appendix A:
Supplementary Figures A1 and A2

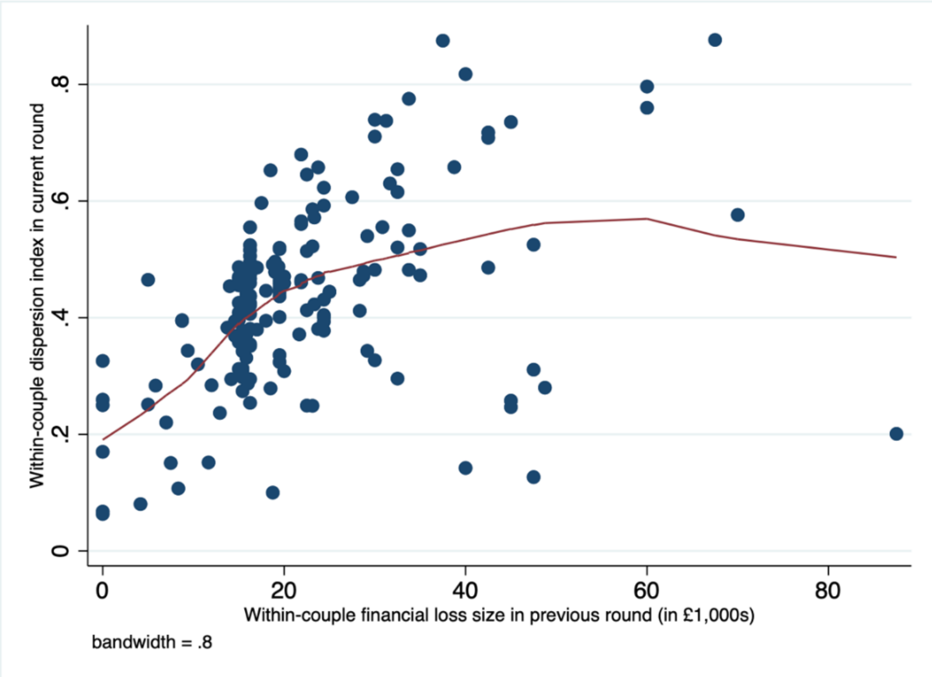

Figure A1. Relationship between diversification index and prior loss size

Notes: Locally weighted regression of the diversification index in the current round *r* as a function of the proportion of the endowment lost in the previous round *r*-1. Each dot is a local average calculated for each participating couple (n=169 unique couples). The maximum number of rounds played per couple is 7. The diversification index is a continuous variable ranging from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers.

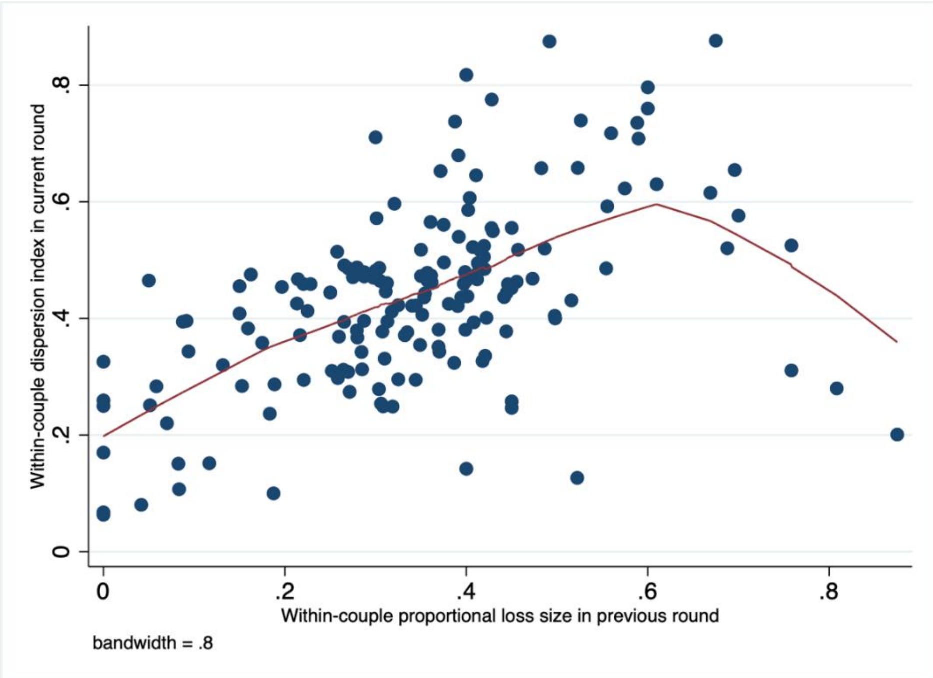

Figure A2. Relationship between diversification index and proportional prior losses

Notes: Locally weighted regression of the diversification index in the current round *r* as a function of the proportion of the endowment lost in the previous round *r*-1. Each dot is a local average calculated for each participating couple (n=169 unique couples). The maximum number of rounds played per couple is 7. The diversification index is a continuous variable ranging from 0 to 1. Higher values of the diversification index imply greater diversification of the cash endowment over the possible answers.