ABSTRACT

THE DESCRIPTION-EXPERIENCE GAP IN THE DOUBLE DOWN GAMBLE

by Christopher R. Fisher

Risk taking on the double down gamble was examined as a function of experience or descriptions. Participants attempted to win a fixed amount of hypothetical money by betting that a coin would land on heads within a predetermined number of trials. Risk increased as a function of trials while the expected value remained constant. Some received information tables of potential losses or probabilities while others experienced simulations. Based on studies that found underweighting of low probabilities when experienced, experiencing a win was hypothesized to increase risk taking. Describing the probability of winning resulted in the most risk taking. The other conditions did not differ from each other. Perceived risk was comparable to the control condition when losses were described or experienced but decreased when wins were experienced or probabilities were described. Degree of handedness and risk taking were not associated with doubling down.
THE DESCRIPTION-EXPERIENCE GAP IN THE DOUBLE DOWN GAMBLE

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Introduction

Choosing between monetary gambles represents a classic paradigm for examining decision making under risk. Monetary gambles encapsulate two essential characteristics of decision making. Much like decisions made outside of the laboratory, monetary gambles can be decomposed into (1) a set of possible outcomes for each alternative with each outcome associated with (2) a probability of actualizing. Decision making under this paradigm has been traditionally examined by presenting decision makers with a description of two alternatives, after which point they are prompted to choose between them. As an example of such a monetary gamble, consider the following:

A: $3, 100% chance
B: $4, 80% chance, otherwise $0

Abundant evidence indicates that in choosing among gambles, decision makers systematically deviate from the axioms set forth by normative models of decision making, such as Expected Utility Theory (Tversky & Kahneman, 1992). Although the following does not constitute an exhaustive review, three principle deviations have been observed. First, rather than weighting probabilities objectively, subjective probabilities follow a non-linear probability weighting function in which low probability events are over-weighted and high probability events are underweighted (Gonzalez, & Wu, 1999). A second finding is that the value of money is characterized by diminishing marginal utility whereby an additional momentary unit is subjectively valued less and less as one departs from $0 (Abdellaoui, Vossman & Weber, 2005). Finally, decision makers exhibit loss aversion—the tendency to weight a loss more than a gain of equal magnitude (Abdellaoui, Bleichrodt & Paraschiv, 2007). One influential descriptive model of decision-making that attempts to account for these deviations is Prospect Theory (Tversky & Kahneman, 1992).

The aforementioned findings are predicated on the assumption that simple descriptions of monetary gambles evoke the same psychological processes as learning them through experience, thereby resulting in similar patterns of choice. Recently, this assumption has been challenged by studies in which the payoffs of each gamble are acquired through experience rather than presented as descriptions of the payoff distributions (Barron, & Erev, 2003; Hau, Pleskac, Kiefer, & Hertwig, 2008). Although there are variations on this paradigm, each has in common one important feature: information is acquired through sequential sampling of the payoff distributions associated with each gamble rather than through description. Adopting the terminology used in Hertwig (2009), there are three variations of the experience-based paradigm. In the partial-feedback paradigm, decision makers sample from each gamble’s payoff distribution over repeated trials while receiving feedback and the obtained outcome after each trial. The full-feedback paradigm is identical to the partial-feedback paradigm, except the outcome of the forgone gamble is simultaneously presented. One important feature of full-and partial-feedback paradigms is that exploration is costly. Another important feature is that decisions are made repeatedly rather than at one time. This means its possible that repeated decision making differs from one shot decision making because risk can be diffused over the repeated trials. There is a potential danger that this difference could be confounded with learning from experience vs. given statements. Researchers have used an alternative paradigm to
circumvent these issues: the sampling paradigm. The sampling paradigm consists of two phases. During the exploration phase, decision makers sample freely while receiving immediate feedback. However, the outcomes obtained during the exploration phase do not apply to their account. The exploration phase is followed by a decision phase in which a one-shot decision is made. One shortcoming of this paradigm, however, is that the exploration phase is costly in terms of time.

Description Experience Gap

One general finding across these three experience-based paradigms is the apparent underweighting of low probability events, a finding that contradicts Prospect Theory (Barron, & Erev, 2003; Hertwig, 2009; Hau, Pleskac, Kiefer, & Hertwig, 2008; Yechiam, & Busemeyer, 2006). Other notable findings include the absence of loss aversion (Erev, Eyal, & Yachiam, 2009) and the reduction of the gambler’s fallacy (Barron, & Leider, 2009) when using the experience-based paradigm. These different choice patterns resulting from the use of the description and experience-based paradigms have been termed the description-experience gap (DEG) (e.g. Hertwig, 2009).

Although the DEG has been reliably observed as an empirical phenomenon, there is disagreement regarding the processes from which it is produced. Explanations can be broadly categorized according to whether the DEG is attributed to statistical or psychological processes. Unlike the precisely stated probabilities typified by description-based paradigms, experience-based paradigms are prone to random variation from sample to sample, a fact that is exacerbated by the small sample sizes (11-15 total) typically observed in the sampling paradigm (Hertwig, Barron, Weber, & Erev, 2004; Hau et al., 2008). When \( p \) is low, the binomial distribution is skewed such that under sampling of the rare event is more likely than oversampling, an effect that could account for the observed underweighting of rare events (Hertwig et al., 2004). As an example, consider a gamble in which the probability of a rare event is .10. Assuming a small sample size of 7, 18 out of 25 participants (72%) would never encounter the rare event. As such, the fact that most participants experience samples that differ from their underlying distributions could plausibly account for the DEG in its entirety.

Along these lines, Fox and Hadar (2006) obtained strong evidence that the DEG is a statistical phenomenon in their re-analysis of the original data from Hertwig et al. (2004). Prospect Theory accounted for 27% of the experience-based choices when the underlying probabilities were assumed. However, when the experienced probabilities were used instead, Prospect Theory was able to account for 69% of the choices, a proportion similar to that of the description condition. Additional support was obtained in a replication in which the experienced probabilities were estimated. The estimations were remarkably accurate, with a correlation of .97 between the estimated and experienced probabilities and a mean absolute error of .06.

Researchers have employed several other methods in attempt minimize the confounding effects of sampling error. Rokow, Demes, & Newell (2008) used yoked description controls who received the experienced outcomes in a variety of formats, such as sequential presentation, frequency format, probability format and reversed presentation. Across each of these formats, there was a high degree of correspondence in choice patterns between the experience-based condition and the yoked controls, suggesting a statistical interpretation of the DEG. Another
approach is to increase sample size in order to produce more representative samples that approximate their underlying distributions (Hau et al., 2008). Increasing payoffs by one order of magnitude lead to increased sample sizes and a corresponding reduction in sampling error. In particular, the median absolute difference between samples and their underlying distributions was reduced from 10.9 to 5.0 percentage points. A reduction in the DEG was observed (from 27 percentage points to 13), but was not entirely eliminated. Requiring a total sample size of 100 resulted in a further decrease in sampling error (3.3 percentage points). However, this requirement did not result in an incremental reduction of the DEG (17 percentage points) above and beyond that of increasing financial incentives.

Preference reversals have been observed using a within subjects design (Camilleri, & Newell, 2009). Although within subject designs do not in and of themselves reduce sampling error, it does allow for an examination of the DEG at the level of the individual. Participants chose between the same gambles on both paradigms with an intervening filler task. On average, participants exhibited preference reversals on 48% of the gambles, 73% of which were in the direction consistent with underweighting rare events when they were experienced. In order to examine the effects of sampling error, the experienced probabilities were sorted according to the magnitude of sampling error using a binning procedure. Consistent with a statistical interpretation of the DEG, their analysis revealed that participants were more likely to choose in accordance with Prospect Theory as their experienced probabilities approximated the underlying probabilities. One direct approach is to eliminate sampling error all together by creating a perfectly representative set of outcomes from which all outcomes are sampled without replacement (Ungemach, Chater, & Stewart, 2009). A reduction from 31 to 21 percentage points was observed, suggesting the DEG is not entirely a statistical phenomenon.

In terms of psychological explanations, the DEG may result from one of two memory phenomena. One possibility is that limitations in working memory capacity may restrict one to incorporating the most recently encountered outcomes into their probability judgments (Hau et al., 2008; Hertwig, 2004; Rakow et al., 2008). Similarly, a recency effect would exacerbate sampling error by biasing recall of outcomes to those that have been encountered most recently. According to these explanations, a recency effect should be most evident in studies that required large sample sizes. However, no evidence of a recency effect was found when the relative predictability of the first and second halves of the samples were compared (Ungemach et al., 2009; Hau et al., 2008). By contrast, a recency effect was observed when sampling was unrestricted and characteristically small (Hertwig, 2004). The critical factor appears to be whether the sampling process is passive, as when required sample sizes are imposed—or whether the sampling process is an active one (Rakow et al., 2008). Moreover, working memory capacity was not associated the tendency to rely more heavily on recently encountered outcomes.

A second psychological explanation posits that the DEG arises from biased judgments of the experienced probabilities. Whereas sampling error produces deviations from the underlying probabilities, biased judgment can result in distortions of the experienced probabilities. Underestimating rare events could, therefore, contribute to the DEG. As previously noted, estimates of experienced probabilities were remarkably accurate (Fox & Hadard, 2006). Using the median parameter estimates from Tversky & Kahneman (1992), Prospect Theory accounted for 63% of the data. On the other hand, others have found a slight bias in which low probability
events were overestimated rather than underestimated (Hau et. al., 2008). These results substantiate the interpretation that low probabilities are underweighted. Ungemach et al. (2009) found a similar pattern using frequency estimates: the frequency of rare events was slightly overestimated. Prospect theory was applied to the frequency estimates to predict participants’ choices. The best fitting parameters of the probability weighting function implied underweighting of rare events. Taken together, the examination of judgment bias tends to support the underweighting of rare events rather than account for the DEG.

**Double Down Gamble**

Although the overall pattern of results regarding the DEG is somewhat inconsistent, there appears to be sufficient evidence that the gap is more than a statistical artifact to warrant further investigation. The purpose of the proposed study is to extend previous research by comparing description and experience-based decision making on a different gamble called doubling down. Doubling down is a sub-gamble that is sometimes played during games such as black jack and roulette. As a simple illustration of doubling down, imagine that someone has accepted a gamble in which there are equal chances of winning or losing $50. Upon winning, a person receives $50, at which point the gamble ends. In the event of a loss, however, a person has two options: either pay $50 or ‘double down’ by doubling the previous gamble—in this case, a 50-50 chance to win or loss $100. Although the process of doubling down may in principle continue indefinitely, a maximum wager is often imposed to ensure that there is sufficient collateral to support a loss. As one progresses through trials, the losses accumulate. Consequentially, the amount one can potentially win is fixed. For example, if one wins in the third trial, the total winnings would be $200 minus the accumulated losses or $200-($50+$100) = $50. Although the amount one can win is fixed, the appeal of doubling down is that the cumulative probability of losing decreases exponentially over the course of more and more trials. Yet the catch is that the low probability of losing is associated with a potentially catastrophic loss. Thus, there is a commensurate tradeoff between escalating losses and the increasing probability of winning.

In more general terms, the doubling down gamble begins with a decision to enter a gamble in which there is a probability, p, of winning $x and a probability, 1-p, of losing $x dollars. As soon as one wins, the gamble is terminated. However, in the event that one loses, there are two options: terminate the gamble by paying the loss or proceed to the next trial in which the stakes are doubled. As one progresses through subsequent trials, the losses accumulate. Thus, if a win occurs, the net winnings equal the initial wager, $x, and is defined by $(x2^{t-1}) - (x(2^{t-1}-1)) = x$ for all t trials. The expected value on the tth trial is constant and is defined by the following equation:

$$E(x) = p2^{t-1}x - (1-p)2^{t-1}x$$

Rather than proceeding sequentially, it is possible to double down by committing in advance to a maximum of t potential trials. The expected value for playing the gamble up to t trials is zero and defined as:

$$E(x) = x(1-p^t) - xp^t(2^t-1) = 0$$

when $p = .50$. Although the expected value is zero for all t trials, doubling down entails more risk as trials increase (see Table 1).
Doubling down has several attractive features as a research paradigm. One notable feature is that it can be played according to one of two procedures, with each capable of addressing different issues. As previously noted, doubling down can be played in a sequential manner in which a decision to double down is made after observing each outcome. A sequential procedure is well suited for examining the sunk cost fallacy, as one may continue to play in attempt to recover a series of losses. Alternatively, doubling down can be played by committing to a particular number of trials in advance. The nature of the gamble is transformed into one that is characterized by the disjunctive probability of winning at some point over the course of t trials. In this case, the gamble pits two kinds of risk against one another, the potential amount lost vs. the probability of losing. Since risk increases as trials increase while holding constant the expected value, doubling down could be used to index risk taking.

It is worth noting the St. Petersburg Paradox, with which doubling down has several structural similarities in addition to several important differences. In the St. Petersburg Paradox, a person is presented with a gamble in which a coin is flipped until heads obtained, at which point the gamble is terminated (Samuelson, 1977), similar to doubling down. If the coin lands on heads on the first trial, 1 dollar is awarded. If the first obtained head occurs on the second trial, two dollars is awarded. If the first head is obtained on the third, four dollars is awarded and so on and so forth. Much like doubling down each additional trial increases the winnings by a factor of two while the probability of winning is decreases by a factor of two (if \( p = .50 \)), thereby producing a constant expected value on a trial-by-trial basis. Unlike doubling down, playing the St. Petersburg Paradox has the potential for an infinite number of trials, and by extension, has an infinite expected value, as shown below:

\[
E(x) = \sum_{i=1}^{\infty} 2^{-i} \cdot 2^i = \infty
\]

By contrast, doubling down has a constant, finite expected value over the course of n trials. One of the main distinguishing features of doubling down is the escalating quantities of money one must wager for the possibility of gaining \( Sx \), whereas the variable of interest in the St. Petersburg Paradox is how much one is willing to pay to enter.

**Hypotheses**

The primary objective of the present study was to investigate the DEG on the doubling down paradigm. Three description conditions and two experience conditions were employed. Rather than playing sequentially, participants committed to a specific number of trials (i.e. coin flips) in advance. This allows one to examine how risk taking may differ when the disjunctive probabilities are learned through experience versus presented as a description. In addition, several secondary objectives were undertaken. First, decisions were examined in relation to individual differences in risk taking and degree of handedness as a marker of interhemispheric interaction. Second, perceptions of risk were examined to see whether they varied according to experimental condition. Finally, potential losses, potential winnings and probabilities were examined to determine how each factored into participants’ decision making.

Beginning with the description conditions, a control condition described the structure of the doubling down gamble without an explicit description of losses or probabilities as a function of trials (see Appendix A). The purpose of this condition was twofold. First, behavior on the
doubling down paradigm has not been investigated in previous studies and is normally described without a tabulation of losses and probabilities in gambling situations. Thus, it was important to observe decision making on the doubling down paradigm without experimental manipulations. Second, it formed the basis upon which the remaining conditions were developed, as it was necessary to provide minimal information regarding the basic structure of doubling down, even in the experience conditions. The remaining two description conditions were formed by presenting additional loss and probability information separately. Participants are unlikely to be aware that probabilities and losses are nonlinear functions of trials. Thus, presenting loss and probability information separately allows one to determine independent influence of information that is not likely to be intuitive. These aspects of risk are likely to have differential influence on risk taking. While the total that one can win at any given round is fixed, the potential losses escalate as one commits to more trials. Including a table that juxtaposes this information should result in a reduction in the number of double down trials relative to controls, a condition that will be referred to as the description loss (DL) condition (see Appendix C). A second aspect of risk is the increasing disjunctive probability of winning as one commits to more trials. Relative to those in the control condition, an increase in the number of trials should occur when participants are presented with a table that juxtaposes the fixed amount of potential winnings to the increasing probability of winning. This condition will be referred to as the description probability (DP) condition (see Appendix B).

Two groups learned about the consequences of applying the double down strategy through experience with a trial run before they have to actually play "for keeps." These participants experienced the consequences of committing to five rounds of doubling down. Generally speaking, it is possible to experience two types of outcomes on the doubling down paradigm—one that results in a win and one that results in a loss. Relative to those in the control condition, those who experience a loss (EL) of five rounds in a row prior to playing should exhibit a reduction in risk taking, whereas those who experience a win in one of five rounds (EW) prior to playing should exhibit an increase risk taking (see Appendix D). Thus, what is being learned by experience is not the probability of winning in any one round. Rather, it is the disjunctive probability of winning at least one round in a series of five when the probability of losing each round is 0.5.

Each of the four experimental conditions was expected to differ from the control condition. Since the DL condition compares the potential constant winnings to escalating losses, it is reasonable to expect participants to commit to fewer rounds. Similarly, a reduction in trials to which participants commit should be observed after experiencing a loss. One the other hand, those in the DP condition, which emphasizes the increasing probability of winning as one commits to more rounds, should commit to more rounds. Most critically for the purpose of the proposed study, the experience and description conditions will be examined for the presence of a DEG. Experience is predicted to have more impact on risk taking than description. In particular, the EW condition is expected to promote risk taking than the DP condition, while the EL condition is expected to result in less risk taking than the DL condition. Taken together, these hypotheses imply the following ordinal relationship: EL < DL < Control < DP < EW.

Similar predictions can be made regarding perceptions of risk as a function of trials. Compared to those in the control condition, those in the EW and DP condition should perceive
risk as increasing at a slower rate as trials increase, whereas those in the DL and EW conditions should perceive risk as increasing at a faster rate as trials increase. Assuming these effects are stronger for the experience conditions than their description counterparts, the following ordering of slopes is implied: EL > DL > Control > DP > EW.

To the extent that committing to more rounds is indicative of risk taking, performance on the double down paradigm should correlate with established self-report measures risk taking. To address this possibility, the Domain-Specific Risk-Taking scale (DOSPERT) was administered (Blais & Weber, 2006). Risk taking is not a unidimensional construct. Instead, it varies across ethical, financial, health/safety, recreational and social domains. Financial risk taking includes investing in moderate growth stocks and gambling. Due to the high similarity to doubling down, financial risk taking should be correlated with the number of rounds to which one commits. Risk taking in the recreation domain may be correlated with doubling down, as both may involve some degree of thrill seeking. Correlations between the other domains and doubling down were not expected and thus were not investigated in the present study. It is possible that high risk takers will respond differently to the experimental conditions compared to low risk takers. The behavior of high risk takers is predicted to be invariant to the experimental manipulations. They will engage in risk taking regardless previous experience or the manner in which risk is communicated. On the other hand, the behavior of low risk takers is predicted to be sensitive to the experimental manipulations. For example, the increasing probability of winning described in the DP condition should increase risk taking.

Degree of handedness, as opposed to being right or left dominant, can account for some individual differences in risk taking (Christman, Japser, Varalakshmi, & Bruce, 2007). Mixed handers tend to focus on perceived risks and consequently engage in less risk taking. This holds true except in the domain of recreational risk in which they tend to be more risk seeking. The primary mechanism through which this is thought to occur is increased access to risk-sensitive right hemispheric processing through increased inter-hemispheric interaction. While degree of handedness may be related to doubling down through its common link to risk taking, it may account for other variability in doubling down.

Based on previous research, a general tendency for loss aversion should be observed in the double down gamble (Abdellaoui et al., 2007). However, the degree to which potential losses, potential wins and probabilities are factored into decisions should vary according to experimental condition. Given the emphasis on probabilities, those in the DP condition should assign more weight to probabilities compared to the other conditions. Those in the EL and DL conditions should display more loss aversion compared to the other conditions while those in the EW condition should weight potential winnings more than those in the other conditions.

Methods

Participants

One hundred forty participants were recruited from the introductory psychology participant pool in exchange for partial course credit. Since doubling down has not been examined in previous studies, there was no basis for performing a power analysis. However, using 25 participants per condition or more should allow for the detection of medium effect sizes.

Design
The present study used a 1X5 between-subjects design, consisting of three description conditions and two experience conditions. A control condition described the structure of the double down gamble and served as a basis for the remaining four experimental conditions. In addition to the control condition, a second description condition included a tabulation of probabilities as a function of trials while a third description condition included a tabulation of losses as a function of trials. One experience condition resulted in a win while the other resulted in a loss.

**Materials**

The instructions for each condition were based on those in the control condition, which simply described how to double down and the procedures common to each condition. The instructions for the other conditions differed only with respect to their inclusion of the description or experience manipulations. Thus, the following was common to each condition:

The instructions asked participants to imagine they are presented with the opportunity to play doubling down while at a casino and were instructed to make their decisions as though the money is real (see Appendix A). Participants decided how many times to flip a coin until heads was obtained, which constituted a win. The gamble began with a 50-50 chance to win $500 dollars and continued until a won occurred or the coin flips were exhausted. Each time a loss occurred (tails), the stakes were doubled on the subsequent coin flip and losses accumulated throughout the process. When a won occurred at any point throughout this process, a total of $500 was won after paying previous losses. Participants were told that they had $127,500 in their savings account and that the casino instated a limit of 8 trials, which was imposed to ensure that participants could pay $127,500 in the event that all 8 trials were lost. They were told that after playing the gamble, their total assets would be computed by adding winnings to or subtracting losses from the $127,500 in the savings account. To give participants some incentive for treating the hypothetical money like real money, the resulting assets were converted to lottery tickets that were submitted to a lottery for a $50 gift certificate. The instructions emphasize that the more money they have after playing, the higher their chance of winning the lottery. Participants then committed to 0-8 coin flips. Those who did not want to play were able to specify zero coin flips, in which case the $127,500 will be directly converted to lottery tickets.

The instructions for the DL condition included a table with the net total one can win in a specific trial (which is always $500) and the amount one could lose in the specified trial (see Appendix C). An example was provided to illustrate how to interpret the table. The instructions for the DP condition included a similar table, except the disjoint probability of winning within a specified number of rounds will be presented. An example was also provided to clarify the interpretation of the table. Finally, the instructions for the EW and EL conditions explained that they would observe a simulated play of five rounds so that can get a feel for the gamble.

The DOSPERT is a 30 item scale that measures risk taking across five domains in which individuals tend to differ: ethical, financial, health/safety, recreational and social (see Appendix E). The Edinburgh Handedness Inventory was used to measure degree of handedness (see Appendix F).

**Procedure**

Participants were seated individually at computers where they completed each task. A randomized block design consisting of five blocks of 25 participants was used to ensure equal
allocation of participants to conditions. After reading the instructions, participants decided how many coin flips they would like to play. Participants were told that the outcomes were determined by a virtual coin flip based on a random number generator. In reality, each participant won on the first trial, unless zero trials were specified. Before making a decision, those in the EW and EL condition experienced one simulation of 5 trials. A fixed sequence of outcomes was used in both experience conditions. In the EW condition, the following sequence was used: Lose, Win, Lose, Lose Win. After encountering the first win, participants were informed that the gamble would normally be terminated at that point. However, the remaining three flips will be performed to see what the outcomes would have been otherwise. A sequence of five losses was displayed in the EL condition. Upon completing the gamble, participants rated the perceived risk of doubling down for each number of coin flips on a Likert scale ranging from 1 to 10 such that higher ratings indicated more perceived risk. Next, they indicated the extent to which potential losses, potential winnings and the probabilities factored into their decisions. The DOSPERT was then administered, followed by the Edinburgh Handedness Inventory.

Results

Double Down

To test the predicted pattern of means for the number of coin flips to which participants committed, the following contrast was used: Experience Loss (-2), Description Loss (-1), Control (0), Description Probability (1) and Experience Win (2). While the contrast was significant $F(1, 135) = 9.32, p = .003$, the residual variability was also significant $F(3, 135) = 3.67, p = .014$, indicating that the contrast did not adequately describe the data. Post hoc comparisons using Tukey’s HSD revealed that the number of flips in DP condition was significantly higher than the other conditions ($p$’s < .01), except the EW condition ($p = .124$). Moreover, the control, DL, EW and EL conditions did not differ significantly from each other ($p$’s > .43; see Table 2).

Perceptions of Risk

Perceptions of risk as a function of trials (0-8) were analyzed using a linear interaction contrast. The following weights were applied to the linear contrasts according to condition: Experience Loss (2), Description Loss (1), Control (0), Probability Win (-1) and Experience Win (-2), with higher weights indicative of steeper slopes and thus more perceived risk. The linear interaction contrast was significant, $F(1,135) = 28.68, p < .001$. However, a test of the residual variability revealed significant departures from the predicted linear relationships, $F(31,135) = 6.32, p < .001$. As shown in Table 3, the control, DL and EL conditions trended in a linear fashion while the DP and EW conditions exhibited a sharp upwards trend from zero to one flips followed by a relatively flat slope. The sharp increase in perceived risk between zero and one flips in the DP and EW conditions most likely reflects the qualitative difference between assuming no risk and assuming some risk. It could be argued that the perceived risk for zero flips does not reflect the risk associated with doubling down per se and should be excluded from the analyses. However, excluding perceived the risk for zero flips yielded similar results.

Self-Reported Risk Taking

Two subscales of the DOSPERT—recreational risk and financial risk—where entered into a regression to determine whether self-reported risk was associated with the number of trials that participants selected. Overall, the model was a poor fit to the data, only accounting for 0.8% of the variability in trials, $F(2,128) = .52, p = .60$. Further inspection revealed that neither
recreational risk \( (b = .090, t(128) = .96, p = .34) \) nor financial risk \( (b = .062, t(128) = -.66, p = .58) \) was predictive of the number of trials chosen. In several cases, the perceived risk did not increase monotonically as a function of trials. For this reason, recreational and financial risk was used to predict the perceived risk associated with each participant’s decision. However, recreational risk \( (b = -.155, t(128) = -1.66, p = .10) \) and financial risk \( (b = .092, t(128) = .98, p = .33) \) were not predictive of the perceived risk associated each participant’s decision, \( F(2,128) = 1.478, p = .23, R^2 = .023 \). To explore the possibility that the relationship between risk taking and trials as well as the perceived risk differed by condition, the two subscales were combined to form a composite measure of risk and regression were performed individually for each condition. The results reveal no differences by condition for flips \( (p’s > .55) \) and the perceived risk of each participant’s decision \( (p’s > .29) \). Participants were dichotomized into low and high-risk takers by performing a median split on their composite risk scores. Low risk takers were not more responsive to the experimental manipulations compared to high risk takers, as evidenced by the non-significant condition by risk taking interaction, \( F(4,130) = .44, p = .78 \).

**Degree of Handedness**

Contrary to predictions, the relationship between degree of handedness and number of coin flips was not observed, \( b = .082, t(138) = .97, p = .34 \). The same held true when the perceived risk of the decision was examined in relation to degree of handedness, \( b = .058, t(138) = .69, p = .49 \). However, as in previous research (Christman, et al., 2007), mixed handers tended to be more risk seeking than dominant handers in the financial and recreation risk domains, \( b = -.258, t(138) = 3.14, p = .002 \).

**Self-Reported weightings**

Self-reported weightings of probability, potential winnings and potential losses were entered into a regression to determine the extent to which they factored into participants’ decisions. Across all conditions, the model accounted for 12% of the variance in the number of flips chosen, \( F(3,133) = 6.30, p < .001 \). The weighting of potential losses was inversely related to number of flips, \( b = -.34, t(133) = -4.05, p < .001 \), whereas the weighting of potential winnings was associated with more trials, \( b = .203, t(133) = 2.33, p = .021 \). Unlike previous research, potential losses were not weighted more than potential gains, \( t(133) = 1.43, p = .15 \). Contrary to predictions, potential losses were not weighted more in the DL condition \( (t(52) = -1.63, p = .109) \) or EL condition \( (t(52) = .14, p = .890) \) compared to the control condition; probability was not weighted more in the probability description condition compared to the control condition, \( t(52) = .24, p = .81 \); and potential winnings were not weighted more in the experience win condition compared to the control condition, \( t(52) = -2.68, p = .009 \).

**Discussion**

In the present study, the existence of a DEG was investigated in the double down gamble. Participants decided in advance to flip a virtual coin a specified number of times. The gamble was structured such that committing to more flips entailed more risk as defined in terms of payoff variability, while holding constant the expected payoff. All participants received a basic description of the double down gamble. While some received additional information describing either the probability of winning or potential losses as a function of trials, others experienced either a win or loss prior to making a decision. Compared to the control condition, the DP and
EW conditions were expected to increase trials whereas the DL and EL conditions were expected to decrease trials. Based on previous research regarding the DEG, the aforementioned effects were expected to be stronger for the experience conditions compared to their description counterparts.

The expected DEG was not found. To the contrary, tabulating the probability of winning as a function of trials encouraged the most risk taking and the other conditions did not differ appreciably from each other. One possible reason is that participants were aware that losses escalated exponentially but were not aware of the relationship between probabilities and trials. For example, committing to only four trials ensured nearly a 94% chance of winning, which may be counter-intuitive. However, this explanation remains speculative because probability judgments were not obtained in the control condition.

One surprising finding was that doubling down was unrelated to risk taking in the financial and recreational risk domains as measured by the DOSPERT. No relationship was observed even when the perceived risk of the decisions was used as an alternative measure or risk taking. It could be argued that the complex nature of doubling down obscured the relationship between risk and trials. However, there is partial evidence against this argument. The lack of relationship between doubling down and risk taking was present for conditions in which perceived risk increased in a linear fashion. Another remaining explanation exists: it is possible that participants were not aware that the expected payoff was constant—in which case risk and expected payoff would have been confounded.

Although the expected DEG was not observed, perceptions of risk differed markedly by condition. Emphasizing the downside risk in the DL and EL conditions had no appreciable effect on risk perceptions with respect to the control condition. On the other hand, the emphasis on upside risk in the EW and DP conditions nullified the linear relationship that was observed in the control condition. Perceived risk was relatively constant across trials for these conditions.

Unlike previous research on loss aversion, self-reports indicated that in general participants did not place more weight on potential losses than potential winnings (Abdellaoui, Bleichrodt & Paraschiv, 2007; Tversky & Kahneman, 1992). Interestingly, the weighting of potential losses, potential winnings and probabilities did not differ by condition. For example, it seemed reasonable to expect probabilities to receive more weight in the DP condition. One limitation of these finding is the possibility that self-reports do not accurately reflect the decision processes that were employed.

**Limitations**

Due to limitations in methodology, the findings in the present study must be interpreted with caution. As with many previous studies, one problem is that experience was not representative of the underlying distribution of outcomes. Even if experiences were representative, there is reason to suspect that working memory limitations would become an issue, as the present study would require 256 samples. Another issue is that the experiences may not have been credible, especially for those in the EL condition for which the probability of five successive losses is about 3%.
Future Research

To address these issues, the following recommendations are made for future research. First, one way to ensure a representative experience would be to require participants to sample without replacement from the payoff distributions associated with each number of trials (Ungemach, Chater, & Stewart, 2009). Working memory limitations could be minimized by reducing the number of trials from eight to four. As a consequence, the number of simulations could be reduced from 256 to 16. Second, a full description condition is recommended, one that includes a tabulation of losses, probabilities and expected values. Including the expected values would eliminate the possible confound of expected payoff with risk. Moreover, using a full description condition would allow more comparability to previous studies that used simple gambles. Third, to address the issue of credibility, participants should be asked to rate the credibility of the simulations after rendering their decisions. Credibility ratings could be used as a covariate to control for unwanted differences. Finally, those in the experience condition should estimate the parameters for doubling down, such as probabilities, expected payoffs, winnings and losses. Doing so allows one to explore the possibility that the DEG, should one be found, is a product of biased judgment rather than differences in subjective probability weighting or utility.

Conclusion

Despite the limitations inherent in the present study, doubling down is a versatile and well-controlled paradigm. The following properties make doubling down ideal for studying decision making under risk. Unlike the Balloon Analogue Risk Task (Lejuez et al., 2002), risk increases while holding the expected value constant. Thus, risk is not confounded with expected value in doubling down and thus provides a more pure index of risk taking. Another important feature is the constant net winnings. This ensures that net winnings are not confounded with risk. The reference point can be manipulated to include or exclude the loss domain. In the present study, the reference point was the status quo, meaning that participants chose between $0 or doubling down with the potential for a loss. Doubling down can be played entirely in the gain domain by presenting a choice between $X dollars and $X in addition to doubling down, such that $x is sufficiently large to produce outcomes greater than $0. Doubling down can be played sequentially or by making a binding decision to play a maximum number of trials. Sequential decisions are well suited for studying the time course of decision making and the sunk cost fallacy, whereas binding decisions are well suited for studying disjunctive probabilities. Finally, information can be information can be presented either as tabular descriptions or acquired through experience.
References


Instructions for the Control Condition

Imagine that while you are at a casino you are presented an opportunity to play a gamble called doubling down. To make it as realistic as possible, imagine that the decision you make is based on real money. Here is how doubling down works: you must commit to a number of times you would like to flip a coin until it lands heads. As soon as it lands on heads, you win $500 and the gamble ends. If the coin lands on tails, you lose $500 and you double down on the next flip. This means the gamble is repeated, but the stakes are doubled. Each time you lose the stakes double from the previous coin flip and your losses accumulate. If at any point you win, the gamble ends and you will have $500 left over after you pay your previous losses. Based on the $127,500 in your savings account, the casino has calculated that you have exactly enough to play up to 8 times.

Your task is to determine in advance how many times you will commit to flipping the coin. The computer will play until you either win or the coin has been flipped the number of times you specified. Your total assets will be calculated by adding you winnings to or subtracting your losses from the $127,500 you have in your savings account. At the end of the gamble, your total assets will be converted to lottery tickets that will be placed in a drawing for a $50 gift certificate. If you choose not to play, the $127,500 will be converted directly to lottery tickets. Notice that the more total assets you have, the more tickets you will have and the greater chance you will have at winning the lottery. Once you enter the number of coin flips you want to commit to, the computer will perform the gamble by flipping a virtual coin. You will see the the results of each round if you decide to play.
Appendix B

Instructions for the Description Probability Condition

Imagine that while you are at a casino you are presented an opportunity to play a gamble called doubling down. To make it as realistic as possible, imagine that the decision you make is based on real money. Here is how doubling down works: you must commit to a number of times you would like to flip a coin until it lands heads. As soon as it lands on heads, you win $500 and the gamble ends. If the coin lands on tails, you lose $500 and you double down on the next flip. This means the gamble is repeated, but the stakes are doubled. Each time you lose the stakes double from the previous coin flip and your losses accumulate. If at any point you win, the gamble ends and you will have $500 left over after you pay your previous losses. Based on the $127,500 in your savings account, the casino has calculated that you have exactly enough to play up to 8 times.

The table below shows the total amount you can win at a certain round and the chance of losing each round up to that point. According to the table, the total you can win in the third round, as in all other rounds, is $500. If you commit to playing 3 rounds, the chance of winning is 87.5% or a 7 in 8 chance. Notice that for each additional round you commit to, the chance of losing is cut by half. If you commit to doubling down on up to 8 rounds your chance of winning $500 is 255 out of 256.

Your task is to determine in advance how many times you will commit to flipping the coin. The computer will play until you either win or the coin has been flipped the number of times you specified. Your total assets will be calculated by adding you winnings to or subtracting your losses from the $127,500 you have in your savings account. At the end of the gamble, your total assets will be converted to lottery tickets that will be placed in a drawing for a $50 gift certificate. If you choose not to play, the $127,500 will be converted directly to lottery tickets. Notice that the more total assets you have, the more tickets you will have and the greater chance you will have at winning the lottery. Once you enter the number of coin flips you want to commit to, the computer will perform the gamble by flipping a virtual coin. You will see the results of each round if you decide to play.

<table>
<thead>
<tr>
<th>Number of Coin Flips</th>
<th>Total Amount that could be won</th>
<th>Chance of Winning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0</td>
<td>100% to win $0</td>
</tr>
<tr>
<td>1</td>
<td>$500</td>
<td>50% or 1/2</td>
</tr>
<tr>
<td>2</td>
<td>$500</td>
<td>75% or 3/4</td>
</tr>
<tr>
<td>3</td>
<td>$500</td>
<td>87.5% or 7/8</td>
</tr>
<tr>
<td>4</td>
<td>$500</td>
<td>93.75% or 15/16</td>
</tr>
<tr>
<td>5</td>
<td>$500</td>
<td>96.88% or 31/32</td>
</tr>
<tr>
<td>6</td>
<td>$500</td>
<td>98.438% or 63/64</td>
</tr>
<tr>
<td>7</td>
<td>$500</td>
<td>99.219% or 127/128</td>
</tr>
<tr>
<td>8</td>
<td>$500</td>
<td>99.61% or 255/256</td>
</tr>
</tbody>
</table>
Appendix C

Instructions for the Description Loss Condition

Imagine that while you are at a casino you are presented an opportunity to play a gamble called doubling down. To make it as realistic as possible, imagine that the decision you make is based on real money. Here is how doubling down works: you must commit to a number of times you would like to flip a coin until it lands heads. As soon as it lands on heads, you win $500 and the gamble ends. If the coin lands on tails, you lose $500 and you double down on the next flip. This means the gamble is repeated, but the stakes are doubled. Each time you lose the stakes double from the previous coin flip and your losses accumulate. If at any point you win, the gamble ends and you will have $500 left over after you pay your previous losses. Based on the $127,500 in your savings account, the casino has calculated that you have exactly enough to play up to 8 times.

The table below shows the probability of losing a specified number of rounds. According to the table, the total you can win in the third round, as in all other rounds, is $500. If you commit to playing 3 rounds, there is a possibility that you could lose $3,500. Notice that for each additional round you commit to, the amount you could lose nearly doubles each time.

<table>
<thead>
<tr>
<th>Number of Coin flips</th>
<th>Total Amount that could be won</th>
<th>The amount you could lose</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>1</td>
<td>$500</td>
<td>$500</td>
</tr>
<tr>
<td>2</td>
<td>$500</td>
<td>$1,500</td>
</tr>
<tr>
<td>3</td>
<td>$500</td>
<td>$3,500</td>
</tr>
<tr>
<td>4</td>
<td>$500</td>
<td>$7,500</td>
</tr>
<tr>
<td>5</td>
<td>$500</td>
<td>$15,500</td>
</tr>
<tr>
<td>6</td>
<td>$500</td>
<td>$31,500</td>
</tr>
<tr>
<td>7</td>
<td>$500</td>
<td>$63,500</td>
</tr>
<tr>
<td>8</td>
<td>$500</td>
<td>$127,500</td>
</tr>
</tbody>
</table>

Your task is to determine in advance how many times you will commit to flipping the coin. The computer will play until you either win or the coin has been flipped the number of times you specified. Your total assets will be calculated by adding you winnings to or subtracting your losses from the $127,500 you have in your savings account. At the end of the gamble, your total assets will be converted to lottery tickets that will be placed in a drawing for a $50 gift certificate. If you choose not to play, the $127,500 will be converted directly to lottery tickets. Notice that the more total assets you have, the more tickets you will have and the greater chance you will have at winning the lottery. Once you enter the number of coin flips you want to commit to, the computer will perform the gamble by flipping a virtual coin. You will see the results of each round if you decide to play.
Appendix D

Instructions for Both Experience Conditions

Imagine that while you are at a casino you are presented an opportunity to play a gamble called doubling down. To make it as realistic as possible, imagine that the decision you make is based on real money. Here is how doubling down works: you must commit to a number of times you would like to flip a coin until it lands heads. As soon as it lands on heads, you win $500 and the gamble ends. If the coin lands on tails, you lose $500 and you double down on the next flip. This means the gamble is repeated, but the stakes are doubled. Each time you lose the stakes double from the previous coin flip and your losses accumulate. If at any point you win, the gamble ends and you will have $500 left over after you pay your previous losses. Based on the $127,500 in your savings account, the casino has calculated that you have exactly enough to play up to 8 times.

Your task is to determine in advance how many times you will commit to flipping the coin. The computer will play until you either win or the coin has been flipped the number of times you specified. Your total assets will be calculated by adding your winnings to or subtracting your losses from the $127,500 you have in your savings account. At the end of the gamble, your total assets will be converted to lottery tickets that will be placed in a drawing for a $50 gift certificate. If you choose not to play, the $127,500 will be converted directly to lottery tickets. Notice that the more total assets you have, the more tickets you will have and the greater chance you will have at winning the lottery. Once you enter the number of coin flips you want to commit to, the computer will perform the gamble by flipping a virtual coin. You will see the results of each round if you decide to play. Before you make your decision, you will be given an opportunity to see 5 computerized coin flips. This will allow you to get a feel for what it's like to play the double down gamble before you play with money.
Appendix E

Domain-Specific Risk-Taking Scale

Instructions: For each of the following statements, please indicate the likelihood that you would engage in the described activity or behavior if you were to find yourself in that situation. Provide a rating from Extremely Unlikely to Extremely Likely, using the following scale:
1 (Extremely Unlikely), 2 (Moderately Unlikely), 3 (Somewhat Unlikely), 4 (Unsure), 5 (Somewhat Likely), 6 (Moderately Likely), 7 (Extremely Likely)

1. Admitting that your tastes are different from those of a friend. (S)
2. Going camping in the wilderness. (R)
3. Betting a day’s income at the horse races. (F)
4. Investing 10% of your annual income in a moderate growth mutual fund. (F)
5. Drinking heavily at a social function. (H/S)
6. Taking some questionable deductions on your income tax return. (E)
7. Disagreeing with an authority figure on a major issue. (S)
8. Betting a day’s income at a high-stake poker game. (F)
9. Having an affair with a married man/woman. (E)
10. Passing off somebody else’s work as your own. (E)
11. Going down a ski run that is beyond your ability. (R)
12. Investing 5% of your annual income in a very speculative stock. (F)
13. Going whitewater rafting at high water in the spring. (R)
14. Betting a day’s income on the outcome of a sporting event (F)
15. Engaging in unprotected sex. (H/S)
16. Revealing a friend’s secret to someone else. (E)
17. Driving a car without wearing a seat belt. (H/S)
18. Investing 10% of your annual income in a new business venture. (F)
19. Taking a skydiving class. (R)
20. Riding a motorcycle without a helmet. (H/S)
21. Choosing a career that you truly enjoy over a more secure one. (S)
22. Speaking your mind about an unpopular issue in a meeting at work. (S)
23. Sunbathing without sunscreen. (H/S)
24. Bungee jumping off a tall bridge. (R)
25. Piloting a small plane. (R)
26. Walking home alone at night in an unsafe area of town. (H/S)
27. Moving to a city far away from your extended family. (S)
28. Starting a new career in your mid-thirties. (S)
29. Leaving your young children alone at home while running an errand. (E)
30. Not returning a wallet you found that contains $200. (E)

Note. E = Ethical, F = Financial, H/S = Health/Safety, R = Recreational, and S = Social.
 Appendix F

Edinburgh Handedness Inventory

1. Writing
2. Drawing
3. Throwing
4. Scissors
5. Comb
6. Toothbrush
7. Knife (without fork)
8. Spoon
9. Hammer
10. Screwdriver
11. Tennis Racket
12. Knife (with fork)
13. Cricket bat (lower hand)
14. Golf Club (lower hand)
15. Broom (upper hand)
16. Rake (upper hand)
17. Striking Matching (match)
18. Opening box (lid)
19. Dealing cards (card being delt)
20. Threading needle (needles or thread according to which moves)
21. Which foot do you prefer to kick with?
22. Which eye do you use when using only one?
Table 1. Risk by Trials: defined in terms of the standard deviation of payoff as a function of trials when x = $500, p = .50 and t = {1, 2, … 8}
Table 2. Mean Trials by Condition.
Table 3. Perceived Risk by Condition

![Graph showing perceived risk by condition across different coin flip counts.]