The Realization Effect: Risk-Taking After Realized Versus Paper Losses

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Abstract

Understanding how prior outcomes affect risk attitudes is critical for the study of choice under uncertainty. A large literature documents the influence of prior losses on subsequent risk attitudes. The findings appear contradictory: some studies find that people become more risk seeking after a loss, whereas others assert the opposite – that they become more risk averse. In this paper, we show that these seemingly inconsistent findings can be explained by individuals’ differential responses to realized versus paper losses. Following a realized loss, individuals avoid risk; if the loss has not been realized – a paper loss – individuals are more likely to chase their losses and take on even greater risk. We provide support for our framework using existing data and across two experiments. We also show that giving individuals flexibility in choosing when to realize losses can lead to lower earnings in environments where loss-chasing decreases expected returns. These findings can be reconciled by drawing a distinction between how paper and realized outcomes affect choice bracketing, and have important implications for contract design and optimal monitoring.

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“A person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise.”

– Kahneman and Tversky (1979)

“Losses that come on the heels of prior losses may be more painful than average. Conversely, after a prior loss, the person becomes more loss averse.”

– Barberis, Huang and Santos (2001)

1 Introduction

Understanding how prior outcomes affect risk attitudes is critical for the study of choice under uncertainty. Standard expected utility theory assumes prior outcomes can only influence risk-taking if there is a substantial change in wealth (Savage, 1954). In turn, an individual’s risk preferences should be stable with respect to small and moderate losses (Rabin, 2000).

However, empirical evidence suggests that risk attitudes are not always independent of the history. Prior losses significantly affect subsequent risk-taking in a variety of settings, from choices over lotteries in laboratory experiments (Thaler and Johnson, 1990) to trading decisions of experienced market-makers (Coval and Shumway, 2005; Liu, Tsai, Wang and Zhu, 2010) and investors (Kaustia and Knupfer, 2008). Research in this domain has produced contradictory empirical results: following a loss, individuals have been shown to become either more risk seeking (Andrade and Iyer, 2009; Langer and Weber, 2008; Weber and Zuchel, 2005), or more risk averse (Liu et al., 2010; Shiv, Loewenstein, Bechara, Damasio and Damasio, 2005). The empirical contradiction has produced a similar contradiction in theoretical work on dynamic choice under uncertainty. For example, in the models of Barberis, Huang and Santos (2001) and Dillenberger and Rozen (2014) individuals respond to losses by taking on less risk, while in Shefrin and Statman (1985) and Weber and Camerer (1998) losses lead to more risk-taking. The extent of this inconsistency is encapsulated by the two quotations above, both from papers exploring how prior losses affect risk attitudes. The first statement suggests that individuals take on more risk after a loss, whereas the second posits the opposite, that a loss leads to less risk-taking.

In this paper, we attempt to reconcile these seemingly inconsistent findings within a unified framework. In doing so, we draw a distinction between a loss that is realized (e.g. selling a losing stock or cashing out after a loss) and one that is not realized – a paper loss (e.g. holding a losing stock or not cashing out after a loss). Using existing data and new experimental evidence, we demonstrate that individuals take on more risk after a paper
loss and less risk after a realized loss. Our first experiment provides support for the main predictions: ceteris paribus, the same loss is followed by less risk-taking if it is realized and by more risk-taking if it is not. Our second experiment replicates these results in an environment akin to a casino – where risk-taking is detrimental to wealth – and shows that giving individuals flexibility in realizing their asset positions leads to greater loss chasing and lower earnings than when realization is imposed exogenously.

Our proposed distinction in how individuals respond to realized versus paper losses has important implications for commitment and monitoring in contexts where loss chasing bears negative consequences for wealth (e.g. casino gambling). Particularly, an individual with flexibility in realizing his wealth position will want to avoid experiencing negative realization when he is in the red – a phenomenon known as the disposition effect (Odean, 1998; Shefrin and Statman, 1985). Unrealized prior losses lead to even greater risk-taking as the individual attempts to climb out of the “hole.” Given such loss chasing, flexibility in realizing one’s position may lead to greater losses than if realization was imposed exogenously, particularly in contexts where continued risk-taking may be detrimental to wealth.1 Section 3 provides direct evidence for this behavioral pattern.

The results of this paper offer a unifying principle – realization – that reconciles two rich strands of literature on the dynamics of risk attitudes (Barberis, 2013; Barberis et al., 2001; Benartzi and Thaler, 1995; Gneezy and Potters, 1997). Particularly, the differential effect of realized versus paper losses on risk-taking contributes to the emerging literature on how non-standard factors such as emotions (Caplin, 2003; Caplin and Leahy, 2001, 2004; Koszegi, 2006) and other psychological factors (Loewenstein, 1996; Loewenstein, Weber, Hsee and Welch, 2001) affect risk attitudes.

In Section 4, we outline a potential theoretical framework that is consistent with the observed behavioral pattern. The main result follows from one simple assumption: paper losses are integrated and evaluated jointly with prospects in the same choice bracket while realized losses are not. In this framework, individuals engage in narrow framing – they evaluate choices and gambles within a given mental account or choice bracket separately from other sources of wealth (Rabin and Weizsäcker, 2009; Thaler, 1985). Choices within a bracket affect each other and are evaluated jointly (Read, Loewenstein and Rabin, 1999), while choices in different brackets are evaluated independently.2 A paper loss is integrated

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1Rick and Loewenstein (2008) discuss contexts in which individuals may engage in suboptimal decision-making to recoup losses when they perceive themselves as “in the hole.”

2For example, betters on the racetrack are far more likely to favor the longshot at the end of the day if they had suffered earlier losses (Ali, 1977), presumably because the betting day serves as a distinct mental account or ‘choice bracket’: if betting choices were integrated with the rest of the individual’s wealth, then
into the decision problem, and prospects are evaluated jointly with respect to this loss. In turn, a loss-averse individual becomes more willing to take a gamble if it offers a possibility of erasing the previous negative outcome. Realization stops the integration process and updates the reference point: the individual closes the choice bracket of prior outcomes, internalizes the loss and evaluates subsequent prospects relative to a new choice bracket. In turn, this framework predicts that individuals should take on more risk after a paper loss than a realized one. The Appendix outlines a formal framework for a general set of gambles.

The paper proceeds as follows. Section 2 reviews prior work and provides empirical support for the differential effect of realized versus paper losses on risk-taking. Section 3 presents two investment experiments which provide direct support for our predictions. Section 4 outlines a potential framework consistent with the observed results. Section 5 concludes with a discussion of implications for optimal monitoring and contracts.

2 An Empirical Contradiction

In this section we analyze existing empirical evidence and demonstrate that distinguishing between realized and paper losses reconciles the contradictory results. We begin with studies conducted in the lab, and then discuss non-experimental data.

Langer and Weber (2008) adapted the investment game of Gneezy and Potters (1997) to study risk-taking in a dynamic context. In the game, individuals were asked to make a series of investment decisions from an initial endowment. Over the course of 30 rounds, participants could either invest part of their endowment in a risky, positive expected-value asset, or to keep it. After each round, a randomization device determined whether the investment would be lost or multiplied. Importantly, if the investment was lost, the participant learned this information but did not part with the loss. All earnings were realized at the end of the experiment. If the participant ended the study with less money than the endowment, he would pay the difference to the experimenter; if he ended the study with more money than the endowment, the difference would be paid to him. In turn, participants in this study experienced paper gains and losses after each round prior to the end of the experiment.

We obtained and analyzed the individual-level data from the authors to examine risk-taking following a gain or a loss. As can be seen in Figure 1A, overall investment in risk increased as the rounds progressed. We separated the data by investment after a loss and investment after a gain, and calculated the change in investment after each outcome. Running prior losses would be too trivial to affect subsequent behavior. For further evidence of choice bracketing, see Barberis, Huang and Thaler (2006); Kahneman and Lovallo (1993).
a non-parametric Mann-Whitney test on the results reveals that the increase in risk-taking was driven by participants’ responses to losses: individuals took on significantly more risk after a loss relative to both a prior gain \((p < .001)\) and the benchmark of no investment change \((p < .001)\).

Shiv et al. (2005) used a similar investment game to explore the effects of prior gains and losses on risk attitudes. As in Langer and Weber (2008), individuals started the experiment with an endowment and made a series of investment decisions over the course of 20 rounds. In each round, participants made the choice of either investing part of the endowment in a risky, positive expected-value asset, or keeping it. After each round, a randomization device determined whether the investment would be lost or multiplied. Unlike in Langer and Weber (2008), however, earnings were realized after every single round. After each round, if the participant learned the investment was lost, he took that part of his endowment and gave it to the experimenter; if the investment was multiplied, the participant received the positive difference. As such, participants in Shiv et al. (2005) experienced realized gains and losses after each round.

Figure 1B shows investment in risk over time from Shiv et al. (2005). Unlike in Langer and Weber (2008), overall risk-taking decreased as the rounds progress. A similar analysis to the one above reveals that changes in investment are again driven by a differential response to losses, but in the opposite direction. Relative to investment after a prior gain, participants responded to a loss by taking on less risk \((p < .01)\), and did not change their investment behavior in response to gains.

![Figure 1A](image1.png) ![Figure 1B](image2.png)

(a) *Langer and Weber* (2008)  
(b) *Shiv et al.* (2005)

**Figure 1.** Risk-taking after Realized and Paper Losses

A review of the literature reveals that the distinction between realized and paper losses
reconciles the contradictory findings. Andrade and Iyer (2009) gave participants an endowment of $10 and asked them to make two rounds of betting decisions on a gamble akin to a roulette wheel. Participants could bet up to $5 in each round. As in Langer and Weber (2008), earnings were realized at the end of the study, such that first round outcomes were paper gains or losses. The authors found that participants took on significantly more risk after a loss (Experiment 2). Using a similar design of sequential investment decisions with paper outcomes, Barkan and Busemeyer (1999) and Weber and Zuchel (2005) found similar results: individuals took on more risk after a loss. Alternatively, Shiv, Loewenstein and Bechara (2006) found that individuals took on less risk after a loss; in their experiment, outcomes were realized after every round.3

Non-experimental studies examining the dynamics of risk attitudes present a similar contradiction. Coval and Shumway (2005) and Liu et al. (2010) studied the risk-taking behavior of professional traders. Both papers found that morning losses significantly affected risk-taking in the afternoon. Such behavior is not consistent with expected utility theory since, given the horizon of one day, wealth effects from prior losses were negligible and agency concerns were neutral. However, Coval and Shumway (2005) found that morning losses led traders to take on more risk in the afternoon, while Liu et al. (2010) found the opposite – morning losses led to less risk-taking in the afternoon. When discussing discrepancies between the two papers, Liu et al. (2010) note a difference in the composition of paper and realized losses. A larger portion of morning losses were realized in Liu et al. (2010) than in Coval and Shumway (2005). In light of our experimental findings, the difference in the ratio of realized to paper losses may explain the contrast in the two sets of results.

Although these studies provide suggestive evidence for the differential effect of realized versus paper losses on risk-taking, it is not causal. Besides differences in the nature of losses, there were several other discrepancies which may have contributed to the contrasting results: participants were drawn from different subject pools or populations, the risky assets had different distributions, etc. We now proceed to demonstrate the proposed behavioral pattern within the same experimental paradigm.

3It is important to note that in all studies we examine, taking on risk can erase a prior loss if the gamble or investment is successful. As discussed in Section 4, we argue that this is a critical motivation for increased risk-taking after a paper loss. For example, Thaler and Johnson (1990) and Heath (1995) do not find support for loss chasing if the gamble does not allow the individual to offset the prior loss.
3 Two Investment Experiments

To test whether paper versus realized losses have differential effects on subsequent risk attitudes, we adopted the investment game of Gneezy and Potters (1997) to examine how the nature of a prior loss affected individuals’ risk-taking in a sequence of investment decisions. The decision maker receives an endowment, $E$, and makes investment decisions over a series of rounds. In each round, he can choose how much of an amount, $X$, he would like to invest in a risky option and how much to keep. The amount invested in the risky option, $x$, yields a dividend of $kx$ ($k > 1$) with probability $p$ and is lost with probability $1 - p$. The money not invested ($X - x$) is kept by the decision maker. The payoff in each round is:

$$p \cdot (X - x + kx) + (1 - p) \cdot (X - x)$$

After the choice of $x$ is made, the outcome of the risky option is determined and revealed to the decision maker. The decision maker then moves on to the next round where he is presented with the same choice.

The amount invested $x$ provides a robust metric for capturing treatment effects and differences in attitudes toward risk. Similar paradigms have been used to test for myopic loss aversion in students (Gneezy and Potters, 1997) and professional traders (Haigh and List, 2005), to demonstrate decreased (and increased) risk-taking following a prior loss (Langer and Weber, 2008; Shiv et al., 2005), to examine gender differences in risk attitudes (Charness and Gneezy, 2012) and to show the effect ambiguity aversion and illusion of control on portfolio choice (Charness and Gneezy, 2010).

3.1 Realized and Paper Losses

Undergraduates ($N=129$) from a university-wide subject pool were recruited to participate in an experiment on decision-making. Participants were randomly assigned to individual computer stations and given a set of instructions that were read aloud. Each was endowed with an envelope of $8 in cash in the beginning of the study and asked to count it: the envelope contained 7 one-dollar bills and 4 quarters.

Participants were told that they would make 4 rounds of investment decisions. In each round the participant would decide how much of $2 to invest in a lottery (in increments of quarters). With a $1/6$ chance the lottery would succeed and pay dividends $k = 7$ times the amount invested $x$; with a chance of $5/6$ the lottery would fail and the money invested would be lost. In each round, participants were randomly assigned one “success number”
between 1 and 6. This number was displayed on their computer screen in the beginning of each round. Participants would then enter the amount they would like to invest \( x \). Note that in this case, \( p \ (1/6) \) and \( k \ (7) \) were chosen such that that \( p \cdot k > 1 \), making the expected value of investing higher than the expected value of not investing.

Once this was done, the experimenter rolled a six-sided die in the front of the room. Participants were welcomed to examine the die to make sure it was fair. If the outcome of the die roll matched a participants success number, the lottery would succeed and they would earn \( 7x \) plus the amount they did not invest \((2-x)\). If the outcome was any other number, the lottery would fail and participants were left with the amount they did not invest. After learning the outcome of the die roll, participants would move on to the next round, be assigned a new “success number” and make the same decision again. All outcomes were written on a board in front of the room to keep information constant between treatments.

To test for the differential effect of realized versus paper losses, participants were randomized into either the Realized or Paper treatment. In the Realized treatment, at the end of the 3\(^{rd}\) round participants had their wealth positions realized: if they had lost money by the end of the 3\(^{rd}\) round, they took this amount out of their envelope and handed it to the experimenter. If they had won, this amount was given to them. After realizing their earnings, participants made one last investment decision in the 4\(^{th}\) round and were paid according to the outcome.

In the Paper treatment, participants did not realize their earnings at the end of the 3\(^{rd}\) round. They continued on to the 4\(^{th}\) round and were paid at the end of the experiment. Time between rounds was normalized across treatments such that those in the Realized treatment did not have a longer break between the 3\(^{rd}\) and 4\(^{th}\) rounds than those in the Paper treatment. As a robustness check to ensure that the intervention of the experimenter in the Realized treatment did not drive the results, we also ran a second Paper Social (Paper S) treatment. The procedure in Paper S was the same as in the Paper treatment, except that at the end of the 3\(^{rd}\) round the experimenter came up to each participant and verbally informed them how much money they had won or lost relative to the original endowment.\(^4\)

Note that given a sequence of decisions and outcomes, the wealth positions and information were the same for participants in all three treatments. However, those who had lost money from their $8 endowment by the end of the 3\(^{rd}\) round in the Realized treatment had to physically part with it. This served as the manipulation of exogenously inducing realization. In contrast, those who had a similar loss by the end of the 3\(^{rd}\) round in the Paper and Paper

\(^4\)We ran the Paper S treatment as a robustness check after running the Paper and Realized treatments, using the same lab and subject pool.
$S$ treatment could still potentially avoid parting with their endowment and experiencing a negative realization by taking on more risk in the 4th round.

In this setup, we predict that those who are losing at the end of the 3rd round in the Paper and Paper $S$ treatments should *increase* their 4th round investment. In contrast, those who are losing at the end of the 3rd round in the Realized treatment should *decrease* their investment in the 4th round. In the analysis below, we use the change in investment between rounds as our main dependent variable.

### 3.1.1 Results

Investments did not significantly differ by treatment in rounds 1 through 3 (see Appendix Table 1). However, participants in the Paper and Paper $S$ treatment took on significantly more risk in the 4th round (average investment $\bar{x} = \$1.01$ and $\$0.96$, respectively) than those in the Realized treatment ($\bar{x} = \$0.63$; $t(79) = 2.71, p < .01$ and $t(86) = 2.38, p = .02$). In line with our predictions, the variation between the two treatments was largely driven by differences in how individuals responded to a loss that was realized versus one that was not.

**Figure 2. Investment Change (\$) after a Loss**

We examine the investment change between rounds 3 and 4 for participants who lost the lottery in rounds 1, 2 and 3 – the lottery failed all three times (see Figure 2). Consistent

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Unpaired, two-sample $t$-test.
with our predictions, in the Paper and Paper S treatments these individuals increased their investment in the lottery by $0.23 and $0.16, respectively, taking on significantly more risk than the null hypothesis of zero change in investment ($t(26) = 2.28, p = .03$ and $t(38) = 2.41, p = .02$). However, those who had similarly lost in the Realized treatment decreased their investment by $0.15$, taking on significantly less risk than the null ($t(25) = 2.42, p = .02$). Importantly, the change in investment between the $3^{rd}$ and $4^{th}$ rounds was significantly different between both the Paper and Realized treatments ($t(51) = 3.19, p < .01$) and the Paper S and Realized treatments ($t(63) = 3.25, p < .01$). To quantify the effect of realizing a loss on risk-taking, an OLS regression of Investment Change on a treatment dummy (Realized = 1; Paper = 0) for those who lost by the end of the $3^{rd}$ round revealed that realizing one’s loss leads to a significant decrease in risk-taking relative to not realizing a loss of the same size ($\beta = -.38, p < .01$). Changes in investment did not differ between treatments for any other round (see Appendix Table 3).7

Next, we examine the relationship between the amount lost and investment behavior. Looking at each treatment separately, we regress the amount invested in the $4^{th}$ round on earnings at the end of the $3^{rd}$ round relative to earnings if the individual had not chosen to gamble ($\$6$), e.g. someone who had lost $\$3$ by the $4^{th}$ round would have relative earnings of $-\$3$. Relative earnings had a significant effect on $4^{th}$ round investment if the outcome was not realized ($\beta = -.09, p < .01$). Note that the negative coefficient implies that the larger the losses, the more the individual invested in the $4^{th}$ round. In contrast, relative earnings had no effect on investment if outcomes were realized ($\beta = -.002, p = .92$). Regressing the amount invested on relative earnings, a dummy for realization and their interaction reveals a significant interaction effect ($\beta = -.09, p = .015$). This implies that relative earnings had a negative effect on the amount invested, but only if the outcome was not realized.

These results are consistent with the framework outlined in Section 4, where paper prior outcomes are integrated within the same choice bracket as the prospect being evaluated, while realized outcomes are not. A loss averse individual with prospect theory preferences would invest more the greater his losses relative to the reference point – the more he is in the hole. However, this only occurs if the prior losses are integrated with the prospect; if the losses are not integrated, i.e. realized outcomes, the extent of the loss should not affect investment behavior. This pattern is consistent with our results.

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6One-sample t-test with null hypothesis of zero investment change.
7Since the experiment was designed to test the effect of prior losses, probabilities were chosen such that most participants had lost by the end of the $3^{rd}$ round. There were too few observations to conduct any meaningful analyses on prior gains.
3.2 Realization and Flexibility

The second experiment aimed to explore whether giving individuals flexibility in when to realize their positions could lead to lower earnings overall relative to those whose positions were exogenously realized. Particularly, the experiment was designed to mimic environments where taking on risk and chasing losses leads to lower expected returns than keeping one’s money (e.g. casinos, race-tracks), and the choice to realize one’s position is endogenous. The disposition effect predicts that most would choose to not realize their losses, and in light of our findings, take on greater risk. On the other hand, imposing realization exogenously should mitigate this behavior. Hence, flexibility in realization is predicted to lead to lower expected wealth due to a combination of loss chasing and the disposition effect.

Undergraduates ($N=150$) from a university-wide subject pool were recruited to participate in an experiment on decision-making. The lottery was set to yield $2.5$ times the amount invested $x$ with a $1/3$ probability, and to lose with probability $2/3$. Since $p \cdot k < 1$, the expected value of investing in the lottery is slightly lower than the expected value of not investing, similar to gambling on a roulette wheel. Procedures were largely the same as those in the first experiment, except that now participants were randomly given two different “success numbers” from 1 to 6 at the beginning of each round to reflect the higher probability of the lottery succeeding.

In addition to the Paper and Realized loss treatments, a third Flexible treatment was added to test whether flexibility in realization indeed reduced expected earnings. In the Flexible treatment, individuals were asked at the end of the $3^{rd}$ round whether they would like to realize their earnings similar to those in the Realized treatment, or to move on to the $4^{th}$ round. If they chose to realize their positions, the procedure was identical to the Realized treatment; if they chose to move on, the procedure was identical to the Paper treatment.

Similar to the first experiment, we predict that those who had a paper loss by the end of the $3^{rd}$ round would increase their position in the lottery, taking on more risk, while those who had a realized loss would decrease their position and take on less risk. Moreover, we predict a disposition effect in the Flexible treatment – those who had won by the end of the $3^{rd}$ round should want to realize their positions to a greater extent than those who had lost, with the latter group preferring to move on to the $4^{th}$ round without realization. In turn, participants who had lost by the end of the $3^{rd}$ round in the Flexible treatment should increase their position in the risky lottery in the $4^{th}$ round since most had not realized their loss.
3.2.1 Results

Investments did not significantly differ by treatment in rounds 1 through 3 (see Appendix Table 2). However, participants in both the Paper treatment ($\bar{x} = $1.16) and Flexible treatment ($\bar{x} = $1.24) invested significantly more in the $4^{th}$ round than those in the Realized treatment ($\bar{x} = $0.74; $t(78) = 2.68, p < .01$ and $t(79) = 3.49, p < .001$, respectively).\(^8\) Again, these differences were largely driven by the differential response to prior losses that were realized versus those that were not.

**Figure 3. Change in Investment after a Loss**

![Figure 3](image)

In line with our predictions (see Figure 3), those who had lost by the end of the $3^{rd}$ round in the Paper treatment on average increased their investment in the lottery by $0.29$, taking on significantly more risk than the null hypothesis of zero investment change ($t(25) = 2.75, p = .01$).\(^9\) Similarly, those in the Flexible treatment who lost by the end of the $3^{rd}$ round also took on more risk, increasing their investment in the lottery by $0.33$ ($t(23) = 3.14, p < .01$). In contrast, those who had lost by the end of the $3^{rd}$ round in the Realized treatment took on less risk and decreased their subsequent investment by $0.27$ ($t(25) = 2.19, p = .038$).

Investment changes after a loss between the $3^{rd}$ and $4^{th}$ rounds were significantly different between the Realized and Flexible treatments ($t(48) = 3.68, p < .001$) and the Realized

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\(^8\) Unpaired, two-sample $t$-test.

\(^9\) One-sample $t$-test with null hypothesis of zero investment change.
and Paper treatments \((t(50) = 3.44, p = .001)\), but not between the Paper and Flexible treatments \((t(48) = .37, p = .71)\). Changes in investment did not differ between treatments for any other round (see Appendix Table 4).

Importantly, participants in the Flexible treatment displayed a significant disposition effect. Participants who had lost by the end of the 3rd round realized their positions 13% of the time while those who had won realized their positions 44% of the time \((t(38) = 2.33, p = .025)\). Since most who lost by the end of 3rd round chose not to realize those losses, our predictions state that participants in the Flexible treatment should take on more risk in the 4th round, which was observed in the results.

Greater loss chasing had a significant negative impact on earnings. Given that investing in the lottery had a lower expected return than not investing, participants in the Paper and Flexible treatments stood to earn less in the 4th round than those for whom realization was imposed exogenously. Indeed, expected 4th round earnings in the Realized treatment were significantly higher than in both the Paper and Flexible treatments \((t(78) = 2.68, p < .01\) and \(t(79) = 3.49, p < .001\), respectively). Hence, giving individuals flexibility in realizing their positions in a context where risk-taking is detrimental to wealth led to greater losses than when realization was imposed exogenously.

4 Discussion

In one of the first papers to make a distinction between realized and paper losses, Shefrin and Statman (1985) posit that when an individual buys a stock or makes an investment, a mental account is opened. If the asset is sold for lower (higher) than the initial purchase price, the individual codes this as a realized loss (gain). Realizing a gain or loss closes the associated mental account. On the other hand, if the asset goes down (up) before it is sold, the individual codes this as a paper loss (gain). Individuals experience a pronounced drop in utility when a mental account is closed at a loss; the authors argue that a realized loss is more painful than a paper one. Barberis and Xiong (2012) formalize the distinction between paper and realized outcomes in a model of realization utility, which corresponds to an individual’s feelings of regret (elation) upon closing his mental account with a wealth position lower (higher) than when he started (see Ingersoll and Jin (2013) for an extension of these results).

\(^{10}\)A recent study by Frydman, Barberis, Camerer, Bossaerts and Rangel (2012) provides neural support for realization utility: activation in brain regions associated with expected utility was more significant after a realized outcome.
A natural question is whether agents’ risk-taking differs after a loss prior to realization (a paper loss) versus after a loss that is realized. Prospect theory (Kahneman and Tversky, 1979; Wakker and Tversky, 1993) has been used to explain many documented instances of increased risk-taking following a prior loss (Coval and Shumway, 2005; Smith, Levere and Kurtzman, 2009; Weber and Camerer, 1998; Weber and Zuchel, 2005). When discussing dynamic effects of prior outcomes, Kahneman and Tversky (1979) observe that a “person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise.” Particularly, if taking on risk allows an individual to offset a prior loss and avoid a negative realization, then he will take on more risk than if no prior loss had occurred.

Critical to this prediction is the assumption that people integrate the outcomes of successive gambles when evaluating prospects. As noted in Thaler and Johnson (1990), if a prior loss is not integrated with the prospect, subsequent risk-taking may lead individuals to take on less risk. Setting conditions for when a decision maker integrates prior outcomes and when he does not – evaluating prospects with a “clean slate” – is key for determining when a prior loss leads to more risk-taking and when it may lead to less. Note that not integrating a prior outcome is analogous to incorporating it into total wealth and updating (resetting) the reference point to the new wealth level.

This paper posits that integration depends on whether the prior outcome was realized or not: individuals integrate prior paper losses and update their reference point after realization. After a paper loss, the individual may feel that there is still hope he can still recoup his loss and avoid the sure negative realization – he has not “made peace” with his losses. When evaluating prospects, the losses are integrated with the potential payoffs, and as such, gambles that allow the individual to erase the prior outcomes become more attractive. On the other hand, the realization of a loss serves as a natural point for an individual to internalize the negative outcome and close the associated choice bracket (Shefrin and Statman, 1985). Particularly, if a loss is realized – the individual parts with the money – he does not integrate the prior outcome when evaluating a prospect and updates his reference point. Conditional on the gamble allowing the individual to recover from the prior loss, he should be less likely to take on risk after a realized than a paper loss. Consistent with the empirical results, loss chasing should only be observed after a paper loss.

As a simple illustration, take decision maker with with prospect theory preferences and a piecewise linear value function.\textsuperscript{11} Suppose he evaluates gains and losses relative to a

\textsuperscript{11}See the Appendix for a more general illustration of the framework.
reference point of zero and has a loss aversion parameter $\lambda = \frac{5}{4}$.\textsuperscript{12} Such a decision maker will be indifferent between taking or leaving a gamble with a one third chance of winning $250$ and a two thirds chance of losing $100$.

Suppose the decision maker takes the gamble and suffers a $100$ paper loss. If offered the same gamble again, he now compares the sure $100$ loss if he turns it down to the prospect of either winning $150$ or losing $200$ if he accepts the second gamble. Since the gamble allows the decision maker to avoid realizing the sure loss, it is straightforward to show that he now strictly prefers to take the gamble. On the other hand, if the $100$ loss was realized, the prospective gamble is evaluated in a new choice bracket and the decision maker does not integrate the two when choosing to accept or reject the second gamble. As such, he strictly prefers to take the gamble after a paper loss, but is indifferent after a realized loss.

In order to show that individuals take on less risk after a realized loss not only relative to a paper loss, but relative to a baseline with no prior outcomes, more structure is needed. An account proposed in the literature is that losses which are not integrated with prospects may cause the individual to become more loss averse (Barberis et al., 2001; Thaler and Johnson, 1990). The increased loss aversion may be due to a diminished capacity for dealing with bad “news” about future consumption (Koszegi and Rabin, 2009; Pagel, 2012) or the increased salience of the potential downside of risk (Bordalo, Gennaioli and Shleifer, 2012). In the framework of the above example, we assume that a realized loss is not integrated with the prospect. If it is further posited that the loss increases subsequent loss aversion, then the decision maker strictly prefers not to gamble after a realized loss – he is less willing to take on the second gamble than the first.

It should be stressed that the preceding arguments are meant as a preliminary framework to rationalize the observed differential effect of realized versus paper losses on risk-taking. Future work is needed to both identify the mechanism behind the phenomenon and develop a general theoretical structure.

5 Conclusion

In this paper we present the results of two experiments which demonstrate the differential effect of paper versus realized losses on risk attitudes. Individuals take on \textit{more} risk after a

\textsuperscript{12}Kahneman and Tversky (1979) and Thaler and Johnson (1990) take the reference point $r$ to be the status quo. Koszegi and Rabin (2006) formulate the value function as $v(m(x) - m(r))$, where the reference point $r$ is characterized by the full distribution of expected outcomes and $m(\cdot)$ is the “consumption utility” typically studied in economics. Here, we take $r$ to be the status quo for simplicity; all results hold if $r$ is defined in terms of expectations.
paper loss and less if the loss is realized. Using a framework of prospect theory and choice bracketing, we argue that the realization of a loss acts as a closing of the choice bracket constituting the individual’s prior investments or gambles. If the loss is not yet realized, however, people attempt to cover it by taking on even more risk – chasing their losses – in order to avoid a future negative realization. Importantly, we also demonstrate that flexibility in realizing investment decisions may be detrimental to wealth (in certain contexts) due to escalations in risk-taking.

The interplay between loss chasing and the disposition effect has significant implications for the role of choice and monitoring of investor behavior. The results of our second experiment demonstrated that individuals whose investments were unsuccessful were reluctant to realize their losses, preferring to instead take on more risk before their positions were finally realized. These effects can be particularly detrimental in contexts where taking on gambles or investing in particular assets leads to lower expected returns than available alternatives.

Given the behavioral patterns described above, an individual owning a losing stock may be reluctant to sell, choosing to instead keep the stock or even “doubling down” and purchasing more shares. Such trading behavior can spiral out of control and lead to significant losses, which is consistent with the literature documenting overly aggressive trading (Barber, Lee, Liu and Odean, 2006) and a pronounced disposition effect displayed by individual investors (Odean, 1998). The results presented here suggest that giving traders flexibility in realizing their asset positions may lead to significantly lower wealth. In turn, individual investors should adopt policies which facilitate regular realization to prevent detrimental loss chasing. For example, an individual can automatically set his asset positions to be reported to a third party who can exogenously influence the realization of his positions. Our findings are also related to the prescriptions proposed by Weber and Zuchel (2005) regarding the benefits of binding precommitments in investment strategies.

For institutional traders, given the relationship between compensation and trading performance, the reporting of asset positions to the overseeing risk manager can be taken as a natural point of realization – analogous to the closing of the respective choice bracket. Anecdotal evidence suggests that some of the largest losses suffered by financial institutions occurred as a result of traders hiding prior losses while taking on excessive risk in an attempt to cover them. In light of our results, a firm’s monitoring strategy should utilize realization of traders’ asset positions while lowering the incentives for them to hide loses. For example, Camerer and Loewenstein (2004) describe an investment banker whose firm forced traders to

See Jerome Kerviel’s 4.9 billion Euro loss for Societe Generale, Kweku Adoboli’s 2.3 billion dollar loss for UBS and Nick Leeson’s 1.3 billion dollar loss for Barrings, which wiped out the firm.
periodically switch positions (the portfolio of assets that the trader bought and is blamed or credited for) with the position of another trader. This was done to ensure that traders do not make bad trades because of emotional attachment to their previous actions, while keeping the firm’s net position unchanged. In the context of our findings, such a policy would be an effective tool to curb loss chasing, particularly if position switches were performed at times not announced to the traders ex-ante.

Future research should extend our findings to field settings and explore the role of realization in mitigating commonly reported pitfalls in investment and gambling behavior. Particularly, it is important to understand to what extent individuals are aware of the differential effects of realized versus paper losses on their future risk-taking behavior, and whether they would value opportunities and commitment devices that would allow them to curb detrimental loss chasing.
References


6 Appendix A: Data

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<th>Table 1. Total Investment in Risk: Experiment 1</th>
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† Standard errors in parentheses.

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† Standard errors in parentheses.
Table 3.
Investment Change after Loss at End of Round: Experiment 1

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<th>Treatment</th>
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<th>Round 2</th>
<th>Round 3</th>
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<td>$-0.15</td>
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<td>(.08)</td>
<td>(.06)</td>
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</tr>
<tr>
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<td>(.06)</td>
<td>(.04)</td>
<td>(.10)</td>
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<tr>
<td>Paper Social</td>
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<td></td>
<td>(.08)</td>
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<td>(.06)</td>
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</tbody>
</table>

† Standard errors in parentheses.

Table 4.
Investment Change after Loss at End of Round: Experiment 2

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<th>Round 3</th>
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<td>(.08)</td>
<td>(.11)</td>
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<td>Flexible</td>
<td>$-0.10</td>
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† Standard errors in parentheses.
Appendix B: Choice Bracketing and Realization

Consider a dynamic choice problem where at each time $t \in \mathcal{T} = \{1, ..., T\}$, a decision maker faces a choice set $\{L_t, r_t\}$ which represents a decision between taking a non-degenerate, positive expected-value gamble $L_t$ or turning it down and retaining $r_t$, where $r_t$ corresponds to the reference point at the start of period $t$. $L_t$ has two possible outcomes, $x^g > 0 > x^l$, where $x^s$ is the payout in state $s \in \{g, l\}$. Denote the objective probability that state $g$ occurs by $\pi$, with corresponding probability $1 - \pi$ for state $l$.

A loss-averse decision maker evaluates outcomes using the prospect theory value function $v(x)$. In turn, the decision maker evaluates the gamble $L_t$ as $V(L_t) = \pi^g v(x^g) + \pi^l v(x^l)$. Lottery outcomes are evaluated relative to a reference point of zero, $r_t = 0$.

To examine the differential effects of realized versus paper outcomes on risk-taking, we first define the role of realization in determining whether outcomes are evaluated jointly within the same choice bracket—integration—or separately in different choice brackets.

Let $\{R_t\}_{t=2}^T$ be the stochastic process indicating whether a realization of an outcome—selling of a stock or parting with money lost in a gamble—occurs at time $t$, $R_t : s \times \mathcal{T} \rightarrow \{0, 1\}$. Let $\{\tau_n\}$ be a sequence of hitting times ($R_{\tau_n} = 1$) such that $\tau_1 = \inf \{t \in \mathcal{T} \text{ s.t. } R_t = 1\}$ and $\tau_n = \inf \{t \in \{\tau_{n-1} + 1, ..., T\} \text{ s.t. } R_t = 1\}$ for $n \geq 2$.

Then the decision maker’s value function can be defined as:

$$v(x_t, \lambda_t) = \begin{cases} 
(x_t + \sum_{s=1}^{t-1} L_s)^\alpha & \text{if } v(\cdot) \geq 0 \\
-\lambda(z_t) \cdot \left[-(x_t + \sum_{s=1}^{t-1} L_s)^\alpha\right] & \text{if } v(\cdot) < 0
\end{cases} \quad (1)$$

where $s = \max \{\tau_n \text{ s.t. } \tau_n \leq t\}$. A note on the timing notation: the realization of a prospect evaluated at time $t$ occurs at the start of the next period $t + 1$: $R_{t+1} = 1$ if the outcome is realized or $R_{t+1} = 0$ if it is not.

The expression in (1) formally denotes the distinction between paper and realized outcomes. Particularly, the decision maker evaluates a prospect $L_t$ jointly with the preceding sequence of outcomes $\{x_{\tau}, ..., x_{t-1}\}$ within the same choice bracket if no prior outcome in that sequence had been realized ($\forall \, n \in \{\tau+1, ..., t\}: \, R_n = 0$). The realization of a prior outcome (e.g. $R_t = 1$) closes the choice bracket containing the preceding sequence, and the prospect $L_t$ is evaluated separately in a new choice bracket.

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14For example, if $t = 5$ and outcomes had been realized in $t = 3, 5$, then $R_t = \{R_1 = 0, R_2 = 0, R_3 = 1, R_4 = 0, R_5 = 0\}$ and $\tau_n = \{\tau_1 = 3, \tau_2 = 5\}$. 
In the last period, the outcome from the final choice is always realized, $R_T = 1$. This feature is analogous to the end of a trading day, where the choice bracket is closed exogenously. In addition, we follow Barberis and Xiong (2012) in assuming that the decision maker derives utility from an outcome according to expression (1) only if the outcome was realized. The strong assumption that individuals only derive realization utility is made for simplicity; all results hold if we assumed that the utility derived from a realized outcome was greater than from a paper one.\(^{15}\)

### 7.1 Dynamics

We follow Barberis et al. (2001) to allow loss aversion $\lambda_t$ to depend on prior outcomes represented by $z_t$ and assume this dependence takes a linear form $\lambda(z_t) = \lambda \cdot z_t$, with $\lambda \geq 1$.\(^{16}\) The authors posit that a prior loss makes the decision maker more sensitive to subsequent losses.\(^{17}\) We take the baseline $z_t = 1$ if the prior outcome $x_{t-1}$ met expectations (equivalent to no prior outcome), and let $z_t > 1$ if the prior outcome was below expectations (a loss) and $z_t \leq 1$ if the outcome was above expectations (a gain). In turn, the decision maker appears more loss averse after a prior loss, a process termed sensitization.

Take $a = 1$ for simplicity. We examine the interplay between sensitization and realization in a choice problem with three periods, $t = 1, 2, 3$. Suppose a decision maker is indifferent between gambling or not in period $t = 1$, $\lambda(z_1) = \frac{\pi x^g}{x^l(\pi-1)}$, and breaks the indifference by choosing to gamble. The gamble results in a loss $x_1 = x^l$ that is not realized ($R_2 = 0$). Our first proposition follows:

**Proposition 1 (Paper Losses).** A decision maker who experiences a realized loss, ($R_t = 0$), will be more likely to take on risk than one who had not experienced a prior loss.

**Proof.** The decision maker takes the gamble if $\lambda(z_2) < \frac{\pi(x^g+x^f)}{x^l(2\pi-1)}$. Since the loss was not realized, $\lambda(z_2) = \lambda(z_1)$, and $\frac{\pi x^g}{x^l(\pi-1)} = \lambda(z_2) < \frac{\pi(x^g+x^f)}{x^l(2\pi-1)}$, the decision maker takes on more risk after a paper loss. \(\square\)

On the other hand, if the loss $x_1 = x^l$ was realized ($R_2 = 1$), then our framework makes a clear prediction:

\(^{15}\)Shefrin and Statman (1985) make the point that realizing losses at the closing of a mental account hurts more than the equivalent paper loss within a mental account. Similarly, Thaler (1999) writes “one clear intuition is that a realized loss is more painful than a paper loss.”

\(^{16}\)Barberis et al. (2001) set $\lambda_t = \lambda + k(z_t - 1)$ such that setting $k = 0$ reduces the model to the standard form.

\(^{17}\)Similarly, Thaler and Johnson (1990) suggest that “a prior loss might even sensitize people to subsequent losses of a similar magnitude (p. 657).” Participants in their experiments anticipated that a loss would hurt more after a prior loss than if it had occurred by itself, suggesting sensitization.
Proposition 2 \textit{(Realized Losses)}. A decision maker who experiences a realized loss, $(R_t = 1)$, will be less likely to take on risk than one who had not experienced a prior loss.

\textit{Proof.} Realization closes the choice bracket of prior outcomes and the prospect is evaluated independently. Without the motivation of erasing a loss with a possible gain, the decision maker strictly prefers not to take the gamble since $\lambda(z_2) > \lambda(z_1) = \frac{\pi x^9}{2^{(\pi-1)}}$.

Note that in the preceding analysis we have assumed that the decision maker is naive in the sense that he expects to evaluate each prospect with respect to a clean slate. Namely, he does not expect to integrate prior outcomes when evaluating future prospects. In any period $t$, the decision maker makes choices as if he will use the same value function (1) in $\{t + 1, ..., T\}$ as he did in $t = 1$. In our setup, a sophisticated decision maker indifferent between gambling in period $t + 1$ will always take the gamble in period $t$, regardless of the nature of the period $t$ outcome. This prediction is not supported by our experimental results in Section 3.

7.2 Example

7.2.1 Fixed Gable

Take a positive expected value gamble $\left(\frac{1}{3}, 2.5; \frac{2}{3}, -1\right)$. Suppose a decision maker makes choices over a sequence of 3 gambles. At each decision node (1, 2, 3), his choice is whether to accept the gamble or reject it. The sequence of gambles is depicted in Figure 1 below.

At node 1, the decision maker takes the gamble if $0 < \frac{1}{3}(2.5 - 0) + \frac{2}{3}\lambda(z_1)(-1 - 0)$ and does not take if the reverse inequality holds. Solving the inequalities, he takes the gamble if $\lambda(z_1) < \frac{5}{4}$. Take a decision maker whose $\lambda(z_1) = \frac{5}{4}$: he is indifferent between taking or leaving the gamble, and note that at node 1, $z_1 = 1$.

Assume the decision maker gambles when indifferent. He then learns the outcome (win or lose). In the second round (nodes 2a and 2b), he is offered the same gamble but his earnings from the first round are not realized. Particularly, the decision maker does not receive 2.5 if at node 2a and does not give up 1 if at node 2b. Given our framework, the prior outcome is coded as a \textit{paper} loss or gain, and the decision maker evaluates the second gamble as part of the same choice bracket as the first gamble. Particularly, he integrates the outcomes from the first gamble when considering the second prospect.

\footnote{For evidence on naivitè about future preferences in time discounting, see O’Donoghue and Rabin (1999) and Della Vigna and Malmendier (2006); for naivitè in predicting future tastes, see Loewenstein, O’Donoghue and Rabin (2003); for naivitè about future emotions, see Loewenstein (1996).}
At node 2b, the decision maker takes the gamble if $\lambda(z_2)(-1) < \frac{1}{3}(2.5-1) + \frac{2}{3}\lambda(z_2)(-1-1)$ and does not take it if the reverse inequality holds. Solving the inequality, he takes the gamble if $\lambda(z_2) < \frac{3}{2}$. Note that at node 2b, $z_2 = 1$. Hence, the decision maker is *more* likely to take the gamble at 2b than at 1.

At node 2a, the decision maker takes the gamble if $2.5 < \frac{1}{3}(2.5 + 2.5) + \frac{2}{3}(-1 + 2.5)$ and does not take it if the reverse inequality holds. Since the inequality always holds, the decision maker always takes the gamble at node 2a.

At node 3d the decision maker has lost twice and his position is realized – he parts with the $2$ he had lost. In our framework, he evaluates the gamble in a new choice bracket, taking it if $0 < \frac{1}{3}(2.5 - 0) + \frac{2}{3}\lambda(z_3)(-1 - 0)$ and not taking it if the reverse inequality holds.
As at node 1, the decision maker takes the gamble if $\lambda(z_3) < \frac{5}{4}$. But since $z_3 > 1$, a decision maker who was indifferent between taking the gamble at node 1 will not take the gamble at node 3d. Hence, the decision maker is more likely to take a gamble after a loss within a choice bracket (paper loss) and less likely to take a gamble after a loss when the choice bracket is closed (realized loss).

Since the decision maker would have realized an overall gain at nodes 3a, 3b and 3c, it is straightforward to show that he is more likely to take the gamble at those nodes than at node 1.

### 7.2.2 Fixed Loss Aversion

Take a positive expected value gamble ($\frac{1}{3}, k; \frac{2}{3}, -1$). The decision maker faces 3 gambling decisions in the same way as in the above section.

At node 1, the decision maker takes the gamble if $0 < \frac{1}{3}(k - 0) + \frac{2}{3}\lambda(z_1)(-1 - 0)$ and does not take it if the reverse inequality holds. Solving the inequalities, he takes the gamble if it offers a positive return $k > 2\lambda(z_1)$. Take a decision maker who is offered a gamble where $k = 2\lambda(z_1)$: he is indifferent between taking or leaving the gamble.

At node 2b, the decision maker takes the gamble if $\lambda(z_2)(-1) < \frac{1}{3}(k - 1) + \frac{2}{3}\lambda(z_2)(-1 - 1)$ and does not take it if the reverse inequality holds. Solving the inequality, he takes the gamble if $k > \lambda(z_2) + 1$. Note that at node 2b, $z_2 = 1$. Hence, the decision maker will be willing to take a gamble with a lower expected value at node 2b than at node 1 (since $\lambda(z_2) + 1 < 2\lambda(z_1)$).

It is straightforward to show that the decision maker will always be willing to take a gamble with a lower expected value at node 2a than at node 1.

Following the analysis from the above section, we can show that at node 3d the decision maker will only take a gamble with a higher expected value at node 3d than at node 1. Similarly, he will take a gamble with a lower expected value at nodes 3a, 3b and 3c than at node 1.