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Shedding Light on Human Monetary Decision-Making: Experiments from the Gambling World and Everyday Choices

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ABSTRACT

This thesis explores the relationship existing between behavioral finance and sports gambling and the insight it can demonstrate for the stock market and financial assets by shedding light on human monetary decision-making. We observe that, due to human biases, we make irrational and questionable decisions in the face of loss aversion, specifically dealing with human behavior involving spending money. As money allocation for sports betting requires the same processes as money allocation for the financial markets, the psychological influences that cloud our judgment have a presence in both scenarios. The irrationality of humans is evident when looking at economic decisions of different sorts, and only when we remove the biases can we begin to make sound decisions.

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Chapter 1

Introduction

Money is money. Twenty dollars found on the street is nominally worth the same as having to spend an hour working for it. However, does that same sentiment hold true in the gambling world as well? Is 20 dollars won or lost on a bet really just that? Furthermore, does winning or losing that 20 dollars change its value?

The global sports betting market is massive. To put a number to it, it's estimated that combined worldwide, the total size of the market is approximately $250 billion (Sports Betting Dime), or in other words, over $17 billion more than what Amazon made in 2018 (MacroTrends). To give more perspective, the conservative estimation of the market cap in the U.S. alone is $60-73 billion, up from $20 billion in 2009 (Sports Betting Dime). Those figures represent *legal* sports betting, while the estimates of the illegal market cap range anywhere from $80-200+ billion. It's safe to say American sports betting reigns supreme above the rest. And speaking of supreme, even more interesting is the gradual legalization of many types of sports betting in various states across the country after the Supreme Court struck down the federal law from 1992 that essentially banned commercialized sports betting in all states (Liptak and Draper, NY Times). States now have the right to legalize sports betting whenever they please, and the NY Times projects it will open up the door to an estimated $150 billion in now legal wagers that were previously outlawed.

Focusing on two of the more popular sports basketball (NBA and college) and football (NFL and college), we can begin to see trends of how bettors spend their money and make bets. Interestingly enough, although each sport is very different in nature (number of games, where it's

played, rules, point values, objective), in pursuing various sportsbooks (Bovada, BetOnline, and Bookmaker) one will find there tends to be more bets available for those two sports than the other sports. Besides the pure entertainment value of watching the NFL and NBA, reasons for the high demand of bets for each league could include the intricate makeup of NFL games (a myriad of possible outcomes of scoring, yards gained, etc.) and the large individuality of NBA games (a single player being able to generate thousands of combinations of stats, taking over a game, etc.), among others. Given the large traffic of bettors and the bets they place, tendencies emerge that shed light on human behavior and the decisions we make with our money.

We also know from neuroscience that emotion plays a huge role is our decision making. Our economic decisions are no different. The current emotional state we are feeling heavily drives the decisions we ultimately end up making. Regardless of whether there is any correlation with the factors that change our mood, people tend to conform their decisions to their emotions (Kahneman). Losses bring pessimism and negativity. Wins bring optimism and positivity. Those emotions in and of themselves don't mean anything; but when the people experiencing them are simultaneously? additionally? betting money on sports, they might. Or, from what we have observed from previous research, they do.

Another factor to consider is whether in the context of investing or gambling exactly why these emotions are present and playing a part in our decisions. The mainstream literature frames both "investing" and "gambling" as a rational activity in the mind of the participant. The outcome is always of interest, and the end goal is to earn money. Obviously, the scale of the bets and bettor wealth is different across the board, but we can also assume a vast majority of the bettors do not fall under the category of a billion-dollar individual making $5 bets. That, specifically, is what cements our emotional interest in the bet's outcome.

In that there are mostly only two outcomes to sports bets (a push occasionally happens where neither the bettor nor the bookie wins), we can observe emotions on opposite sides of the spectrum following the conclusions of the bet. We all react differently to wins/losses of bets, but the larger the sample size we observe the more opportunity we have to test if the mainstream assumption of human behavior holds true. For example, 1) Is gambling activity "rational"/efficient? and 2) To what extent is there the presence of positive feedback loops in the sports betting industry? 3. What about the presence of risk aversion? With the huge continual increase in the popularity of college basketball and football, the NFL, and the NBA, as well as sports betting even more so following the continued legalization, now is the perfect time to continue to study and investigate the trends in betting strategy and activity. As a result, the sample sizes will only continue to increase, and then potential correlation would only strengthen. Above all, the results of more research, especially given the relatively short period of time the bets take to reach their end value, may lead to more insight in the field of Behavioral Finance.

As far as the nature of the sports bets themselves are concerned, the types of bets I looked at were point spreads (a.k.a. the line), the over/under (total number of points combined between teams, and the moneyline (which team will win outright). There are many other types of sports bets that can be observed and studied such as parlays[1], teasers[2], buying half a point[4], futures[5], and propositions, that would no doubt generate interesting data potential relations. However, due to the larger frequency of the spread, over/under, and moneyline bets, and the simpler, fewer variable natural of them, I chose to focus specifically on the conclusions I could drawn from those particular types of bets.

Point Spread

Point spreads attempt to create a bet in which each side has about a 50% chance of winning. Obviously, most often teams aren't 100% evenly matched, so in order to account for this, the bookmaker (the person setting the bet terms) gives a handicap to the worse team 'x' of a certain number of points or deducts that same 'x' number of points from the better team, depending on how one wants to phrase it. For example, say the Cowboys and the Redskins are playing, and the Redskins are the better team. The bookmaker might decide the Redskins are seven points better than the Cowboys and would, therefore, quote the point spread as Redskins -7. In other words, if the Redskins started at -7 points and the Cowboys at 0 points, they would be projected to be tied at the end of the game. It can also be quoted in the opposite way of Cowboys +7. In this case, if the Cowboys started with +7 points and the Redskins with 0 points, they would be projected to tie as well. These bets are usually set up so that the investor risks $11 for every $10 they stand to win (due to the bookmaker's commission) and quoted in terms of 100.

Over/Under

Over/under bets deal simply with the total number of points scored combined between the two teams. One is able to bet on the combined score being either over or under a specified value determined by the bettor. The point difference doesn't matter, nor does it matter whether point difference is large or small. All that matters is the total points of both teams. Over/under have generally the same payouts as the point spread bets and usually require risking $11 to win $10. These bets are quoted in terms of 100 as well.

Moneyline

Moneyline bets are also very straightforward as they bet on the outright winner of the game with nothing to do with the score of the game or how many points are scored. If a bettor bets on a team to win and they do, the bettor wins. However, there is a catch. Similar to the teams in most point spread bets, the teams playing in money bets most often aren't similarly talented. To adjust for this, the bookmakers reflect this in the odds of each team winning, thus affecting the amount of money won betting on each time. Given the non-50/50 nature of moneyline bets, their payouts look different than both the point spread and over/under bets. One might see a bet between the Panthers and the underdog Falcons looking like this: Panthers -200, Falcons +180. In this case, the bettor would have to risk $200 to win $100 if betting on the Panthers, or risk $100 to win $180 for the Falcons. Choosing the underdog is less likely to hit, so the bettor is compensated for the greater risk. At the same time, betting on the favorite is more likely to hit, and so in return the bettor has risk more than he/she stands to win.

Chapter 2

Literature Review

The Efficient Market Hypothesis

The ideas reflected in Efficient Market Hypothesis (EMH) have been around for more than a century. It became more prominent when Eugene Fama published his thesis on this topic in 1965. Over the following years, the hypothesis was reviewed and altered (by Fama himself too), which has resulted in roughly the hypothesis we have in our world today. The firm believers of the EMH have their own differing opinions on just how efficient the market is (weak6, semi-strong7, and strong8), but all have the consistent view that along with the EMH exists the

"random walk hypothesis" (Fama 1970). The random walk posits that stock prices move randomly and, therefore, can't be predicted consistently enough to generate "abnormal returns" and to allow someone to "consistently beat the market." Naturally, from the belief of true market efficiency and random price changes we have the world of rational investors and decision makers. All financial experts agree that when investing their money and making decisions on stocks, investors should be rational. They are acting on all the same information as the rest of the field, all in order to become more profitable. This, in theory, should eliminate the ability to find relevant stocks at a bargain over time. Even inside information would then be reflected in the stock prices. While this sounds good and reasonable, we can't accept one hundred percent as it is when we regularly see stocks trading at unjustified prices. Unjustified prices would take the appearance of an asset possessing a price from which an investor could make arbitrage by buying and then reselling it. Given that arbitrage does exist in the financial markets, we some to at least some degree the EMH can be disproved.

A few theories that serve as good examples of the EMH are the January Effect, the high-to-low book market ratio effect, and small firm effect. The January Effect posits that stocks see an increase in the month of January that they don't experience in any other month. Some potential explanations are that investors try to take advantage of tax-breaks and sell off losses, or there is increased buying at the beginning of the year leading to higher prices. The high-to-low book market ratio effect says that companies with higher book-to-market[9] ratios will experience greater returns than companies with lower ones. However, that comparison would include companies such as Apple vs. Caterpillar. Apple clearly has the potential for exponential earnings increases with the type of business it does (i.e., company it is) in comparison to the most often positive growth and but more steady growth of Caterpillar, due to its respective nature. Lastly,

the small firm effect hypothesizes that small market capitalization[10] firms experience greater returns than large market capitalization firms over time. This could be explained potentially by small firms experiencing more risk, and, therefore, needing to generate more return, or that large firms are already well established and will inherently experience fewer price increases and less return. A true form of EMH would nullify any trends that seem to be accurate in these theories, accurately showing the true prices, while no investors are able to consistently outperform the market. At this point emerged the Behavioral Finance movement as an alternative to the EMH.

Behavioral Finance Critique

Following the dot.com bubble and especially the financial crisis of 2008, we saw the emergence of a big wave of Behavioral Finance theory. Experts began to dig deep into the real reason for the crisis -- the financial system couldn't have crashed that hard itself, the actions of the investors within the system had to have been the real reason. If the EMH really holds, how could 2008 have happened? The strong-believers claim random walk and pricing still shows EMH support. However, as we see excess volatility, overreactions, momentum, and price under reactions present, another explanation has to be found. We know that asset bubbles, inherently dangerous themselves, are even more dangerous when financed with debt (Malkiel 2011). Even though this was the case in the crash, it wasn't solely the reason the crisis took place. Malkiel further argues that saying the EMH and Behavioral Finance aren't competing theories but actually coexist to a certain extent. But Behavioral Finance takes an interesting turn. The players in the financial markets are humans, and humans are imperfect and *irrational* decision makers (Kahneman). Kahneman states emotions and hard-wired biases inherently play a part in our

financial decisions. Among many external factors, tendencies such as conformity, herd behavior, blind interpretation of feedback, and various others, all result in the purchasing and selling of stocks at misvalued prices.

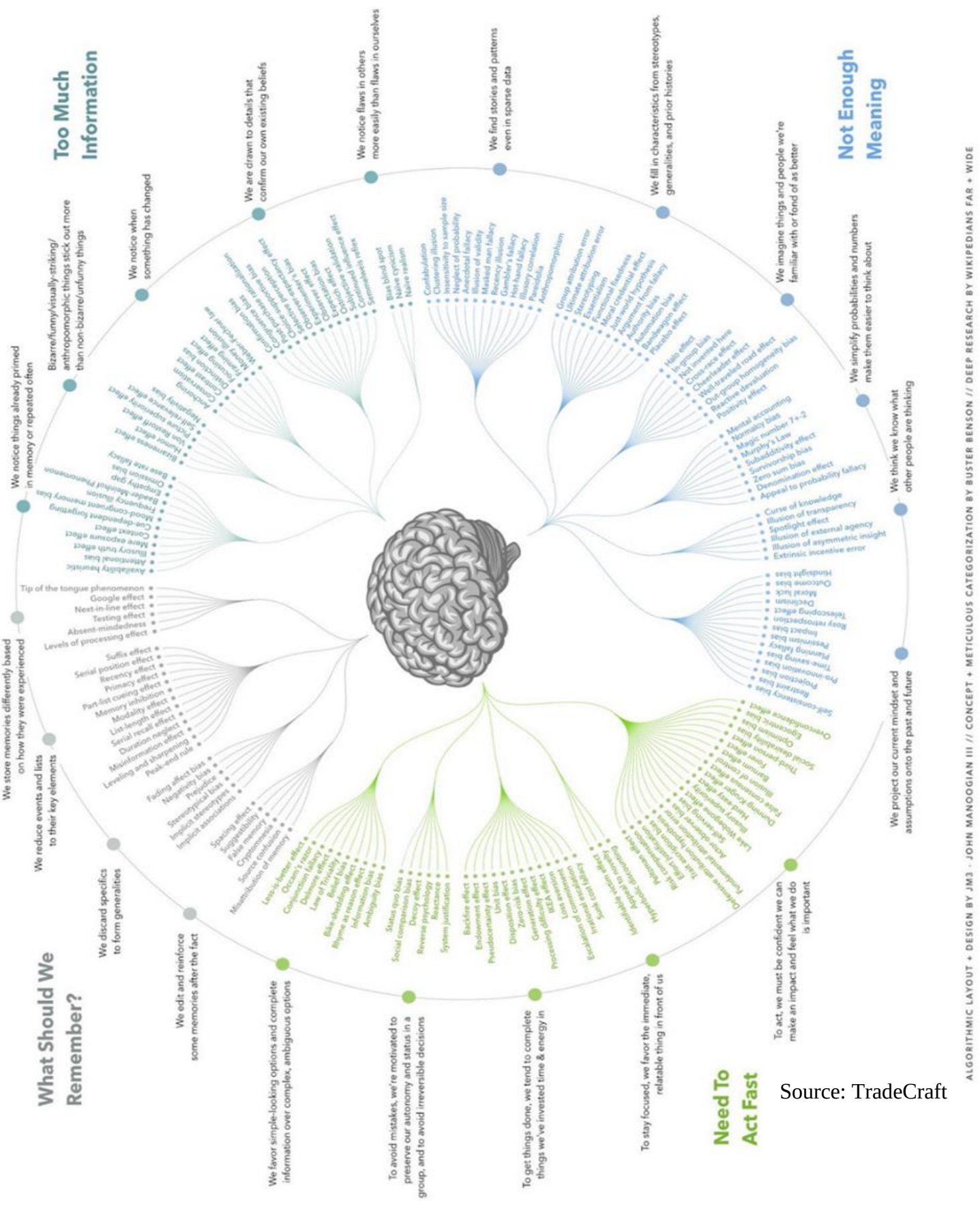
Cognitive Bias

Although extremely capable, our brains are subject to limitations in the form of cognitive biases. A cognitive bias is the error in thinking while processing and interpreting new information resulting in a divergence from rational judgment. The biases are prevalent everywhere and affect a large majority of our everyday decisions. The picture on the next page from TradeCraft's site illustrates both the scope of the biases and from which scenarios they rise.

Conformity and Herd Behavior

The true scope of our inability as humans to largely resist conforming to our environment can be observed perfectly in the experiment carried out by social psychologist Solomon Asch. The subjects were placed in a room with seven other people, all of whom were confederates helping conduct the experiment, and were told they would be doing a vision test. Three lines of different lengths were shown on a card, and all eight people had to state aloud which of the three lines was the same length as a comparison line that was placed next to the three original lines. The answer was obvious and very easy to see. The catch, however, was that the subject was always the last in line to answer. Additionally, for 12 of the 18 trials, every one of the confederates intentionally answered incorrectly. What Asch observed was that just under one third of the subjects conformed to the confederates' answers despite the blatantly obvious

Figure 1.



Source: TradeCraft

response. How can it be that for such an insignificant task, a task that possesses neither any kind of benefit nor detriment, as humans we still feel the need to comply with the peer group around us to the extent to lying/contradicting our intuition and basic information? Asch states that human beings conform for two reasons: 1) we don't want to stick out and be the only outlier even in a group setting where there's no relationship between the subjects and anyone else, and 2) we believe the group around us knows more than we do and think it would be wise to conform to their behavior or actions. These phenomena can be easily applied to the world of sports betting and assets in the financial markets. Herd behavior, or acting on the basis of how the masses around are acting, without a doubt exists in the betting and financial world. People still are mimicking monetary decisions based on what the world around them is doing and saying, whether those decisions are rational or irrational. In fact, it might be even more present in the fields of sports betting and the markets given the ramifications of their decisions now result in loss or gain.

Gambler's Fallacy

Gambler's fallacy is that tendency for humans to believe that if the occurrence of an event has been high in the past, it's most likely going to be low in the future. For example, people are likely to falsely think that if the roulette ball in a game of roulette has landed on red three times in a row, there's a greater chance in lands on black the next spin. However, that's an irrational thought because each roulette spin is independent of each other and the odds are the same each time.

Misinterpretation of Information and Feedback Loops

Trends also seem to show humans act on just as much bias following a financial decision as they do while they're in the process of making it. While technical analysis can be done successfully and can generate returns at times, our interpretations of feedback/information of the choices we make with our money are often made very blindly. Falling prey to influence of feedback loops can and does result in huge sums of money lost while both betting or playing the stock market. A coin landing on heads five times in a row doesn't mean that it "has" to land on tails the next time. A sports team performing better than what experts or the spread would predict by blowing another team out in the first half does not mean that will continue to happen in the second half. A stock experiencing positive momentum for several weeks does not make a guarantee it will experience a positive return the next trading day. The example about the coin, the sports team, and the stock illustrate the existence of the aforementioned gambler's fallacy that has always been prevalent in the betting world. Relevant to both sports and everyday life, this fallacy is a mistaken belief that the frequency of an event occuring during a specific time period affects the frequency of the event in the future. That is clearly not the case. Despite the knowledge of these trends, humans as a whole still can't seem to remove all emotion or impressionability when electing where to allocate their money with the chance of losing it being a possibility.

Optimism and Illusion of Control

Kahneman also writes on what he calls "pervasive optimistic bias" which influences our perception of illusion of control, or, in other words, how much control of our lives we have. It's

no secret that, as a whole, humans are overly optimistic. In the betting world, that takes form in us being more confident than we should be that each bet we make is going to hit. It gives us the feeling that we are "so sure" whichever side of the bet we choose is the right one. That feeds into our inflated sense of illusion of control. Humans incorrectly assume they have more control of the outcome of an event than they really do. It's especially prevalent in scenarios where an individual wins a bet and is certain the main reason is because of his/her "control" of "accurately taking into account and correctly deciding" on all the available information pre-bet while completely ignoring the role chance plays and assigning predictions of future outcomes to the mirroring of past events.

Anchoring

Relevant both to considering the price of an asset and to deciding on a figure for an over/under or spread for a bet, the anchoring effect exhibits a tendency for humans to be influenced by numbers that are completely irrelevant. In *Thinking, Fast and Slow* Kahneman uses the following example:

> "...you might find it interesting that most people when asked whether Gandhi was more than 114 years old when he died, will provide a much larger estimate of his age at death than they would if the anchoring question referred to death at 35 years old. The funny and powerful examples shared here show that our behavior is influenced, much more than we know or want, by the environment of the moment."

That can be applied just as easily to decision-making pre-game sports bet. Irrelevant numbers can be present around the process of making a bet, influencing the side a bettor takes.

Hot Hand Fallacy

Effectively the opposite of gambler's fallacy, the hot hand fallacy phenomena is the belief that someone experiencing a string of successful outcomes is "hot," and thus the following outcome will demonstrate the same success. It is especially relevant in basketball when a player makes two or three shots in a row and everyone, believing that he has a "hot hand," believes he will make the next shot also. Regardless of how many shots the player has previously made, each individual shot is completely independent of all the rest.

Framing

Other research shows how easily we can be swayed in one direction simply by how a question or statement is framed. If being told a team had a 90% chance of winning vs. a 10% chance of losing, the results would show that the given team was picked to win at a higher percent when the statement was framed as the probability of winning being given. Which way the chances are listed is completely irrelevant and the odds are the exact same; however, we can't seem to move beyond the influence of the framing.

Loss Aversion

The overarching theme that Kahneman delves deep into is the inherent existence of loss aversion wired into humans which transitively many times leads people to the point at which they cannot make a truly rational decision when dealing with money. To us in large part, losing

$10 hurts more than winning $10 feels good. Furthermore, and for the purpose of this literature, the evidence of these phenomena (as previously mentioned) exist not only in the financial markets but also just as much within the sports gambling world.

Sports Betting

This study is not the first to look for trends or find holes in the sports betting market, nor for bets specifically on the NFL and NBA. Avery and Chevalier (1999) focused a study on the NFL in particular on biases of betting on the point spread (a prediction of how much the favored team will by and the underdog will lose by) of a game. They hypothesized that bettors bet predominantly on past winners, advice released by "experts," and well-known or prestigious teams. Furthermore, they presented evidence explaining how point-spreads move before the start of a bet based on the predictable manner of human behavior in reaction to sentiment that might be potentially unanticipated or fully anticipated. Potential profitability was the main significance of their study.

One influential study is *Point Spread Shading and Behavioral Biases in NBA Betting Markets* done by Humphreys, B. (2010). He hypothesizes that bookmakers influence investors betting by shading the lines one way or another to ensure more equal numbers of bets on either side. In the data presented in his study, less than 50% of the bets on the favored team hit the bet payoff - which wouldn't over an extended period of time be the case if the true probabilities were 50/50 as "designed to be."

Perhaps one of the more relevant studies to this study and investigating betting trends is the one Max Bazerman's conducted many times over his teaching career at MIT. Known today

as the dollar auction, Hazerman decided to auction a $20 bill starting at $1 with increments of a $1 dollar minimum. The catch, however, was that the second highest bidder had to still pay whatever his bid was, still without receiving the $20. What we can take away from Bazerman's experiment is that humans seem to be more loss averse than reward seeking. In one of the many Bazerman's experiments, the auction ended at $204. In other words, the winner of the auction paid $204 in return for the $20 bill and the second place bidder paid $203 for nothing. The point at which price reached about $10 is where Bazerman saw a drop to two bidders. Those bidders are then locked-in until someone settles. The fact that after the price started to reach above $20 one person didn't just take the loss and waited all the way to $203 to take it shows you just how much humans are averse to loss. Even when the extra $20 dollars is relatively worthless in the $200 range, the thought of losing $20 less dollars is just too attractive to give up.

Sports Betting and the Efficient Market Hypothesis

While both sports betting and the EMH seem to have their nuances, how exactly do they relate to each other? Is sports betting efficient? And, if not, can the inefficiencies be taken advantage of? Some data says certain intricacies within certain sports might show potential opportunities to generate some profit.

In a study done by Corey Shank in 2018, it was found that there are some potential inefficiencies in NFL games that might need to be further researched. Primarily, he claims that sportsbooks not only "underestimate the abilities of the home team as they are more likely to cover the spread when they are a substantial underdog" but especially when they haven't covered in the previous games. Additionally, Shank believes that "games are more likely to cover the

over than the spread when the closing line is large or small. The tables below present his data found in the study broken out by each trend.

Table 1 below shows a slight inefficiency when betting on the home underdog. Quoted in terms of the home team, from the table we can see that when the spread is heavily against team (up to 10 points and greater of an underdog), that they covered the spread 63% percent of time -- way above a 50/50 bet and even still significantly above any kind of percentage the bookmaker would take. Even just the line at +6, the home underdog still covered 54.1% of the time. If validity does hold for this trend, an investor could look for lines existing with large home underdog spreads and potentially generate returns.

Table 1

Home Spread	Home Wins	Home Losses	Home Win %
Less than or equal to -10	107	100	0.517
Less than or equal to -7	247	257	0.490
Less than or equal to -4	393	403	0.494
Less than or equal to -2	564	598	0.485
Less than 0	616	650	0.487
Equal to 0	28	23	0.549
Greater than 0	311	324	0.490
Greater than or equal to +3	231	238	0.493
Greater than or equal to +6	99	84	0.541
Greater than or equal to +10	29	17	0.630

Table 2 on the following page touches on the trend of the home team as well. When on a two-game losing streak of losing against the spread, the home team covered the spread in the next game 53% of the time. This should not be mistaken with the law of averages saying that averages are averages for a reason and, therefore, if a team has experienced the same result consecutively, then it must be more likely to yield the differing result the next time. It's purely a recorded observation that has the potential to be a legitimacy bearing continued research and

data. At least in the NFL, it appears as home teams with two game losing streaks against the spread might serve as a possible avenue to generate returns.

Table 2

Streak	Home Wins	Home Losses	Home Win %
Home team 2 game winning streak	218	235	0.481
Away team 2 game losing streak	265	235	0.530
Home team 2 game winning streak	219	223	0.495
Away team 2 game losing streak	231	271	0.460

A little less specific than the trend in previous table, Table 3 on the next page shows the percent of games the over hit (more points were scored than the set over/under value) on a spectrum of different values. Interestingly enough, the over win percentage is greatest on either end of the range of the spectrum. The total points greater than or equal to 52, less than or equal to 40, and less than equal to 38, won 54.6%, 54.8%, and 56.8% of the time, respectively. In contrast, the spread greater than or equal to 44.5 or less than or equal to 44, solely yielded an average over win percentage of 50.1%. The plausibility of this trend must rely on an outlier(s) that either tend to score a lot of points or very few points. In some cases, those teams must perform to an even more extreme, whether that be scoring more or less points than usual, that bring about this observation. The consistency of these scenarios would give a bettor opposite sides of over/under for which to search conceivably generating positive returns.

With this study being done solely on the NFL, we can't generalize it to other sports necessarily, but we can note that within the relationship between the sports betting market and the EMH, there does seem to be some inefficiencies that might refute the EMH's soundness.

Table 3

Total	Over Wins	Over Losses	Over Win%
Less than or equal to 38	79	61	0.564
Less than or equal to 40	165	136	0.548
Less than or equal to 42.5	338	316	0.517
Less than or equal to 44	499	481	0.509
Greater than or equal to 44.5	498	512	0.493
Greater than or equal to 46	371	374	0.498
Greater than or equal to 48	212	209	0.504
Greater than or equal to 50	115	114	0.502
Greater than or equal to 52	59	49	0.546

Chapter 3

Methodology

Before technology, expanding our mind and gaining knowledge could be done only by thinking and by actual physical research. There was no internet with infinite information at our disposal. Our ability to reason, be logical, make connections, among many other things, is obviously what sets us apart as a species and has allowed us to progress to the current state we are at today. Included as well is the innate capacity for the following generations to absorb and build on what was previously developed and generated by the preceding generations. With our ability to think, what are known as "Thought Experiments" are a natural accompaniment.

Using Thought Experiments

The Stanford Encyclopedia of Philosophy states "thought experiments are devices of the imagination used to investigate the nature of things" and "should be distinguished from thinking about experiments" and "counterfactual reasoning in general." The reality of our world is what it

is; however, the question is how, from just thinking, can we learn about that reality. Thought experiments allow researchers to quickly observe and explain what historically has been a mystery. The fields of philosophy, mathematics, economics, history, and the sciences that many of us dedicate their lives studying all used and still use these thought experiments in order to progress our understanding of the world. In the sciences alone, the work of the ingenious Newton, Galileo, and Descartes is relevant today because they were able to take reality and put it into a form in which humans can wrap their brains around, specifically through laws and discoveries that are themselves abstract and are solely a manner of explaining worldly phenomena in a way understandable by the natural human intellect.

Lucretius

A perfect example of that is an early thought experiment in the form of a poem by first-century BC poet and philosopher Lucretius in his poem *Lucretius, De rerum natura* (Lucretius On the Nature of Things). He writes about the bound, or lack thereof, of space. There's no experiment possible, especially during that time, that allows us to try to find the "end" of the universe. However, there are aspects we know from living everyday life as well as hypothetical scenarios by which we can reason and arrive at the conclusion (to the extent of what we're capable of conceptualize) that the universe has to be infinite and go on forever -- Lucretius does exactly that. The image on the next page from the the Stanford Encyclopedia of Philosophy website is a hyperbolic and comedic way of showing a finite universe would just seem a little bit "off" when truly thought about profoundly. Lucretius poses the situation of what would happen to a spear if thrown towards the "edge of the universe."

Figure 2

Source: Lucretius on the Nature of Thing

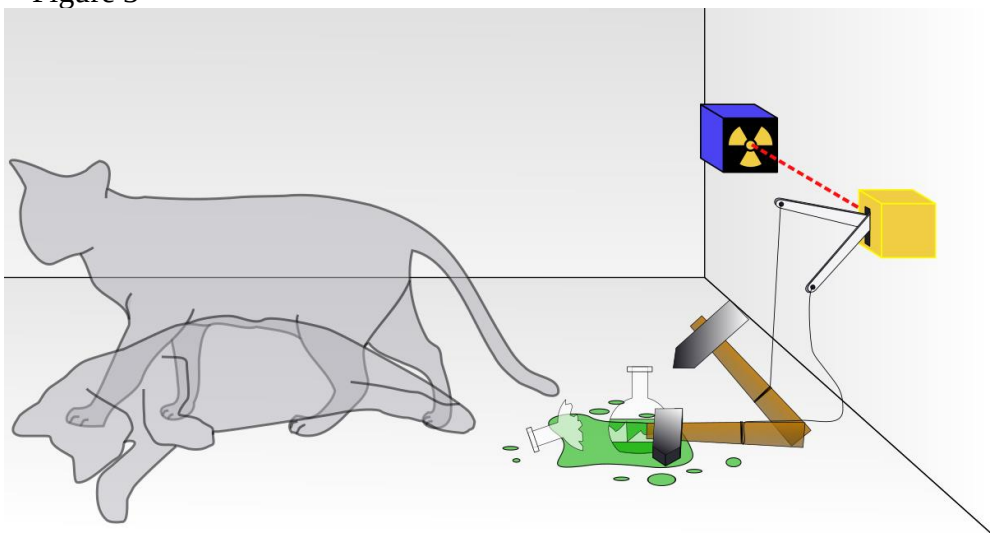
Schrödinger

Another example to illustrate the nature of these experiments is that of Schrödinger's cat. In 1935, Erwin Schrödinger, a Nobel prize-winning physicist, came up with following thought experiment summarized by National Geographic as well as a diagram from Wikipedia:

> "A cat is placed in a steel box along with a Geiger counter, a vial of poison, a hammer, and a radioactive substance. When the radioactive substance decays, the Geiger detects it and triggers the hammer to release the poison, which subsequently kills the cat. The radioactive decay is a random process, and there is no way to predict when it will happen. Physicists say the atom exists in a state known as a superposition—both decayed and not decayed at the same time. Until the box is opened, an observer doesn't know whether the cat is alive or dead—because the cat's fate is intrinsically tied to whether or not the atom has decayed and the cat would, as Schrödinger put it, be "living and dead ... in equal parts" until it is observed."

The diagram below shows what the thought experiment looks like. The cat is represented in both states of "living and dead."

Figure 3



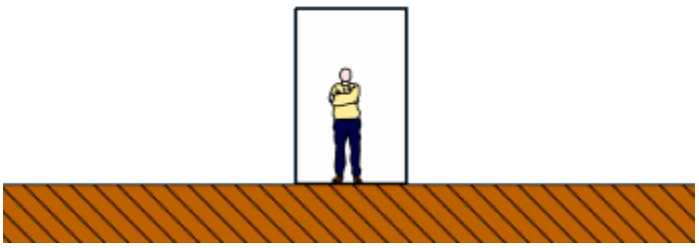
Source: National Geographic

Effectively, Schrödinger is saying the cat is both dead and alive *simultaneously*. He labels that "superposition," the idea that the cat is in both states at the same time. This paradox really puts the "thought" in "thought experiment." One must really think about what the reality is with two aspects that are mutually exclusive. Seeing it one way or another, or in other words guessing, leads to a high probability of being wrong. You can't, however, be wrong by considering all possible states and assuming it's a combination of all of them until actually seeing the cat. Either way, this demonstrates the cognitive make-up of these thought experiments. For this one in particular, there is nothing available except the "trials" and "experimenting thoughts" of one's mind.

Einstein

Even German Scientist Albert Einstein, one of the most famous scientists ever, used Thought Experiments to develop his theories. A thought experiment involving elevators, tennis balls, and rockets is what he employed in order to establish his theory of general relativity. The thought experiment went like this: Picture you are in an elevator, or more specifically, you are in some kind of room that would appear like what the inside of an elevator would look like, and you are secluded from the rest of the world outside. If you pick up a tennis ball and drop it, it falls to the floor just like you would expect given everything experienced here on Earth. The question Einstein posed was, "Does that mean 100% that the elevator is located in some gravitational field like the one of Earth? The picture from Online Einstein shows a basic drawing of the scenario.

Figure 4

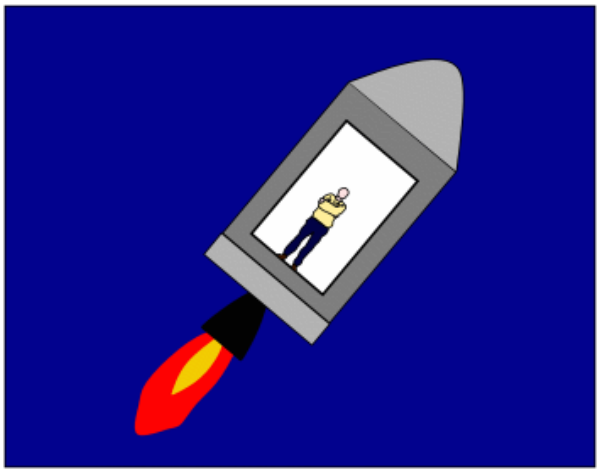


Source: Einstein Online

The answer to Einstein's question he found out was *not necessarily*. Hypothetically, you could be way out in space, nowhere close to any significant mass concentrations and the gravitational influence they possess. What you think is just an elevator, could actually be an elevator cabin inside a rocket, as long as that rocket is traveling at 9.81 meters per second (the acceleration of free fall from Earth's gravity), then the ball would "fall" similarly. In this

scenario, if you dropped the tennis ball you would not be able to discern between two situations from your vantage point. Is the tennis ball falling closer to a huge mass like Earth? Or is it that the elevator room floor is accelerating towards you? Again, the image below illustrates the scenario.

Figure 5



Source: Einstein Online

What Einstein was examining was the question of the equivalence principle under the theory of general relativity. Webster's defines it as: a principle in the general theory of relativity: the mass of a body as measured by its resistance to acceleration under the action of a force is equal to the mass as measured by the effect of a gravitational field on the body. Einstein clearly had no way of ever conducting this experiment in real life, but nonetheless he was able to produce his theory by solely thinking and using thought experiments.

Kahneman

More recently, Kahneman has used thought experiments to examine human behavior, both rational and irrational, and how it's related to decision-making -- particularly in regard to

spending money. In the 1990's, Kahneman created the term he called "mental accounting" which posits that we assign different value, characteristics, and sentiment to two different things that at their foundation and most basic level are the same and of equal worth. One of his more famous thought experiments sheds light on this phenomenon.

The scenario is about a woman who has bought two theatre tickets for $160. She is excited to see show, but upon arriving at the theatre she realizes she can't find the tickets. There's no sign of them anywhere and she feels uneasy about the large amount of money she's now wasted. What effect does that have on the show? Will she buy replacement tickets for another $160, or chalk it up as a loss and go home? That was the question and scenario Kahneman posed in the 1980s to a sample of people. He found that almost nine out of 10 presumed that the woman having lost her tickets, would pass up on seeing the play. But what if the scenario was changed slightly?

This time, the woman didn't buy the tickets in advance, but rather came with $160 in cash to buy the tickets at the box office. When she gets to the theatre and opens her purse to pay, she realizes somehow the money is missing. Does she use her credit card instead? Kahneman saw more than half of the people change their answer and say yes in this scenario,

The $160 is worth the same in both scenarios, so why would the sentiment be different for the participants of the experiment? Kahneman believes we mentally account objects and money in an irrational way explaining the movie tickets get pinned into their own category of entertainment where repurchasing them would seem excessive and superfluous, while putting the misplaced cash into a category of "general" money which there exists more of, and therefore, seeing no issue of using more of it to still end up seeing the play. It's the same ideology of

humans accepting, maybe even without thinking, paying more for something on vacation than they would otherwise in a normal, everyday-life setting. The discovery of this illogicality was made possible through the successful carrying out of the thought experiment behind it. It enabled Kahneman to explain the reasoning behind something that without the mental effort and energy would have gone undiagnosed and remained an unexposed concept.

Thinking, Fast and Slow

Kahneman went even deeper in his research though. Although important and informational in themselves, the results of many of his thought experiments don't paint the whole picture of why we think the way we do and the effects of it. In the first section of his book *Thinking, Fast and Slow*, a book of research conducted by Kahneman with a large portion of overlapping research done jointly with other famous behavioral economist Amos Tversky, Kahneman breaks down the two ways in which the brain creates thoughts, System 1 and System 2. On the next page is the list from the book Kahneman created distinguishing the two types.

The significance of breaking down human decision-making into these systems is highlighted by the fact that the heuristics and biases to which humans fall prey influence primarily our System 1 thoughts. Human decision-making in his opinion is inherently vulnerable to misinterpretation of the large amount of stimulation and inputs we receive in our waking lives daily. What does it mean if the thought systems yield differing results even when that stimuli and those inputs are identical? Kahneman and Tversky's thought experiments look to explore the answer to that question and address the heuristics and biases arising from our environment.

Many of Kahneman and Tversky's experiments deal with money which seems to ignite more irrationality in us than just about anything else able to be considered. Just like we are easily manipulated by money, money can be easily manipulated to take on different forms

Figure 6.

System 1
Fast, automatic, frequent, emotional, stereotypic, unconscious. Examples (in order of complexity) of things system 1 can do:
• See that an object is at a greater distance than another • Localize the source of a specific sound • Complete the phrase "war and ..." • Display disgust when seeing a gruesome image • Solve 2+2=? • Read a text on a billboard • Drive a car on an empty road • Come up with a good chess move (if you're a chess master) • Understand simple sentences • Connect the description 'quiet and structured person with an eye for details' to a specific job

System 2
Slow, effortful, infrequent, logical, calculating, conscious. Examples of things system 2 can do:
• Brace yourself before the start of a sprint • Point your attention towards the clowns at the circus • Point your attention towards someone at a loud party • Look out for the woman with the grey hair • Dig into your memory to recognize a sound • Sustain a higher than normal walking rate • Determine the appropriateness of a behavior in a social setting • Count the number of A's in a certain text • Give someone your phone number • Park into a tight parking space • Determine the price/quality ratio of two washing machines

• Determine the validity of a complex logical reasoning • Solve 17 × 24 Source: *Thinking Fast, and Slow*

(i.e. cash, credit card, debit card, etc.), producing different consequences and behavior with how we spend it. Generally, the mistakes we make in how we spend and allocate our money are derived from an error in thinking, stemming from the ease in which our systems can give alternate signals and cloud our judgement. Once used to determine the truth about something as sophisticated, complicated, and multifaceted as the infiniteness of the universe, thought experiments are used nowadays to determine the truth of why humans may or may not value something as simple as a $1 bill the same way. These thought experiments are instrumental in the field of behavioral finance, the world of sports betting, and vastness of the financial markets.

Chapter 4

Thought Experiment Results and Betting Data

The goal of this paper is to continue to demonstrate the relationship and overlap between behavioral finance and sports betting to probe and hopefully discover useful connections and applications for the financial markets. Through various thought experiments and a collection of betting data, I hope to accurately analyze the behavior and decision making of the subjects participating in my studies. As with the experiments of Kahneman, Tversky, and Schrödinger, I want to explore some kind of theory or hypothesis for the purpose of discovering its consequences. The desired consequence in this case is not only the observance of some sports betting trends stemming from behavioral finance, but also the idea of a potential means to avoid

falling down the rabbit hole of irrational decision-making and/or some way to profit off the irrationality of others.

In order to continue to reinforce and demonstrate the evidence of the large presence of psychology in monetary decisions within humans, along with gathering as much data from bets as available to me, I set up and retried various experiences that display human heuristics and biases containing a relation with sports betting.

Gummy Bears and Blindfolds

Something as simple as a piece of candy, but manipulated by the perception of sight, showed how easily susceptible humans are to being fooled or to making incorrect assumptions by bias. Experiment #1 consisted of trying Haribo gummy bears without being presented the bag or label, and of naming the flavor of each bear one color at a time. Twenty people tried each of the five different kinds of bears first with a blindfold and then without.

Table 4

Without Blindfold			With Blindfold		
Color	Haribo Flavor	Responses	Haribo Flavor	Responses	Correct Guesses
Red	Rasberry	11	Rasberry	20	5
Red	Cherry	13	Cherry	17	3
Orange	Orange	24	Orange	22	2
Yellow	Lemon	24	Lemon	15	5
White	Pineapple	24	Pineapple	15	3
Green	Strawberry	7	Strawberry	13	1
Green	Watermelon	12	Watermelon	18	2
Green	Green Apple	5	Green Apple	0	
Total		120		120	21

From the results from Table 4 on the previous page, you can see that we are heavily influenced solely by the color of the gummy bear. The percentage of correct "flavors" guessed from 79% to 17% when the blindfold was used, or in other words, when the participants had no idea of the color of the gummy bear. Interesting to note, the gummy bears whose colors are almost always paired with the same flavoring (orange, lemon, and pineapple) were guessed 100% correctly without the blindfold. The accuracy drops off vastly in the blind test. Furthermore, the green gummy bear, which is "flavored" strawberry, had significantly more guesses of flavors of green fruit rather than the true strawberry. For the same green gummy bear in the blind test, not a single "green apple" guess was given.

What this experiment sheds light on is the factors affecting human decisions. Similar to someone believing right-off-the-bat that a yellow gummy bear, or any piece of yellow candy, is lemon-flavored, we see investors falling susceptible to familiarity the same way. By choosing a stock of a company over another based-on recognition regardless of the similar performance shows how the bias translates. The same is true for a sports better who, in deciding how to place a bet between two equally talented teams, decides to place the bet on the team that gets more media attention or coverage than the other.

The True Value of a Reese's Cup

Continuing with the theme of candy, the second experiment conducted involved the same 20 participants setting a buy and sell price for a pack of two Reese's cups. I handed the pack of Reese's to each participant and asked them to first give me the price at which they would buy from me, and then second at what price they would sell it for if someone walked into the room asking for a Reese's. One would expect the buy and sell price to be relatively the same as the Reese's isn't inherently changing values in either

direction. However, what was observed was that the average price of the subjects for buying the Reese's was just over $0.91 while the average selling price came out to $1.07. Regardless of what the Reese's actually cost, this price differential demonstrates how humans are more averse to loss than they are attracted to gain. This loss aversion stems largely from the ownership establishment taking place. When the participants believe they "own" Reese's, they feel the need to be compensated more for it leaving their possession than if they were just buying it outright. In rational thinking, any person should be willing to pay and accept the same amount of money. This translates perfectly into same observed behavior but with money as the object of consideration.

When $20 is Worth More Than $20

The third experiment I conducted was a repeat study of the dollar auction previously mentioned and done by Max Bazerman at MIT. However, to get a different perspective, I decided to conduct the experiment with two different groups of people but with a twist. One group of ten ran through a practice round before doing it as a real auction after the first one ended. The other group of ten did the real auction first and then was made to believe there was a recording error the first time and the auction had to be repeated. The first group was informed of the first run-through was a practice round before the run-through was conducted. In the first group's practice round, the bill being bought for $26 dollars. However, when the experiment was said to be a real auction during the second trial, the price jumped up to $42. When there wasn't actually going to be money changing hands, the subjects did not feel like same aversion to loss and the auction was accompanied with commentary from the bettors along the lines of "if I got locked into the last two person bidding war, I wouldn't actually pay much more than I'd be getting." Clearly that was a false belief because *even* with the practice round taking place before and the bettors

realizing quickly just how out of hand the auction can get, they still let themselves be influenced by trying to minimize as much loss as possible when pretty soon the winning of the $20 or not becomes insignificant. On the other hand, the second group having the real trial coming first, their $20 bill sold for $53. Interestingly, when the second trial was performed after the first one was ruled moot, the price dropped to $29. From this sequence, it appears as if given the fact that following the first "real" trial the two highest bidders really believed they were following through with the payments and experienced the oncoming feeling of loss (paying me the money), it was enough to stick with them that following the second trial they subjects were smarter and got out earlier (but even still paying over $20).

Although the nature of the auction means that only two players are left in the game pretty quickly when the bidding reaches a certain price, it does show that while still irrational, some of us (but not all) have the capability of at least beginning to learn from our behavior. This trend definitely does not apply to the majority, though, as in the next experiment we observe a trend far from learning and becoming less susceptible to bias.

Trivia and Overconfidence

As a way to display the stringent effect that overconfidence has on just about every decision we make involving the test of the knowledge and information we possess, I carried out a simple experiment consisting of ten trivia questions. Thirty participants were given ten questions (five at a time) that all had numerical values as answers and were asked to produce a high-value and low-value as a range that would make them 90% confident that the true value was somewhere in

between. Namely, they were asked to come up with a 90% Confidence Interval (CI). The trivia tests are shown below.

Choose a low and a high value so that you are 90% confident

that the true value lies in the interval

Example:

Test 1

0. What is the seating capacity of Beaver Stadium?

_100,000__ _110,000__

1. What is the average weight of the adult blue whale in pounds?
_____ _____ o
2. In what year was the Mona Lisa painted?
_____ _____ o
3. How many independent countries were there at the end of 2000?
_____ _____ o
4. What is the air distance, in miles, from Paris, France to Sydney, Australia?
_____ _____ o
5. How many bones are in the human body?

_____ _____

Total = _____

Test 2

6. How many total combatants were killed in World War II?
_____ _____
7. How many books were in the Library of Congress at the end of 2000?
_____ _____
8. How long, in miles, is the Amazon River?
_____ _____
9. How fast does the earth spin at the equator, in miles per hour?
_____ _____
10. How many feet high is the world's largest waterfall (Angel Falls, Venezuela)?
_____ _____

Total = _____

Given the number of questions in each individual test was five, you would expect to see an average of 4.5/5 (5*.90) for the scores of each of the test. However, the two tests being broken into two sections may show how much we let overconfidence affect our decision making.

The first test was given to the subjects just as shown above with the instructions, that I also read aloud, at the top of the page. They took the test individually and then handed them back into me. I tallied up the scores, and then told them the results. In table 5 on page 41, you can see that in the first test, the average number of correct guesses only came out to 1.7 correct out of 5, far below what a 90% Confidence Interval would suggest. This is clear evidence that overconfidence skews our ability to honestly reveal how much information we actually know. The questions given on the test were no doubt very difficult, but that was intentional in order for the guessing aspect to be present and to trigger easy influence to bias. It is effective to the extent that all 30 people were so sure about their ranges (whether conscious or non-conscience) that they that they put ranges with very little leeway and ended up missing all five of the questions. Nonetheless, the results from Test 2 prove even beyond Test 1 how prone to overconfidence we are.

The particular variable that makes the results even more surprising is the different way it was set up from Test 1. Before Test 2, I read them the answers and scores to Test 1, explained how many more they all should have gotten correct based on the 90% CI, and then expounded on the existence of overconfidence in so many of our life processes including this one. In essence, I told them humans fall victim to overconfidence bias, and in this experiment, it showed up as the participants invariably picked smaller ranges instead of being safe -- which was due to how

confident, or really *overconfident*, they were. If it were possible for us to be completely rational, the participants in the study should then realize they simply need to make huge ranges to ensure without a doubt the true value falls within. Yet even with that knowledge, what would seem like a logical and natural transition did not occur: only four of the 30 participants showed even a single increase in the number guessed right. From the table you can see the average correct guesses went from an already very low 1.7 to 1.87 in the second test, making the jump in percentage between the tests a mediocre 2.67%. There's no specific percentage increase that should be observed; however, the percentage should have increased at least enough so that the average number of correct guesses is around that 4.5 90% CI given that the subjects knew the purpose and goal of the study. Only three people answered four correct, and no one answered all five. And what might be the most astonishing of all the statistics is that the number of participants who got zero questions right actually increased (8 to 11) for the second test. We are so certain and convinced of what we think we know that we are blinded to the degree to which we are overconfident -- even after being made aware of it.

Table 5

	Test 1	Test 2
Average Number of Correct Guesses	1.7	1.87
Percent Correct	34.67%	37.34%
Number of Scores of '0'	8	11
Percent of Scores of '0'	25%	36.67%

Following the experiment and after reading aloud the second test answers, I had participants tell me that the reason the scores weren't much better on the second test was because they were significantly harder. The difficulty of the questions is certainty subjective depending on the breadth and detail of knowledge each participant bears. Moreover, even if Test 2 was

significantly harder for every single one of the 30 subjects, that still should not affect the ability to identify a proper 90% CI range if they do not think over confidently. That actually especially should be the case if the questions were harder because it should urge the subjects to make very large ranges given the uncertainty.

Betting Data

Lastly, to demonstrate where these behavioral finance aspects actually show in the field of sports gambling, I gathered data and observed the betting patterns of 10 subjects over the course of several months. I even went as far to write down much of the dialogue spoken in between many of the subjects before, after, and during betting. The sports bet on included college football, college basketball, NFL, and NBA. As for the types of bets, the spread, over/under, and moneyline made up the majority of the bets placed. A lot of the data I collected reflected the effects of the many potential biases that could have arisen over the time period.

Two of the more obvious biases that were present were the availability heuristic and the gambler's fallacy. The gambler's fallacy was especially clear for the bets placed on the NBA games. Following the 2017-2018 season where the Golden State Warriors won their third NBA championship in the last four years, there was a huge amount of hype and optimism for them going into the 2018-2019 season as always seems to be the case. That was reflected in both the bets and commentary made by the ten subjects. Despite the Warriors being towards the bottom of the league in record against the spread (ATS) last season and at this point in the 2018-2019 season, the subjects bet on the Warriors to cover almost twice as much as they actually did.

Table 6

Average Number of Warriors Games Bet On Amongst Subjects (range b/w 55-63)	61
Warriors Picked ATS (%)	82.30%
Warriors Record ATS (Wins-Losses-Ties through 4/8/19)	35-44-1

Table 6 above shows that of the average of 42 Warriors games bet on by the subjects, they bet on the Warriors to cover over 82% of the time. But the Warriors only actually covered 30 out of 78 games (42%). It's easy to succumb to all the attention and positive publicity which always surrounds the Warriors with the recent significant success they've had, by having exciting, high-scoring players such as Stephen Curry, Kevin Durant, and Klay Thompson, and by frequently being nationally-televised. This may have swayed all 10 subjects to continually incorrectly make bets heavily influenced by their emotions. Dialogue such as "{The Warriors} are always more likely to cover. They have Steph and Klay who can go off (score a lot) any second unlike the other team," and "They've lost against the spread the last three games, I promise you they're due to cover tonight" serve as perfect examples of how humans think when deciding about money. The fact that the Warriors have established themselves as a dynasty and the best team in the NBA year in and out makes them more "available" to us, hence the availability heuristic, and influences our bet choice. Furthermore, any individual betting on the "hunch" that a team is "due" for anything has already been completely swallowed up by the gambler's fallacy and lost all chance at making a rational decision.

Despite what many sports bettors might tell you, in-game betting perhaps might show even more irrationality in human decision-making. Most sportsbooks give their users the capability of continuing to make bets on the game in progress with the bookie changing the lines/spreads based on the course of the game. Information is always good when making a financial decision; however, the interpretation of that new information just like any previous info brings the susceptibility to falling victim to all the human biases, particularly overconfidence and confirmation bias. Another variable is the fact that you have less time to process information and resort to relying on heuristics, leading to behavioral problems. The new information from the game starting and time passing makes many bettors feel as if this new information gives them a better idea of what the outcome will be, prompting an additional bet on the game. In reality though, seeing how the game is playing out for the most part just exacerbates the emotion or biased thinking while placing a bet.

Table 7

Number of Live/In-Game Bets	601
% Won	20.3%
Average Pre-Game Bet Amount	$25.72
Average In-Game Bet Amount	$33.23

The Table 7 above clearly exhibits the confirmation bias' effect on the subjects' bets selections. If seeing the first half of a basketball game really could with little margin make it easy to predict the end of the game, more bettors would be profiting off those types of bets and the

win percentage of the subjects would most likely be higher, despite their amateur betting knowledge. What's even more interesting than the low win percentage is the difference in the average bet amount between pre- and in-game bets. The in-game amount being almost 30% more shows exactly overconfident the subjects are while making bets they believe they now have enough information to win for certain. It also demonstrates the problem humans run into when interpreting information. Confirmation bias, or the tendency to search and support information that agrees with your existing opinions and views all while neglecting anything contradictory, most definitely applies here. While the game is going on, often we are watching it with a lense looking for signs to *confirm* a view about a bet we've already placed or are going to place. In the first half of the Duke vs. UNC ACC semi-final game on 3/15/19, there was a point where Duke got down 12 points. One of the subjects then spoke up and said: "See, I told you. It's going to be just like the other two games (referring to the UNC winning the two previous games played against Duke this season) and won't be close." He double-downed[12] and made a second bet on UNC winning outright, but this one being a live bet and almost twice the amount of money. Duke, however, ended up winning the game by one, and the bettor's wallet was a little bit lighter after he let himself be influenced by a view he was completely set-on. UNC getting up double digits was information he was "looking" for and in his mind confirmed his first bet and contributed to him placing another. The conversation following the game of: " I always lose money when I live bet," responded to with "I always lose money when I bet, period," still isn't enough to generate full awareness of the need to remove all emotion and irrationality when gambling.

Of all the bets made among the four sports (plus the NCAA tournament games to this point), there were interesting outcomes as far as win percentage is concerned. From the table

below, it was observed that the NBA had the lowest success rate, 22.09%, for the subjects winning their bets of all of the sports. Perhaps that speaks to it being the most efficient of the sports betted on. It might be that the bookmakers are more skilled/accurate in setting each bet and that it really does require a high knowledge of basketball and other information to consistently hit the bets. A possible explanation might consist of the individuality and superstar prowess the NBA has. One player, e.g., LeBron James, can by himself take over and win a game, to an extent. That leaves less uncertainty of outcomes when his talent is that great, that undeniable, and most important that unstoppable. On the other hand, NFL is the sport that requires the most teamwork and allows for the smallest possibility of a single person dominating all aspects of the game. It does not matter how talented the quarterback of a team is if his offensive line is unable to block for him. That's very different than one of LeBron's teammates merely having to hand him the ball and letting him do what he wants. The more potential variability of the NFL, along with all the home team and over/under trends previously mentioned, might make it easier to win bets more often than the rest of the field and produce a higher winning percentage, 53.37%.

As for the college sports, college football is like NFL in that it really requires skilled players at every position to be successful. However, there's a greater discrepancy in talent in college than there is in professional, so one player may be able to control a game to a greater extent than an NFL player and is potentially why the college football bets hit at a higher percent. That may lead to more certainty for the bookmakers and require more knowledge to have a higher betting win percentage, hence the betting win percentage, 42.06%, being in between NBA and NFL. In regard to college basketball, even though the nature of the sport is very similar to the NBA, there are fewer superstars, and the makeup of the sport (rules, number of games, age of

players, etc.) seems to give it the most variability of all sports. With this variability come more incorrect lines, over/unders, and money lines thus allowing for the bettors to win bets with less knowledge and information on the sport. The bet winning of 57.58% is the highest of all sports. To demonstrate that further, of the 176 bets the ten subjects have made on the NCAA Basketball Tournament up to this point (through the Elite Eight, i.e. the four teams and three games left), have been right 59.66% of the time. The NCAA basketball tournament has earned the nickname "March Madness" given its incredible unpredictability and haphazardness and that it takes place in March. For whatever reason, in all the games played throughout the tournament everything else seems to go out the window other than how each team happens to play in that particular game. In a regular season game, or perhaps even a conference tournament game, where stats, strength of schedule, preparedness, and team chemistry, among many other factors, might help give a prediction of the outcome of the game, in March Madness that might all be completely irrelevant. For example, last year in the 2018 NCAA Basketball Tournament, University of Virginia (UVA) became the first number one seed to lose to a 16 seed[11], which was the University of Maryland Baltimore County (UMBC). The talent discrepancy between the two teams was very large, and UVA had the capability of blowing them out. However, in the craziness that March Madness is, UVA lost the game. The takeaway here is the even greater uncertainty existing in the NCAA Basketball Tournament affects even the games that should be almost certain. A very miniscule number of people picked UMBC to upset UVA, but an even smaller fraction of people would have picked that upset were the game to be played during the regular season. UVA was a 20.5-point favorite, and you would have had to bet 10,000 to win 100 by taking them with the moneyline. The immense unpredictability is very apparent in the fact that UVA lost by 20, 40.5 points off what the sportsbook predicted. Here exists the opportunity

for bettors to generate returns by capitalizing on inaccurate lines, and moneyline predictions by the sportsbook. Table 8 shows the breakdown for each sport.

Table 8

	Sport				
Variable	NBA	NFL	College BB	College FB	*NCAA Tournament
# of Bets	850	815	910	775	176
Win %	22.09%	53.37%	57.58%	42.06%	59.66%

*Falls under sport of college basketball and is data for 64 of the 67 games

Chapter 5

Dialogue

Of all the subjects I had participating my experiments and from whom I took betting data, I went even further with those whose betting patterns I followed and whose dialogue I took note of around and during the bets. Although not empirical, the many conversations and statements made only point more to how we are thinking irrationally when making monetary decisions. The humor surrounding the dialogue, although unrelated, was an undeniable, engaging consequence of monitoring the betting behavior.

As a first example, one of the subjects when on the topic of being bias-free while betting said: “Bias is definitely completely out of all my bets. I literally only looked at how the teams have played in the past, and I only bet on my favorite teams when I’m sure they’re going to win.” There are several issues inherent in that comment that a behavioral economist might red flag. For one, the subject is thinking biasedly by believing that all bias has been removed from his decision-making when he/she is placing bets. That is exactly what lowers our guard to

resisting all of the many external and internal influences we experience. Two, the subject fell prey to the recency bias. The fact that a team has won or lost in the past has no bearing on whether the team is going to win the following game. Lastly, claiming he/she only bets on his/her favorite team win he/she "is sure they're going to win" perfectly illustrates overconfidence bias. There is obviously no way of knowing the outcome of a game before it starts.

Another great example is the statement from one of the subjects referring to 2018-2019 Duke basketball star Zion Williamson, highly debated as the most unique and potentially the most overall talented college basketball player that has ever been seen.. While watching Duke play Syracuse in the third round of the ACC tournament, a game in which Williamson did not miss from the field (a perfect 13/13), the subject made the statement "Zion hasn't missed all game, there's no way he can keep that up. The law of averages exist for a reason. I'm going to take a bet on him not finishing the game having made 100% of his shots." While it has been proved that over a large sample that random variables do indeed reflect their underlying probabilities, a small sample size is in no way shape or form "supposed to" abide by the law of averages. Averages and probabilities occur over large population sizes. In the end, the subject of course lost the bet by falsely believing Williamson was "due" for a miss. It can be an expensive mistake to make. This phenomenon touches again on gambler's fallacy. Each of Williamson's shots were independent of each other. Even the 13th shot did not have a greater chance of going in based solely on the fact that he made the previous 12.

A rather humorous example of a bias that creeps in more and more is a sentiment towards live betting that demonstrates the effects of restraint bias. Following a very large loss of a live bet during an NBA game, one of the subjects exclaimed "I'm never going to live bet again; I

can't have any success with it." It takes a mature person aware of the many human biases to make and then follow-through with that statement. However, for the most part, we become influenced to what is known as restraint bias. Humans generally overestimate their ability to control and restrain their impulsive behavior. While making that statement was a good first step to controlling the constant losses of live-betting, since saying those words, that particular subject has made over 20 live bets, of which he's won only six. The best plan of action would be to control his betting book account so he can't make any more live bets. Nonetheless, we see the subject felt he/she could control their actions more than he/she really could.

Chapter 6

Conclusion

This paper verifies two things: 1) the existence of and the scope to which the almost innumerable biases and heuristics that influence human decision-making, and 2) these influences mean that there are potential market inefficiencies in various sports or tournaments within a sport that can be exploited. Particularly from the data on page #37, the study demonstrates that gambling on the NFL and college basketball appears to be the most inefficient markets due to the highest certainty that they possess, allowing for the greatest success rate for the bettors. The relationship between sports betting and human bias, although still requiring more research, can be compared very easily with the human behavior we witness in the financial markets. Valuing a stock follows the same type of thinking and reasoning as valuing the price of a basketball game. Deciding to buy or sell a stock compels our minds to take into account many of the same underlying variables, just with different labels. Our ability to successfully navigate the financial

markets within our life depends on our capability to think big picture and consciously curb the pull the biases enact on our decision making. Producing returns in the market does foundationally require a base of knowledge. However, generating returns happens primarily to those who can resist being succumb to the urges of their inherent and initial thoughts when making a monetary decision. Making a judgment on a stock is generally equivalent to making a judgment on the outcome of a sports game. The awareness and proper action against these biases is where we begin to make sound financial decisions both betting and in the markets.

Chapter 7

Next Steps and Follow-Up Research

There is still much research to be done on this topic that is not encompassed in this paper. For one, more sports betting should be examined. How do behavior and biases look after decision-making when betting on baseball, or, say, hockey? Would that data tell us something different about our behavior in financial markets? Also, how would the behavior of the subjects change if the values at stake were higher? Specifically, would we see a change if $20 auction was raised to $20,000, if the Reese's was swapped out with a car, or the minimum sports bet allowed was $1,000?

Further research should also be done on a different sample population. The bulk of my data came from well-educated, university students who do not fully represent the average population.

Another interesting variable to investigate is the effect a real annual income has on the behavior. Would the flexibility in spending make them bet larger amounts and/or more often? Or

would the loss aversion increase from the realization of what a real annual income comes with and make them bet smaller amounts and/or less?

Lastly, and perhaps the most interesting, research needs to be done on software and algorithms that can be created to *truly* account for these biases and errors in human thinking for both the financial and betting markets. Is it possible to really accurate reflect something that's so abstract and hard to escape? If so, would the markets then finally be one hundred percent efficient?

Appendix

1. A parlay is a single bet that connects together two or more individual wagers while being dependent on all of those bets hitting together.
2. A teaser allows for a bettor to bet on point spreads or game totals and then adjust or "tease" the line to improve their chances of winning. In return, the odds are reduced and the bettor would receive a lower payout upon winning.
3. Buying points gives the option for the bettor to move the line of a bet in either direction of their favor. The catch is that every half point bought, the bettor has to risk 10 extra cents on the dollar to win the same set amount.
4. Futures bets are bets that take place usually at some time in the distant future. The bets generally involve many sequences of events before the outcome of the bet could even be decided. For example, betting on the San Antonio Spurs to win the Championship at the beginning of the season is what a popular futures bet would look like. For the Spurs to win the championship, they have to first make it to the playoffs, win in each round, and then win in the Championship. None of those requirements are certain, and, therefore, make it so the bet might not even have a chance to hit.
5. Propositions bets are bets on a game on occurrences or non-occurrences 2that don't have a direct impact on the outcome of the game. For example, betting on the color of the Gatorade bath at the end of a championship game.
6. The weak form of the EMH states that past prices, historical values and trends, and volume and earnings data do not affect a stock's price and cannot be used to predict the price in the future.

7. The semi-strong form of the EMH states that a stock's price factors in all publicly-available information, and any change in that price is on the basis of that public information. It considers fundamental and technical analysis useless and contends that only material non-public information can be of benefit when trading.
8. The strong form of the EMH states that the market is so efficient that even non-public, insider information still can't generate an investor abnormal returns. It posits that even insider info is always reflected in the stock price and its true value is reflected.
9. The book-to-market ratio compares a company's book value, or accounting value, to it's market value.
10. Market capitalization is the number of outstanding shares of a company multiplied by the current share price.
11. The closing line the line of the bet at the start of the game. It may have changed from the opening line (how the bet opened up) leading up to gametime.
12. Double down is a term borrowed from blackjack which in this case refers to a bettor doubling his initial bet on same outcome previously picked.

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ACADEMIC VITA

Luke Henegar

EDUCATION

The Pennsylvania State University — **University Park, PA**
Smeal College of Business and The College of Liberal Arts — Class of May 2019
Schreyer Honors College
Paterno Fellow Scholar
Bachelor of Science in Finance and Spanish — Dean's List 6/6
Minor in International Business

The University of Alicante — **Saint Vincent Del Raspeig, Spain**
The Council on International Educational Exchange — *January - May 2018*
Highest Spanish Level Track

RELEVANT EXPERIENCE

PNC Bank — **Pittsburgh, PA**
Financial Institutions Group Summer Analyst — *May 2018 - August 2018*

- Helped develop and sell PNC's Capital Market investment products
- Sat in on sales pitches and meetings with current PNC clients and prospects
- Assisted in putting together pitchbooks and updating excel models for client/prospect meetings
- Completed a case study detailing hedging strategies for a PNC partner bank and corporate client
- Carried out various economic presentations presented to the associates and managing directors
- Daily/weekly write-ups of different markets and industries sent out to all Capital Market teams and divisions
- Created bank and company overviews of prospects and current clients to be used as prep for meetings and calls

ESPN U — **Charlotte, NC**
Internship — *May 2016*

- Learned how to create Marketing and Programming plans for the ESPN U channel
- Aided in the logistics planning of ESPN U college sports events and sites
- Sat in on calls with different sports leagues discussing potential ESPN coverage rights to games and tournaments

Morgan Academic Center Student-Athlete Tutor — **University Park, PA**
Finance and Spanish Tutor — *September 2018 – Present*

- Tutor Penn State student-athletes of various sports in Spanish and Finance
- Carry out weekly progress checks and updates with student-athletes

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LEADERSHIP

Schreyer Scholar Advancement Team — **University Park, PA**
Honors College Ambassador — *April 2017- Present*

- Represent the Schreyer Honors College at special events for alumni and donors
- Provide tours of campus and honors housing
- Serve on student panels for alumni, donors, and prospective students and families

ACACIA Fraternity — **State College, PA**
House Manager — *November 2016 - November 2017*

- Serve as a leader in the fraternity as an executive board member
- Manage repair/replacement budget and establish yearly repair/replacement projections
- Repair/replace any broken or non-functioning items or structures around the fraternity house
- Coordinate with vendors about renovations and improvements with the house

Gammacacia Thon Organization — **State College, PA**
Fundraising Volunteer — *September 2015 - Present*

- Raise funds in various states and cities in the Northeast to donate to help fight pediatric cancer
- Write letters to alumni and donors to help the Gammacacia and Penn State Dance Marathon cause

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SKILLS

- Proficient in Bloomberg, S&L, Microsoft Excel, Word, and Powerpoint
- Spanish fluency - Semester in Alicante, Spain - Spring 2018
- Mastery at playing piano (15 years)