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# When to Walk Away and When to Risk It All

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## Abstract

While one might expect athletes to be strongly averse to extending their career too long when there is a chance of losing everything due to a concussion or a catastrophic injury, experimental subjects consistently played longer than the optimal amount for risk-neutral decisions. A commitment to the length of play in advance, as in the case of long-term contracts, led to a greater chance of staying beyond the expected payoff-maximizing point. If the decision frame is altered so that decisions are made in each period rather than through an upfront commitment, the magnitude of potential losses is more evident.

## Keywords

risk, concussion, loss aversion, framing, commitment, long-term contracts

When he retired at age 24, former San Francisco linebacker Chris Borland remarked:

I'm concerned if you wait [until] you have symptoms, it's too late. There are a lot of unknowns. I can't claim that "X" will happen. I just want to live a long healthy life, and I don't want to have any neurological diseases or die younger than I would otherwise. (Florio, 2015)

The hazards of concussions to participants in contact sports highlight the difficult choices involving efforts to balance substantial rewards against risks of permanent,

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irreversible outcomes. Athletes in sports posing concussion risks or other catastrophic health risks must assess whether or not they should continue to play contact sports and risk suffering irreparable brain damage or other devastating effects. Nowhere else has this type of decision been more publicized than in the case of concussion risks to players in the National Football League (NFL). Several players have retired citing concerns regarding concussions. While past players have retired citing health-related concerns, the recent wave of retirements in the face of prospective concussion risks is proactive, rather than reactive. Many players fear waiting until concussion symptoms appear, dreading that, by the time symptoms do manifest, it will be too late.

The incentivized experiment in this article simulates the type of decisions that NFL players and other athletes in contact sports must confront—whether to continue their career at the risk of suffering a concussion, or in extreme cases, irreparable brain damage, or whether to quit and walk away with their current earnings and mind still intact. Analogous challenges are posed by other sports-related fatality risks. To examine whether players prolong their careers past the optimal stopping point, this article employs a financial risk structure that has the same general characteristics as actual athletes' decisions. Whether people make optimal stopping decisions in situations in which an adverse outcome could lead to losing all accumulated winnings to date can also arise in financial and gambling contexts. The experiment presents participants with a multistage “win or lose it all” risk structure in which they must decide how many rounds of a lottery they wish to play before walking away. With each win, participants earn more money toward their bank. Just one loss, however, results in the participant losing everything accumulated up to that point and the termination of play. The scenario consequently incorporates the structure of extreme situations in which catastrophic injuries lead to death and the distinctive challenges posed by risks with dire personal and financial consequences.

How people make decisions within the context of this structure draws on elements from rational choice models and behavioral economics. Increasing the likelihood of a successful outcome increases the attractiveness of a risky decision, consistent with standard economic models. Behavioral influences also intrude as in other sports economics contexts. Participants in our experiments may be subject to a “hot hand” effect, whereby they overestimate the chance of long-term survival as the number of successful trials increases. Thus, the nature of the hot hand influence here is not whether there a hot hand effect exists such as whether basketball players are really on a hot free throw shooting streak as in Arkes (2013). Instead, the issue is whether outside observers of a streak of successes believe that a hot hand effect underlies the streak, making them more likely to believe that the prospects of continued success are greater. The nature of the hot hand influence in this analysis resembles beliefs by bettors in major tennis tournaments that overestimate the future odds of success for past winners (Abinzano et al., 2017) and by people who bet on winning streaks against the spread for NFL games (Paul et al., 2014).

The most consequential behavioral consideration in the experimental situation considered here may be the influence of framing effects. Within the context of this

game in which an unsuccessful outcome leads to losing it all, we examine how the framing of the risk decision affects the chosen strategy. In particular, how is behavior affected by different levels of commitment, which in turn influence the framing of the choices? In one game of the experiment, the risks are framed as round-by-round decisions, where individuals are free to make decisions as they proceed through the game (the “no commitment” game). Thus, the individual must make a separate decision in each round, cognizant of both the prospects of continuing play and the rewards to date that will be lost with an unsuccessful outcome. For the other game of the experiment, participants must commit in advance to how many rounds they wish to play (the “upfront commitment” game). In this game, there is only a single global decision involving how many periods of play will be selected. An upfront commitment to play the game for a specified number of rounds is analogous to players signing and committing to fulfill the terms of a long-term contract. In each instance, there is a specified period of play. Catastrophic injuries can lead to termination of play and, for the extreme injuries considered here, a complete loss of well-being. The main simplification is that the only information that is provided in the experiment is the occurrence of an extreme outcome. While there is not a series of concussion protocols that provide limited information over time, that is true for all experimental structures considered, making it possible to focus on the implications of upfront versus decisions without a commitment and the broader context of the potentially fatal decisions. The main issue explored with the incentivized experiment is whether making an upfront commitment leads to a different pattern of behavior than round-by-round decisions for lottery structures involving an extreme situation in which there is no opportunity to revise the decisions based on the acquisition of unfavorable information about the risk.

From the standpoint of rational economic models, the framing of the choices should be irrelevant. Upfront commitments and choices made after each round should lead to identical outcomes. No unfavorable learning takes place, as the first unfavorable outcome leads to termination of the game. And the payoff structure that will prevail after surviving in each round is fully known in advance. However, the manner in which risks are structured and framed can have a tremendous impact on how individuals make decisions regarding these risks (Tversky & Kahneman, 1981). While the potential importance of framing effects is well-established, predicting the impact of frames *ex ante* is often challenging. In our experiment, the sequential choices made within rounds are also accompanied by information about the current level of the player’s funds. Providing this information makes the potential losses more salient. To the extent that the information about the current level of funds establishes a reference point for considering additional gambles, the behavior in the no commitment scenario is also consistent with Kahneman and Tversky’s (1979) prospect theory. In that model, individuals display loss aversion, as they assess their expected utility relative to a reference point which in the case of our experiment, is the level of the subject’s current assets in the game. In other sports contexts,

researchers have found that reference points such as whether the golfer is above or below par on a particular hole (Stone & Arkes, 2016) are influential.

The importance of decision framing has also led to a variety of different ways in which economists have sought to measure risk aversion, as the different approaches can produce varying estimates (Carbone et al., 2017; Crosetto & Filippin, 2016). Among some of the most popular tasks are those that involve a choice between paired lotteries (Holt & Laury, 2002), investment decisions (Gneezy & Potters, 1997), and the Bomb Risk Elicitation Task (BRET; Crosetto & Filippin, 2013). While our experimental design has some components of these past risk elicitation tasks, the experiment presented in this article has a unique structure and a different purpose, as is discussed further below. Our intent is not to develop a measure of risk aversion as in several of these articles but to assess how the framing of time and decisions affects performance and rationality.

We find that participants play more rounds when presented with an upfront commitment than when faced with no commitment. In fact, participants typically exhibit risk-seeking behavior under the upfront commitment scenario by playing more than the optimal risk-neutral number of rounds. The only exception was when the chance of success was so high that there was only a single potential decision round beyond the optimal risk-neutral number of rounds. Under the no commitment scenario, participants average fewer rounds played than the risk-neutral amount, indicating risk-averse behavior. Based on the difference in the decision structure, we suggest that loss aversion within the context of the decision frame is one source of this difference in behavior.

Looking beyond the mean values of the data provides an additional perspective on whether participants play too long. In a majority of this experiment's scenarios, a significant portion of participants play more rounds than is optimal or predicted under the assumption of risk neutrality. This is true even for the no commitment game in which the average number of rounds played was far below the risk-neutral amount. If people are risk-averse, the optimal stopping point should be even earlier so that the errors that people make in playing too long are even greater than indicated in the experimental results below, which are based on the optimal stopping point for risk-neutral players.

Experimental Design section describes the details of the experiment, the subject population, and the ways in which the experiment in this article differs from other experimental structures that may share some similar components. A chief difference is that our focus is on whether people choose to stop sufficiently soon and how the decision frame affects performance. The theoretical framework that motivates the hypothesis is detailed in Theoretical Framework section. The principal framing aspect is that the quit or risk losing it all decision could be made separately in each round or based on an upfront commitment. While standard economic models would view these decisions as equivalent, the framing of the decisions is quite different, as is the subsequent behavior. Results and Analysis section discusses the basic results of the experiment and reports on the tests of the hypothesis. While some participants choose

to walk away in a timely manner, most stayed on too long except when the chance of success was so great that there was little chance of failing to quit in a timely manner.

## Experimental Design

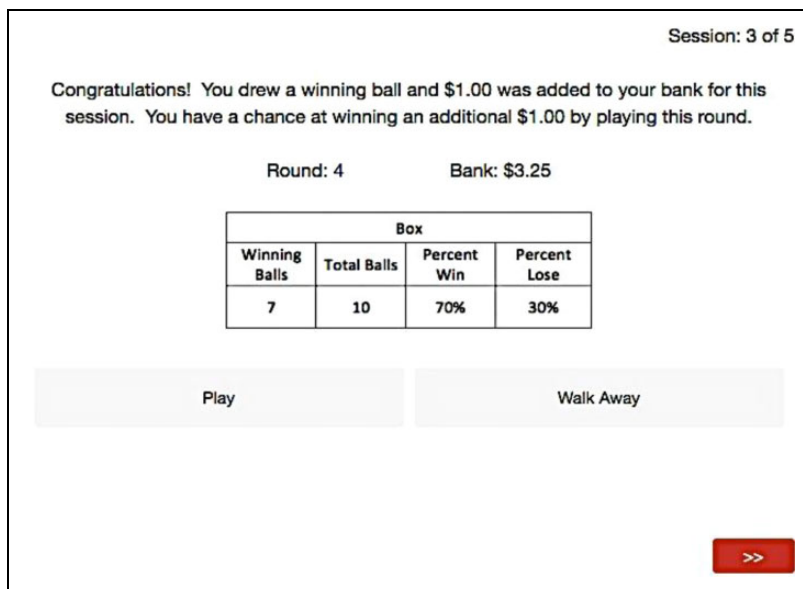
Participants took part in the experiment<sup>1</sup> in a lab on the Vanderbilt University campus using Qualtrics (March 2017), a web-based survey software. Participants consisted of students at Vanderbilt University who were recruited on campus through the use of flyers. Interested students were able to reserve a time to come into the lab and take the experiment. Walk-ins were also welcome. The only requirement for participation was being 18 years of age or older. Participants completed the experiment using computers that were set up in the lab.

The experiment consists of two incentivized games. In each game, participants face a lottery of known probability. Participants are asked to imagine a box consisting of a mixture of winning and losing balls. For each of the games, participants must ultimately choose how many rounds they wish to play the lottery (up to a maximum of 10 rounds per session) before walking away. Choosing to play a round results in a ball being drawn from the box. Drawing a winning ball adds money to the participant's bank. Drawing a losing ball ends the game for that session and results in all of the money in the participant's bank for the current session being forfeited. Choosing to walk away results in the participant earning the amount in their bank for that session but forfeiting any potential earnings from later rounds.

To illustrate, consider the following example. All dollar amounts in this article are in US dollars. Assume the participant has been endowed with initial assets of US\$0.25 and has played three rounds of the game, having drawn winning balls in each of the first three rounds. The participant now must decide whether or not to play the fourth round or to walk away with the US\$3.25 in their bank. If the fourth round is played and a winning ball is drawn, the participant's bank will be US\$4.25, and the participant will face the same decision of whether to play or walk away in the fifth round. If the fourth round is played and a losing ball is drawn, the participant loses the US\$3.25 and earns nothing for that session. Figure 1 illustrates what a participant is shown in such a scenario.

To help participants gain a better understanding of the upfront commitment game, participants play four practice sessions before moving to the real sessions of the game. After completing the practice sessions, participants also have the option of being shown the instructions again before moving on to the real game. Despite the practice sessions, one could be concerned that participants may be suspicious of the authenticity of the drawings. The survey explained to participants that a random number generator from an external website (linked to the probabilities in the experiment) is being used to determine whether a winning or losing ball is drawn.

In both games, participants start the game with US\$0.25 in their bank and have the opportunity to win an additional US\$1 in each round by drawing a winning ball.<sup>2</sup>



**Figure 1.** Example screenshot of experiment.

**Table 1.** Payment Structure (all payments in US dollars).

| Round | Award for Win | Bank     |
|-------|---------------|----------|
| 1     | US\$1.00      | US\$0.25 |
| 2     | US\$1.00      | US\$1.25 |
| 3     | US\$1.00      | US\$2.25 |
| 4     | US\$1.00      | US\$3.25 |
| 5     | US\$1.00      | US\$4.25 |
| 6     | US\$1.00      | US\$5.25 |
| 7     | US\$1.00      | US\$6.25 |
| 8     | US\$1.00      | US\$7.25 |
| 9     | US\$1.00      | US\$8.25 |
| 10    | US\$1.00      | US\$9.25 |

Table 1 illustrates the payment structure for the two games. Four different lotteries are used—60%, 70%, 80%, and 90% chance of drawing a winning ball in each round. The survey informed the participant of the probability of success that would prevail for each round in the session. In the no commitment game, participants play five sessions of each lottery for a total of 20 observations per person and up to 200 possible choices per person. The order in which they play each lottery is determined at random.

In the upfront commitment game, participants face the same lotteries and payment structure as in the no commitment game. Recall that in the no commitment game decisions of whether to play or walk away are made step-by-step at each

round. That is, participants are able to evaluate whether they wish to play or walk away after each round. For the upfront commitment, participants are forced to decide upfront how many rounds they wish to play (0–10) before walking away. To refresh their memory regarding the reward structure, participants are shown in Table 1. They are also reminded that should they lose any round that is played, their entire bank for that session will be lost. For the upfront commitment game, participants play each lottery version of the game only once for a total of four observations per participant for each game.

In addition to an US\$8 showup fee, participants earn additional money based upon the results of the games. For each of the two games, the earnings from one randomly selected session were added to the participant's total winnings. The stakes at hand were large, both in comparison to the pay for other experiments on campus and to work–study opportunities, a fact that led to confidence that participants took the games seriously. Participants also receive a small payment based on the results of a Holt–Laury lottery choice game taken near the end of the survey.<sup>3</sup> All payments were made in cash after the participant had concluded the experiment. The average payment made to participants was US\$18.89.<sup>4</sup> On average, participants took approximately 18 min to complete the experiment. The total number of participants was 111.<sup>5</sup>

This structure of our experiment includes some important components found in the Balloon Analog Risk Task (BART; Lejuez et al., 2002) and the BRET (Crosetto & Filippin, 2013, 2016). The BART (Lejuez et al., 2002) involved a simulated balloon and balloon pump. Subjects were given the option to pump the balloon and earn additional money but deciding to pump the balloon also included a risk of the balloon popping and the participant losing the money in their bank, similar to a participant in our experiment choosing to play another round. However, one major difference is that participants in the BART were not given risk information (i.e., probability of success). The BRET (Crosetto & Filippin, 2013, 2016) presents subjects with a series of 100 boxes, one of which contains a bomb. Subjects are asked to decide at which point to stop collecting boxes, where earnings increase linearly with the number of boxes collected but are reduced to zero if the box containing the bomb is collected. This type of win or lose everything scenario is similar to the one presented in our experiment. In the principal version of their experiment, Crosetto and Filippin (2013) only inform participants whether they have picked a box with the bomb after their choices have been made to avoid loss aversion influencing their use of the experiment to impute a measure of risk aversion. In the no commitment scenario of our experiment, however, we are interested in how the awareness of the amount that is actually at risk if there is an unsuccessful outcome affects behavior, as opposed to how people would decide if hypothetically they were still in the game. By providing individuals with information regarding prior draws and their current bank, we sought to emphasize that, in the no commitment game, decisions were being made repetitively one round at a time. We sought to instead frame the decision in the upfront commitment game as one made at one fixed point in time that was binding upon all future periods. Moreover, our experiment contrasts decisions that are made



sequentially with those based on an upfront commitment, whereas previous studies focus on the sequential decisions alone.

The design of our experiment also shares some of the same mechanics found in literature related to the hot hand effect and gambler's fallacy. Participants must depend on consecutive successful outcomes in order to remain in the game and keep their financial reward. After a stretch of positive results, participants may overestimate their future odds of success (Abinzano et al., 2017; Arkes, 2013; Paul et al., 2014) or may instead believe their luck is destined to run out (Croson & Sundali, 2005; Miller & Sanjurjo, 2018). The behavioral underpinnings of our model share many commonalities with the various hot hand models such as Abinzano et al.'s (2017) finding that bettors of professional tennis matches tended to overestimate the future odds of success and Paul et al.'s (2014) result that individuals betting on NFL games also exhibited a hot hand phenomenon. Applying the hot hand effect to our experiment, we might expect people to overestimate the likelihood of success after a number of successful rounds. Croson and Sundali (2005) also found that casino bettors exhibit the hot hand effect by betting on more numbers after winning than after losing. In this same study, the authors also found that the casino bettors tended to exhibit the gambler's fallacy after five or more particular outcomes—placing significantly more bets against the streak than with the streak. Unlike the studies in these areas, this experiment deals with a scenario where individuals lose everything as soon as they experience one negative outcome and studies how an upfront commitment impacts decision-making.

We seek to compare the decisions made under the no commitment scenario with those made with an upfront commitment to explore the impact of making the potential asset losses in each round more salient. The role of loss aversion and reference dependence effects more generally should play a greater role in the no commitment game in which individuals are cognizant of their current earnings and will desire to avoid losing this earned money. The same cannot be said for the upfront commitment game. Participants in this version of the game are never made aware of the amount of money, if any, in their current bank but instead are considering hypothetical payoff trajectories.

## **Theoretical Framework**

For purposes of this experiment, choosing to play another round is the risky option and choosing to walk away is the risk-free option. A risk-neutral individual is indifferent between playing another round or walking away when the expected value of playing is equal to his or her current bank but will walk away once the expected value of playing becomes less than his or her current bank. A risk-averse individual will always walk away if the expected value of playing another round with an uncertain payoff is equal to the payment guaranteed from walking away. In fact, depending on the magnitude of one's risk aversion and the magnitude of difference

between the expected value of the two options, a risk-averse individual may walk away even when the expected value of playing another round is greater than his or her current bank. The more risk-averse the individual, the fewer rounds he or she will choose to play. The exact opposite holds for an individual who is risk-seeking. The more risk-seeking the individual, the more rounds he or she will play.

For the upfront commitment game, participants cannot evaluate their decision after each round and must instead make projections as to how many rounds it is desirable to play. Risk-neutral individuals seek to play the number of rounds that maximizes their expected payoff by taking into consideration the probability of survival and the payment in each round. The following equation represents the optimal number of rounds,  $x$ , a risk-neutral individual should choose given a probability,  $q$ , of survival in each round or to choose  $x$  to

$$\text{Max}[q^x(x + 0.25)]. \quad (1)$$

The first part of the equation,  $q^x$ , represents the probability of surviving the play of  $x$  number of rounds. The second part of the equation,  $x + 0.25$ , represents the bank amount after playing  $x$  rounds (i.e., the amount of money one would earn by choosing to walk away at that point in the game). To solve for the number of rounds played that maximizes expected payoffs, one must take the derivative of the above equation with respect to  $x$ , set the derivative equal to 0 and solve for  $x$ .

$$\frac{\partial}{\partial x} [q^x(x + 0.25)] = 0,$$

or

$$\ln(q)qx(x + 0.25) + qx = 0,$$

which leads to a value of  $x$  given by

$$x = -(\ln(q) + 4)/4\ln(q)$$

Given the above solution, one can solve for the optimal number of rounds to play for each of the four probabilities given in the experiment. Using the 60% win probability as an example, we get the following:

$$x = -(\ln(0.6) + 4)/4\ln(0.6)$$

or

$$x = 1.708.$$

Rounding to the nearest whole number, we understand that the optimal number of rounds to play under the 60% probability is two rounds. For the 70% probability, we find  $x = -(\ln(0.7) + 4)/4\ln(0.7) = 2.554$ . Thus, it is optimal to play three rounds under the 70% probability scenario.

**Table 2.** “Optimal” Number of Rounds for Risk-Neutral Individual to Play.

| Chance of Win (%) | Optimal Number of Rounds |
|-------------------|--------------------------|
| 60                | 2                        |
| 70                | 3                        |
| 80                | 4                        |
| 90                | 9                        |

Table 2 shows the number of rounds that would be played under the expected utility theory in which an individual is risk-neutral and makes decisions strictly based on what maximizes the expected value of the outcomes over the entire game. For convenience, such risk-neutral strategy is herein referred to as choosing the “optimal” number of rounds to play. It is noteworthy that with a probability of success of 90% that the optimal number of rounds is 9. Given that there is a maximum of 10 rounds that might be played, this experimental treatment will generate a ceiling effect in which there is little opportunity to play too many rounds. Online Appendix Tables A1 and A2 show a more detailed calculation of the expected value for each round under each probability.

The nature of the choice process for the no commitment game is different in that in each period there is a specified value of funds in the participant’s bank, which the participant can compare with the expected rewards associated with continued play. The optimal strategy is the same as in the upfront commitment case since the probability of success is known to participants and is time invariant. Although the analytic structure of the choice of the optimal number of periods of play remains governed by Equation 1, the framing of the sequence of decisions in each period rather than one global decision is different. Except for the final round, the payoff of another successful outcome is not only the immediate reward of an additional US\$1 but also the prospect of being able to continue to earn rewards in future rounds. Solving this problem on a period-by-period basis leads to the following series of binary comparisons. To analyze the optimal solution, it is convenient to work backward from the final period and write down the series of decisions that the participant confronts. In each instance, the amount that will be lost with an unsuccessful outcome looms as one of the components of the binary choice to walk away or continue play, creating a potential role for loss aversion. We illustrate this phenomenon considering the last two rounds of play, Periods 10 and 9.

In the final Period 10, the subject will

$$\text{Max}[q(10 + 0.25), 9.25]. \quad (2)$$

Thus, the potential loss of US\$9.25 is directly compared to the expected gains of continued play.

The choice in Period 9 is analogous, as the subject will

$$\text{Max}[q\text{Max}[q(10 + 0.25), 9.25], 8.25]. \quad (3)$$

Thus, the comparison is between the potential loss of US\$8.25 and the chance to continue and, if successful, either quit with US\$9.25 or risk continuing for another round with the chance of having US\$10.25 or losing it all. It is this salience of the loss component of the decision that distinguishes the no commitment version of the model.

Following the analysis above and given what is known from past literature, we formed the following decisions framing hypothesis:

**Decision Framing Hypothesis:** Participants will play more rounds under the upfront commitment method than under the no commitment method.

$$\text{Rounds Played}_{\text{No Commitment}} < \text{Rounds Played}_{\text{Upfront Commitment}}$$

From an expected value perspective, no difference exists between the no commitment and the upfront commitment methods. Nonetheless, the framing of these decisions differs. The influence of loss aversion also comes into play more starkly in the no commitment version of the experiment. Participants are made aware of their current earnings and are able to evaluate potential outcomes after each round under the no commitment method. Participants can only evaluate potential outcomes once at the beginning of the game under the upfront commitment method and are never informed of the status of their bank as the experiment progresses. Because of this, loss aversion as a salient aspect of the choice has the potential to play a role in the no commitment game, but not in the upfront commitment game. Therefore, it is expected that participants will fewer rounds in the no commitment game than in the upfront commitment game.

## Results and Analysis

### *Basic Findings*

Table 3 shows the average number of rounds played for each of the scenarios in the experiment. Column 1 shows the average number of rounds played by those who “survived,” while Column 2 presents the average number of rounds played by those who eventually “died.”<sup>6</sup> It is helpful to distinguish between these two types of observations because, due to the structure of the experiment, there will be some truncation of the data. Column 1 avoids issues of truncation because individuals who survived necessarily walked away when they desired. On the other hand, certain observations in Column 2 may be truncated for the no commitment game.<sup>7</sup> The observations for Column 2 consist of individuals who drew a losing ball at some point. So, if an individual drew a losing ball after choosing to play in Round 4, that individual is considered to have played 4 rounds. In this example, if the individual

**Table 3.** Average Rounds Played.

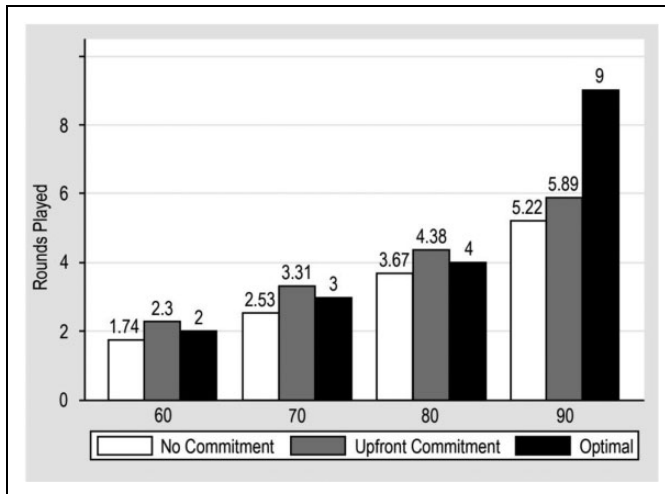
| Chance of Win (%) | Commitment Level | (1)                      |              | (2)                  |              | (3)                 |              |
|-------------------|------------------|--------------------------|--------------|----------------------|--------------|---------------------|--------------|
|                   |                  | Rounds Played (Survived) | Observations | Rounds Played (Died) | Observations | Rounds Played (All) | Observations |
| 60                | None             | 1.735                    | 155          | 1.380                | 400          | 1.479               | 555          |
| 60                | Upfront          | 1.721                    | 43           | 2.662                | 68           | 2.297               | 111          |
| 70                | None             | 2.527                    | 186          | 1.959                | 369          | 2.150               | 555          |
| 70                | Upfront          | 2.906                    | 32           | 3.468                | 79           | 3.306               | 111          |
| 80                | None             | 3.673                    | 217          | 2.379                | 338          | 2.885               | 555          |
| 80                | Upfront          | 3.846                    | 39           | 4.667                | 72           | 4.378               | 111          |
| 90                | None             | 5.222                    | 297          | 3.388                | 258          | 4.369               | 555          |
| 90                | Upfront          | 5.393                    | 61           | 6.5                  | 50           | 5.892               | 111          |

Note. Under the “no commitment” decision method, there are a total of 555 observations. This is because each of the 111 participants played each probability 5 times. There are only 111 total observations for the upfront commitment game because each participant only played 1 time for each probability.

had stopped after Round 4 even after a winning draw, there would be no truncation of the data. However, if the individual would have kept playing additional rounds, then the losing draw in Round 4 in fact truncates the data. For this reason, Column 1 most accurately reflects the preferences for individuals in the no commitment game. Column 3 combines the results of Column 1 and Column 2 and includes observations regardless of whether a person eventually drew a losing ball or not. For the upfront commitment game, Column 3 gives the most accurate representation of the average preferences of the subjects, as truncation is not an issue for this game and individuals can express their true risk preferences.

Figure 2 shows the number of rounds participants played on average compared to the number of rounds that would be played under the optimal strategy that assumes risk neutrality. For the no commitment game, only individuals who survived are included (i.e., Column 1 from Table 3). For the upfront commitment game, all individuals are included (i.e., Column 3 from Table 3). As stated above, these two sample groups provide the best representation of how many rounds individuals intended to play. However, as the results in Column 3 of Table 3 indicate, excluding the observations from the no commitment group leads to an understatement of the difference between the no commitment and upfront commitment groups. For the no commitment game, individuals play fewer rounds than optimal on average (as shown in Figure 2 and evidenced by the *t* tests and Wilcoxon signed-rank tests shown in Online Appendix Table A3).

This result is consistent with the theory of “myopic loss aversion” (Thaler et al., 1997), whereby individuals are less willing to accept risks when they evaluate their decisions more frequently. In addition, individuals will watch their banks grow and consider this bank to be part of their endowment. The endowment effect and loss aversion suggest that participants will be incentivized to walk away earlier and avoid



**Figure 2.** Average rounds played and optimal rounds.

the possibility of losing all the money in their bank (Kahneman et al., 1990; Thaler, 1980). Thus, the fact that individuals played fewer rounds than the risk-neutral, optimal number is in line with predictions based on this prior literature.

While individuals play fewer rounds than optimal on average across all probabilities, the difference is substantially greater in the 90% scenario. Under the 90% probability scenario, individuals in the no commitment game walk away after playing a little more than five rounds, on average. Interestingly, this is approximately the same number of outcomes, where Croson and Sundali (2005) found individuals to fall victim to the gambler's fallacy after observing a streak of five or more occurrences of a particular outcome.

For the upfront commitment game, participants actually play more rounds than optimal for the 60%, 70%, and 80% lotteries. The only exception is that participants played fewer rounds than optimal for the 90% lottery. However, given that there were only 10 possible rounds and 9 was the optimal number for the 90% lottery, this anomalous result is attributable to the ceiling effect that limits the maximum number of rounds people could play. This consistent evidence for the 60%, 70%, and 80% versions—that the number of rounds played exceeds the optimal number of rounds—indicates risk-seeking behavior. These results differ greatly from the results of the no commitment game. One explanation is that participants are not subject to the same framing effects as in the no commitment game because, under the upfront commitment method, participants are only faced with the sure option once and don't feel the dread of losing the money in their bank because the results of each round are not shown. However, this difference does not explain why individuals would play *more* rounds than the optimal amount rather than the exact optimal amount.

**Table 4.** Ordinary Least Squares Regression of Rounds Played.

| Variable               | Both Games                        | No Commitment                     | Upfront Commitment                |
|------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Probability = 70       | 0.851<br>(0.132)***<br>[0.075]*** | 0.753<br>(0.169)***<br>[0.110]*** | 1.009<br>(0.213)***<br>[0.069]*** |
| Probability = 80       | 1.966<br>(0.129)***<br>[0.120]*** | 1.891<br>(0.163)***<br>[0.158]*** | 2.081<br>(0.213)***<br>[0.106]*** |
| Probability = 90       | 3.504<br>(0.124)***<br>[0.163]*** | 3.450<br>(0.154)***<br>[0.196]*** | 3.595<br>(0.213)***<br>[0.153]*** |
| Upfront commitment     | 0.663<br>(0.092)***<br>[0.127]*** |                                   |                                   |
| Holt–Laury risk averse | −0.284<br>(0.109)***<br>[0.226]   | −0.186<br>(0.134)<br>[0.256]      | −0.477<br>(0.185)**<br>[0.298]    |
| Smoker                 | 0.761<br>(0.152)***<br>[0.427]*   | 0.453<br>(0.188)**<br>[0.444]     | 1.316<br>(0.257)***<br>[0.584]**  |
| Male                   | −0.417<br>(0.090)***<br>[0.227]*  | −0.419<br>(0.110)***<br>[0.242]*  | −0.427<br>(0.157)***<br>[0.272]   |
| Constant               | 2.055<br>(0.145)***<br>[0.241]*** | 2.067<br>(0.179)***<br>[0.275]*** | 2.721<br>(0.221)***<br>[0.280]*** |
| Observations           | 1,299                             | 855                               | 444                               |

Note. Regressions conducted using ordinary least squares. The dependent variable is the number of rounds chosen to play for every session of the games. The omitted probability is 60%. To account for truncation, observations for the no commitment game only include those who did not draw a losing ball for that session. For the upfront commitment game, all observations are included. Standard errors are in parentheses. Clustered (by individual) standard errors are in brackets.

\* $p < .1$ . \*\* $p < .05$ . \*\*\* $p < .01$ .

### Evaluating the Decision Framing Hypothesis

**Decision Framing Hypothesis:** Participants will play more rounds under the upfront commitment method than under the no commitment method.

**Result:** True.

As demonstrated by Figure 2 and Table 3, participants play significantly more rounds under the upfront commitment decision scenario than under the no commitment decision scenario. The regression results for the number of rounds played, as shown by the first column of Table 4, indicate that individuals play roughly 0.663 more rounds when faced with the upfront commitment scenario as opposed to the no

commitment scenario.<sup>8</sup> These same regressions were conducted using only the data from Session 1 of each scenario to account for any potential learning by participants. These results are shown in Online Appendix Table A5 and are consistent with the results in Table 4 when observations from all sessions are included. In addition, *t* tests and Mann–Whitney rank-sum tests were conducted for differences in the mean rounds played under each commitment scenario. As shown in Online Appendix Table A6, for most specifications, individuals played a statistically significant greater number of rounds under the upfront commitment scenario. These findings support the claim that individuals under the no commitment method were subject to feelings of loss aversion, causing them to engage in less risky behavior.

The variables capturing demographic characteristics are also influential. Respondents who are more risk-averse based on the Holt–Laury test for risk aversion play fewer rounds. Individuals were defined as “Holt–Laury Risk Averse” if they chose five or more safe choices in the Holt–Laury task, which follows the classification given in Holt and Laury (2002). Smokers are likely to play more rounds, consistent with their greater willingness to engage in risky health-related behaviors. While the negative effect of being male is different than that in some other contexts, these regressions pertain to the incremental effect of gender controlling for the subject’s level of risk aversion, which will capture much of the influence of the gender variable.

### *Rationality Test*

A separate hypothesis was tested as a rationality check of whether respondents adhere to basic monotonicity criteria. The higher an individual’s chance of drawing a winning ball, the more desirable it is to play rather than walk away. Therefore, individuals should play more rounds when the chance of winning is higher. This hypothesis can be tested for each game separately—avoiding the possibility of conflating the effect of the win percentage element with other factors, such as loss aversion, which may impact the performance in the two games differently.

**Rationality Hypothesis:** The higher the probability of winning, the more rounds participants will play.

$$\text{Rounds Played}_{60\%} < \text{Rounds Played}_{70\%}$$

$$\text{Rounds Played}_{70\%} < \text{Rounds Played}_{80\%}$$

$$\text{Rounds Played}_{80\%} < \text{Rounds Played}_{90\%}$$

**Result:** True.

An increased probability of winning raises the relative attractiveness of playing. As predicted, participants choose to play more rounds when the probability of drawing a winning ball is higher. As shown in Figure 2 and Table 3, participants play more rounds in the 70% probability sessions than in the 60% probability



sessions, more rounds in the 80% than in the 70%, and more rounds in the 90% than in the 80%. These probabilities were included as indicator variables in the regressions shown in Table 4. Each of the probability variables is significant for all the specifications and grows larger as the probability of drawing a winning ball increases. Furthermore, *t* tests were conducted for differences in the mean rounds played across probabilities. As shown in Online Appendix Table A7, for each of the probability comparisons in the rationality hypothesis, individuals played a statistically significant more number of rounds when the probability of success was greater.

## Discussion

The results indicate that risk preferences are sensitive to the level of required commitment. On average, individuals tend to display risk-averse behavior under the no commitment scenario. The average number of rounds played suggests risk-seeking behavior for the upfront commitment game, in which subjects make an upfront commitment. These findings suggest that loss aversion is a heavy influence on an individual's decisions regarding risks. When individuals feel as if they have something to lose, loss aversion may influence an individuals' decisions and have them walk away earlier. Under the no commitment method, individuals are given information about their bank in each round. Therefore, participants are shown what they might lose and may feel a level of dread about losing this money that they would not feel under the upfront commitment scenario, where they are not informed of their results round-by-round.

Until now, the results have been discussed in terms of *mean* rounds chosen to play. Yet it is important to know what portion individuals are exhibiting risk-averse or risk-seeking behavior. The results in this experiment can be analyzed by looking at the proportion of individuals who either choose to play "too many" or "too few" rounds. The terms too many and too few are used not in the normative sense but instead refer to whether a participant plays more or less rounds, respectively, than the expected value maximizing strategy. For instance, a participant choosing to walk away after playing three or more rounds for the 60% probability would be considered to have played too many. If the participant in this scenario had walked away without playing at all or after only playing one round, he or she would be considered to have played too few.

Figures 3–6 present a breakdown of the proportion of participants that play too few, too many, or the optimal number of rounds for each of the two games. Because there is only a single potential decision round beyond the optimal risk-neutral number of rounds for the 90% chance of success experiment, we present the results for each of the different chances of success separately. For the no commitment game, one is considered to have played too few only if the individual survived and played fewer rounds than optimal and are only considered to have played an optimal amount if they played and survived the optimal number of rounds. In

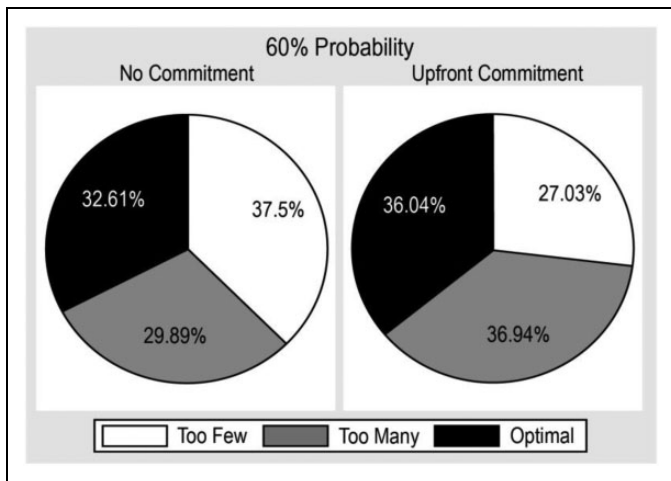


Figure 3. Length with respect to optimal—60% win probability.

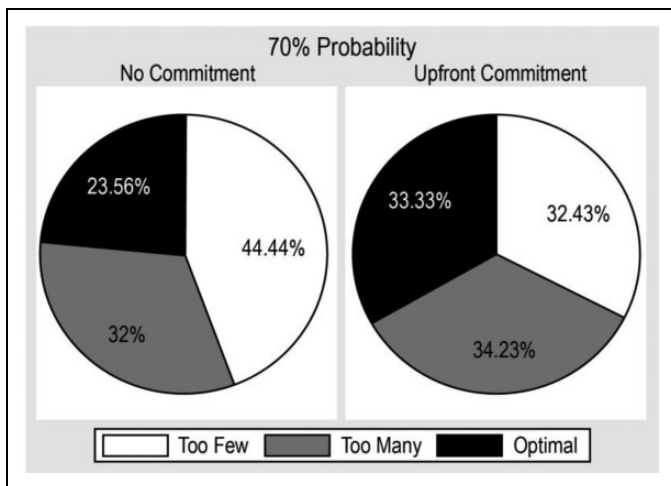
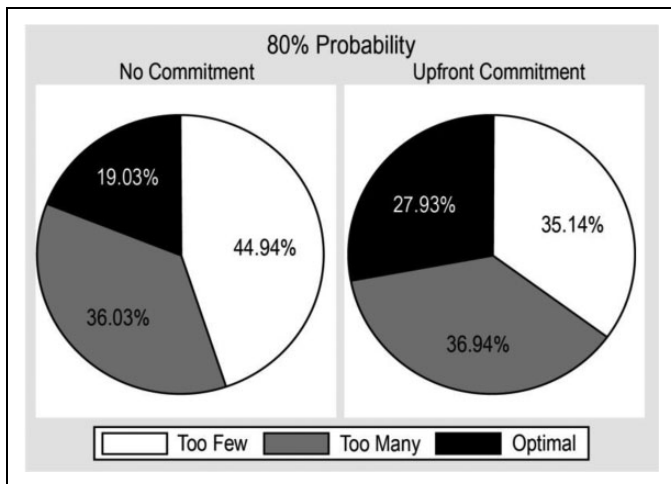
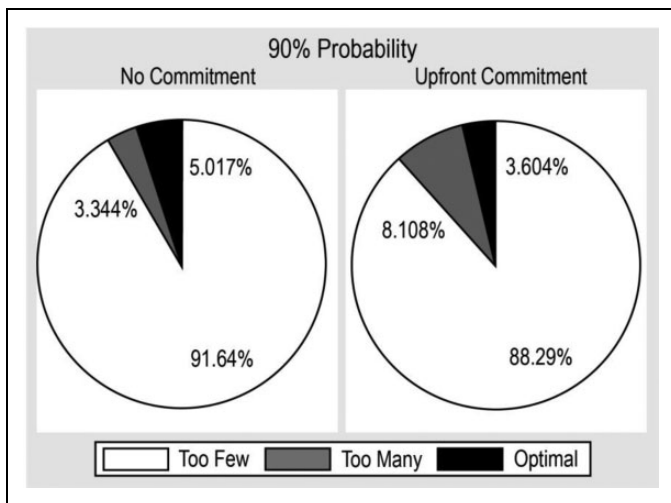


Figure 4. Length with respect to optimal—70% win probability.

other words, participants were not considered to have played too few in the no commitment game if they died before reaching the optimal number of rounds because they were never given the opportunity to play the optimal amount. By the same token, individuals who died on the optimal round were not included because one could not say with certainty that they would have walked away had they survived that round. Those who played more rounds than optimal were considered to play too many because survival is irrelevant past the optimal number of



**Figure 5.** Length with respect to optimal—80% win probability.



**Figure 6.** Length with respect to optimal—90% win probability.

rounds. For the upfront commitment game, survival is also irrelevant because individuals always have the opportunity to express their desired choice for the number of rounds they wish to play.

Figures 3–5 tell an interesting story not revealed by looking solely at the mean number of rounds played. Overall, individuals do a poor job of selecting the risk-neutral number of rounds that leads to the highest expected value of earnings.

In neither game does the percentage of participants playing the optimal number of rounds reach more than 36%. For each of the three win probabilities, fewer participants chose the optimal number of rounds for the no commitment game than for the upfront commitment game.<sup>9</sup>

Another striking observation concerns the no commitment game, in which a significant percentage of individuals play too many rounds—indicating risk-seeking behavior. This is something that may not have been predicted when looking solely at the averages, which fell far below the risk-neutral number of rounds for all probabilities. As shown in Figures 3–5, roughly one third of the participants play too many rounds under the no commitment game.

These results are also surprising because we tend to believe that most individuals are risk-averse. In fact, the Holt–Laury task indicated that 77.5% of the individuals in this experiment were risk-averse, 13.5% were risk-neutral, and only 9.0% were risk-seeking. Yet a much larger percentage than 9.0% played too many rounds. This may indicate that individuals are making mistakes when it comes to their decisions and that the type of risk structure presented in this experiment causes them to take on more risk than they may otherwise desire.

The 90% win probability scenario is markedly different from the other chance of success scenarios. As indicated earlier, participants are allowed to play a maximum of 10 rounds. This is only one more round than the optimal number of rounds, nine, for the 90% win probability scenario. Thus, only by playing the maximum number of rounds, is it possible for individuals play too many rounds. Individuals may feel added discomfort in choosing to play a number of rounds that is close to the maximum allowed. This is one possible explanation for why very few individuals play too many rounds under this scenario, while a very high percentage of individuals play too few rounds.

## Conclusion

The results of this experiment demonstrate the important roles that framing and timing play with regard to decisions concerning risk. While individuals appear to respond rationally to increases in probability, choosing to play more rounds as the chance of winning increases, the win or lose it all structure poses challenges for individuals. Most participants either played too few or too many rounds than would be optimal to maximize their expected payouts. In addition, individuals react quite differently depending on whether the risks are framed as a round-by-round decision as opposed to one involving an upfront commitment that is made in one step. In the upfront commitment game, a larger portion of participants accepted greater risk and played too many rounds than in the no commitment game. One explanation for this divergence is that making the potential losses explicit in the no commitment game increases their prominence. Providing information on the asset levels may establish a reference point, consistent with loss aversion. When faced with round-by-round decisions, individuals are cognizant of the money they are at risk to lose. This is not

the case when forced to make an upfront commitment. In this situation, individuals never have the similar feeling of dread, as the amount of money they have at stake is never made “real” in the same way that it is in a round-by-round scenario.

These experimental findings have implications for the types of recurrent and high-stakes risks that are confronted by athletes. The decision that many athletes in contact sports face regarding the risk suffering long-term health consequences from concussions is analogous to the experiment in this article. These athletes must weigh the financial gain of prolonging their careers against the potential risk of sustaining a lifelong injury or disease. The results of this experiment indicate that individuals placed in such a scenario may incur more risk than is desirable. This potential problem is amplified when individuals are asked to make long-term commitments with regard to risk. Athletes often enter into multiyear contracts, which, similar to the upfront commitment game, may cause them to engage in more risk than they might otherwise desire and play longer into their career than they would absent such commitment. Such suboptimal behavior would ultimately lead to more concussions and adverse health consequences. It is not hard to imagine athletes feeling a certain obligation or duty to honor the full duration of their commitment. For example, in an interview with WEEI radio on October 23, 2019, 6-time Super Bowl champion, New England Patriots quarterback, Brady (2019) explained, “I think when you commit to a team for a certain amount of years you kind (of) feel like (there is) the responsibility to always fulfill the contract.” However, upfront commitments combined with such loyalty will tend to produce lifetime concussion risks that exceed the optimal amount.

One promising policy intervention currently used in the NFL and National Hockey League (NHL) is baseline testing. NFL and NHL players must undergo neuropsychological testing before the start of each season. Such testing includes a neurological exam and short tests measuring short-term and long-term memory, concentration, and motor skills. Such annual reassessments may cause individuals to reevaluate health risks and their contractual obligations, similar to the no commitment scenario in our experiment. This should lead to more risk-averse behavior and, consequently, diminish injury risks. Other interventions are likely necessary to cause athletes to more frequently evaluate potential adverse health consequences and nudge closer to risk-neutral decision-making.

### **Authors' Note**

Opinions expressed are my (Scott DeAngelis) own and do not express the views or opinions of my employer.


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## Supplemental Material

Supplemental material for this article is available online.

## Notes

1. This experiment received Vanderbilt University's institutional review board approval (study number 170174).
2. Starting the game with nonzero bank amount forced participants to make a meaningful decision in the very first round. The US\$0.25 amount was chosen because it led to expected values that provided useful comparisons to a separate game that participants played using a different payment structure.
3. The lottery choice game referred to is drawn from Holt and Laury's (2002) paper titled, "Risk Aversion and Incentive Effects." In their experiment, they asked participants to make 10 choices between paired lotteries. They were then able to calculate the range of the participant's relative risk aversion based upon the number of "safe" and "risky" choices made.
4. This payment includes earnings from variants of the experiment in which an increasing payment structure was used.
5. Given the number of participants, sessions, and win probabilities, there were a total of 2,220 observations for the no commitment scenario and 888 observations for the upfront commitment scenario. Standard errors were clustered by individual, and paired tests were used to account for any lack of independence. Given the number of participants, there would be 111 independent observations.
6. "Survived" means that the participant never drew a losing ball. The participant either walked away before drawing a losing ball or happened to play and draw a winning ball in all 10 rounds. If an individual chose to walk away in Round 4, that individual is considered to have played three rounds for that observation. "Died" means that the participant drew a losing ball at some point during the session. If an individual drew a losing ball after choosing to play in Round 4, that individual is considered to have played four rounds.
7. Truncation is never an issue under the upfront commitment game, as individuals are always allowed the opportunity to express their desired number of rounds to play because the draws that determine win or loss are not made until after the individual has picked his or her number of rounds.
8. The results give in Table 4 were derived using ordinary least squares. These same specifications were replicated using Poisson regression and are shown in Online Appendix Table A4.

9. As shown in Online Appendix Table A8,  $\chi^2$  tests found that the proportion of participants playing “too short,” “optimal,” and “too long” in the no commitment game and in the upfront commitment game differed to a statistically significant degree.  $\chi^2$  tests were also conducted to measure the difference of these proportions among the 60%, 70%, and 80% probability win scenarios.

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