Risking Treasure: Testing Loss Aversion in an Adventure Game

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ABSTRACT

Loss aversion is a cognitive bias in which the negative feelings associated with prospective losses have a greater magnitude than the positive feelings of winning equivalent gains. Although well studied in behavioural economics, there is little understanding of whether and how it arises in game contexts. In games, the "magic circle" may free players from their held attitudes, especially because in-game losses and gains are virtual. On the other hand, experienced immersion and a desire to achieve may make in-game decisions similar to out-of-game contexts. Knowing whether cognitive biases like loss aversion affect players is important for game designers when they create decision points and choices for players. We carried out a study in a *Zelda*-style game with 18 decision points about wagering gold at different win:loss ratios. Our results show that despite the temporary and digital nature of the game world, and the virtual nature of the gold, players still exhibited a strong bias towards avoiding losses. Our findings imply that designers should understand and account for loss aversion when setting up risk and reward structures in their games.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**; *HCI theory, concepts and models*; User studies; • **Applied computing → Computer games.**

KEYWORDS

Loss Aversion; Game Design; Cognitive Bias

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1 INTRODUCTION

Loss aversion is a phenomenon of human behaviour and decision making that refers to people's tendency to "prefer avoiding losses to acquiring equivalent gains – it is better to not lose $5 than to find $5" [126]. Behavioural economists such as Tversky and Kahneman have shown that loss aversion occurs in many situations [119, 121], however, there is little knowledge about whether this phenomenon occurs in videogames.

There are reasons to believe that loss aversion will be reduced in games, but also arguments that it will still occur. Games provide an alternate environment in which people are able to act very differently than they do in the physical world (even considering debates over the idea of the "magic circle" and the blurring boundaries of the game world and physical world [30, 94, 114]). For example, since stakes are lower in games, players can take on personas of killers or criminals without having these tendencies in their ordinary lives. Therefore, it is possible that people may be less risk averse in a game world than in the physical world – e.g., players choose to break traffic rules and run from the police in games like *Grand Theft Auto* but would not do this in ordinary life. However, players are still keenly aware of risks and rewards in games, and they may simply be re-calibrating to the realities of the game world. For example, a player who wants to complete a mission in *GTA* may be very risk averse in certain parts of the game where being noticed by the police could result in losing assets, progress, or opportunities.

Games also provide digital currencies, that although linked to out-of-game currencies, employ methods of obfuscating the translation (e.g., V-bucks in *Fortnite*). Money in a game and the assets it purchases are digital (leaving aside those games in which virtual items can be sold for actual currency). If the gold pieces gained in a dungeon crawler are simply "play money," players may not have any strong aversion to loss. This is similar to settings in which people who would not normally gamble are given money to spend at a casino – the fact that losing their initial stake does not involve the player's own money, as well as the primarily hedonic rather than utilitarian aim of gambling, may reduce loss aversion [32, 103, 115].

However, players may again be re-calibrating to a game world in which objects and money have varying degrees of utility for achieving ends in the game. If gold pieces in the dungeon crawler have utility – for example, if they allow the player to purchase a better weapon – then the gold is no longer "play money" that can be thrown away.

Games further allow people to interact with digital assets on a regular basis. Inventory management systems, game lobbies, and new daily or weekly items all encourage players to frequently interact with their in-game assets and currencies, likely more frequently than many people check their bank balances or count their change on the bedside table. Subjective value (according to economists) describes what people are willing to pay for an object [105]. Popular and commercially-successful games like *Fortnite* and *League of Legends* are free-to-play and generate revenue primarily from the sale of 'skins', which are primarily cosmetic and have little in-game utility. That players spend significant money on these game assets suggests that they have high subjective value. Additionally, that players spend time and effort building up their digital assets, suggests that these digital characters, weapons, and currencies have very real value to players as they interact with them over time [79].

These arguments show that it is unclear whether loss aversion will manifest in game environments – and this lack of knowledge is important for game designers, because the ways in which games set up decision points and choices for players can have a large effect on player enjoyment and retention. For example, designers may build risk:reward decisions into a game that is designed to be played aggressively, but if players are loss averse, they may miss out on many of the game's possibilities, creating a game experience very different than what the game designer envisioned. Furthermore, games that are combat-oriented – such as multiplayer first-person shooters and battle royales – may unwittingly disincentivise combat if the rewards for defeating enemy players (e.g., loot, currency, points) do not outweigh punishment for failure (loss of loot, loss of currency, match loss). Clarifying the role of loss aversion in games will allow developers to make more informed decisions about gameplay design and reward structures, and promote the creation of interesting player choices and dilemmas.

To provide an initial understanding of whether loss aversion occurs in games, we built a custom adventure-style game with several decision points that allowed us to measure players' loss aversion. The study involved 18 game rounds: in each round, the player fought their way through two waves of enemies, gathering gold along the way, and then entered a building where they had the opportunity to wager some of their gold based on the outcome of a coin flip. Gold could be used later in the game to buy one of two powerful swords. Wagers had different win:loss ratios – some favorable for the player (e.g., win 1000 : lose 500) and some unfavorable (e.g., win 500 : lose 1000) – and we recorded the number of players who took the wager at each win:loss ratio. If players are loss aversive, they will accept favourable wagers at a lower rate than they reject unfavourable ones, and wagers will only be accepted by the majority when ratios are strongly weighted in the players' favor.

We recorded players' willingness to take each wager, demographic variables such as gender, age, gambling history, and player type, and measures of play experience. Ninety-six participants completed the game on Amazon Mechanical Turk. Our study provides several new findings about loss aversion in games:

- Loss aversion clearly occurred: paired Wilcoxon rank sum tests (two-tailed) on pairs of equivalent wagers (e.g., 0.25 and 4.0) showed overall that players were reluctant to take wagers until the win:loss ratio became strongly favorable, showing an overall bias towards avoiding losses;
- Loss aversion was significantly more pronounced when there was a larger amount of money at stake;
- Different player groups (gender, age, player type, and gambling risk) did not substantially change loss aversiveness;
- Players' subjective satisfaction with their progress was reduced more by losing a wager than it was increased by winning a wager, an indication that even in games, "losses loom larger than gains." [70].

These results show that players in an adventure-style game behave in a similar fashion to people in previous studies of loss aversion, even though the money in our game was not real, and its utility was purely for a future in-game purchase. This means that designers should take loss aversion into consideration when designing decision points in games, as players may otherwise avoid interacting with game features that the developer is trying to make appealing. Further, game designers may be able to leverage loss aversion to create engaging choice-based dilemmas for players, and may be able to manipulate risk and reward in order to influence the paths that players take through a game.

Our work makes three main contributions. We are the first to test loss aversion in a commercial-style video game, and the first to show that loss aversion exists in that context. Second, we provide an understanding of utility in games that can help designers understand what in-game objects are truly valuable to players. Third, we provide a methodological framework for studying loss aversion in games that can be applied to other cognitive biases. Overall, our work will help designers build games that are more engaging for a wider variety of players.

2 RELATED WORK

2.1 Cognitive Biases and Loss Aversion

Cognitive biases were first introduced by Tversky and Kahneman [119] and are usually described as heuristic principles that allow individuals to save time and reduce task complexity when dealing with daily decisions. Cognitive biases can lead to systematic errors of judgement [54, 119] and can be detrimental to our lives, being related to mental health disorders [13, 73, 111], eating disorders [127, 128], and decision errors in the legal system [27, 100, 124]. However, some biases are believed to have originated from evolutionary adaptations [53, 55] that may improve decision making efficacy [64]. Haselton et al. [55] categorise cognitive biases in three areas: shortcuts (heuristics) that lead to fast decision making, but can also be inadequate for the situation; decisions that are not suitable for modern contexts, which they refer to as "artifacts"; and decisions that can lead to increased error rates but reduce resource consumption (error management biases).

Taking cognitive biases into consideration, Kahneman and Tversky investigated economics through the lens of psychology – later known as behavioural economics [29]. In doing so, they developed the idea of 'prospect theory,' a descriptive model of decision making [70] that suggests people are willing to accept greater risks to avoid negative outcomes, but risk averse when uncertain outcomes are more positive. This is because the experience of loss has approximately twice the value of the experience of wins – as demonstrated by the prospect theory value chart shown in Figure 1. Kahneman and Tversky further suggest that decisions are made relative to a neutral reference point, instead of taking into consideration only the final outcome.

These concepts contribute to a cognitive bias known as 'loss aversion,' the tendency to overweigh the drawbacks of losses in comparison to the benefits of comparable gains. In other words, losing something is more important than winning something of equivalent value [67]. This phenomenon can be observed in a variety of contexts, such as the stock market [9, 15, 16, 47], politics [2, 63, 76], and marketing [19, 72, 93], and can also be observed in risky decisions (e.g., a small-scale gamble) and riskless decisions (e.g., someone is given a mug and asked if they wanted to trade it for a pen) [39, 117, 121]. Commonly, loss aversion studies examine a willingness to wager in a random lottery where real money is give to or taken from participants depending on their decisions [25, 39, 130].

There are some situations in decision making, however, where loss aversion is less evident. For example, loss aversion has not been observed in financial transactions where buyer and seller expectations are fairly met [89]. Loss aversion is reduced when decisions are made for others [4, 99], or when monetary loss is relatively small [51]. In gambling contexts, techniques are employed to reduce the pain of loss and motivate continued gambling - such as making large losses seem small [110], and framing the experience as hedonic instead of utilitarian [44, 87].

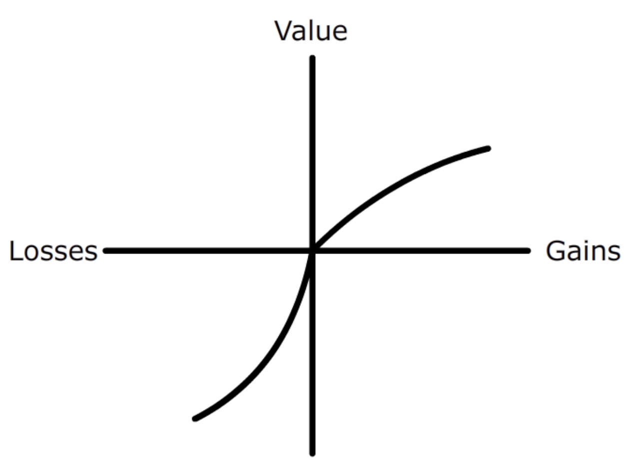

Figure 1: Representation of a hypothetical prospect theory value chart.

2.2 Cognitive Biases in Games

Several areas of research indicate that video game play can affect player cognition [104]. For example, video games have been found to improve reaction time [8, 118], attention [7, 8, 118, 125], visual recognition memory [8, 118], selective visual attention [14], cognitive control [5], and spatial orientation [12, 38, 125], and have also been employed as a useful tool for cognition evaluation and attenuation [6, 11]. The efficacy of video games in the reduction or modification of cognitive biases has also received academic attention. For example, Dunbar et al. [35] developed a serious strategy game intended to inform players about the existence and effects of specific cognitive biases. The authors found that exposure to a single-player version of their game reduced the effects of both confirmation bias and fundamental attribution error in their participants. Other uses of games in bias mitigation research include the comparison of a game and a training video in regards to mitigating fundamental attribution error, confirmation bias, and bias blind spot [108], the development of a serious adventure game with storytelling elements to reduce cognitive biases in teachers [10], and the reduction of alcohol and drugs attention bias by using gamified applications and serious games for health [20–22]. Besides bias mitigation, there are studies exploring the effects of certain cognitive biases in video game players. For example, Gutwin et al. [46] examined a psychological bias called the 'peak-end rule' in casual games. This bias is defined by the importance players place on both the peak and final moments of an experience, which can lead to different perceptions of a whole experience. The authors were able to change participant's recollection of challenge by creating multiple variants of the same game – finding that variants with easier end challenges were perceived to be overall less challenging than variants with more difficult end challenges.

Loss aversion in games has received little research attention. Hamari [49] points out that some social games may use cognitive biases related to loss aversion. For example, a game may stimulate user retention through the endowment effect, in which individuals place greater value on goods that they already own, such that they may value something that they own more than something they don't own, even if the unowned item's objective value is marginally higher. A depletion mechanic – in which an in-game resource, such as a crop, depletes over time without user interaction – may utilise this effect to encourage user retention. This "loss of opportunity" mechanic can also work in the form of returning bonuses for players, invoking loss aversion due to the feeling that said bonus is already owned by the player [28, 77].

In mobile application design, Stockinger et al. [112] developed a gamified personal finance app that utilises several cognitive biases to help users make more informed financial decisions. Loss aversion is invoked through the removal of previously awarded badges in instances of inadequate player performance. This strategy of threatening to remove something earned if a desired behaviour is not displayed has been observed to be more effective for certain player types. Orji et al. [90] found that loss aversion as an engagement mechanism is more effective for players categorised as 'achievers', 'masterminds', and 'socialisers' within the BrainHex model of gamer types.

Despite the ample implementation of engagement mechanics in games, very few empirical studies exist formally in the realm of loss aversion and game design - which instead mainly focus on applying concepts of cognitive biases in gamified applications [31, 62, 113]. Our study has the distinction of applying loss aversion concepts in a digital entertainment game, as opposed to a serious game or a gamified application.

2.3 Games as Different from the Physical World

2.3.1 The magic circle. The magic circle was first introduced by Huizinga [61], who described it as a space of play, isolated and with a clear border from the outside, created by players, and with its own set of rules. This definition was later expanded by Salen and Zimmerman [106] to describe the boundaries of games (digital or otherwise), wherein players give their consent to voluntarily enter a space governed by well-defined rules and set apart from the outside world. This definition of the magic circle in games has been adopted extensively in games research (e.g., [33, 94]), and especially in the study of pervasive games [52, 84, 88, 107] – but is also criticised, with many disagreeing with the concept of a separation between "real" and "play" worlds [30, 33, 94, 114]. Some additional criticisms of the video game magic circle include: the generalization of the magic circle to any type of game [33, 78, 114]; the idea of players having both a "real" identity and a "ludic" identity [33, 129]; the belief that external contexts do not influence in-game behaviour and experience [78, 114]; and the lack of relevance and utility of this concept in game studies [33, 129].

Regardless of the strength of the boundaries between the physical and game worlds, it is usually agreed that people commonly perform actions in games that they would not–or cannot–perform in real life. From stealing cars in *Grand Theft Auto* to exploring dungeons in *Tomb Raider*, actions performed in games generally have few consequences in the physical world. Consequently, failure in games is accepted by players as a way to learn and progress further [41, 43], increasing overall enjoyment during the game experience [65, 66]. However, it is not fully known whether reduced stakes and more ready acceptance of failure modifies the influence of loss aversion in video games – as compared with physical world settings.

2.3.2 Game rewards and value of in-game items. Reward systems are an important characteristic of games, serving as motivational components to encourage players' progress and enjoyment [96, 101, 122]. Various taxonomies have been created to better organise and understand different types of rewards [48, 97, 98, 101, 122], presenting categories that refer to the acquisition of virtual items, such as "item granting system rewards" [122], "rewards of facility" [48, 97, 98], and "enabling rewards" [101]. Each of these suggest that rewards are a ubiquitous feature of video games.

As with reward systems, there are many attempts to categorise and create a definition of in-game items [45, 58, 75, 95]. We highlight Park and Lee's proposal [95], which defines game items based on four dimensions of value: character competency value, which represent the performance advantages that an item can give to the player's avatar, such as more power, speed, or defense; enjoyment value, which relates to how items facilitate the act of engaging and having fun in a virtual world; visual authority, which covers the cosmetic aspects of items, which entail changes to the player's avatar and increase of their social status in the context of a game; and monetary value, which, as the name suggests, relates to how much monetary value players give to items before purchasing them. The authors also suggest that preference for items that have more utilitarian value vs cosmetic value change based on the game genre. For example, MMORPG players tend to value visual authority more than first-person shooters and casual game players.

2.3.3 Game economies vs physical-world economies. Money acquisition is an important source of motivation for people; but although video games players have many motivations to engage in virtual worlds, collecting in-game currency is rarely specifically described as a goal. Motivations for gameplay range from passing time, relaxation, and avoiding boredom, to competition, challenge, and social interaction [37, 109, 131]. Video game currency is, in theory, just another element in game design to engage players and facilitate the act of having fun in virtual worlds. While some digital games contain ways to trade in-game items or in-game currency for real monetary value (e.g., the *Counter-Strike: Global Offensive* marketplace [40]) the value of in-game money is generally limited to the game environment.

However, even in games where the act of selling virtual goods for 'real' monetary gain is actively discouraged and punishable by the developers, it is not uncommon for players to engage in such transactions. Research on these types of game economies and their ties to the physical-world economy (e.g., [50, 74, 83, 116, 123]) mainly focuses on MMORPG economies and the utility of in-game money and virtual goods compared to their physical counterparts. For example, Wang and Mainwaring [123] conducted an exploratory ethnographic study in China to understand the impact of virtual currencies in online games, and highlighted three major issues: realness, which correlates to how virtual currencies with ties to the physical world (which the authors define as "gateway currencies") are designed to feel like "fake money", to facilitate the act of spending money without the spender giving too much thought to it; trust, which relates to the difficulties players have carrying out cash transactions and sharing accounts with other players, both being practices very common in online games but not supported by developers, which lead to alternatives where players are prone to being scammed by other players; and fairness, which refers to the power that real money has in buying in-game advantages, which can break the balance of a virtual world.

Our study differs from previous work by analyzing the effect of loss aversion in a short single-player game experience, with a closed in-game economy, using gambling mechanics utilizing a currency that can only be acquired and exchanged within the game world. This allows for analysis of how much utility players assign to the acquired game currency that is free of ties with the physical-world economy, how open they are to risking currency acquired in the game, and how losing or gaining this currency will affect their satisfaction while playing the game.

3 STUDY: LOSS AVERSION IN AN ADVENTURE GAME

The goals of our study were to find out whether loss aversion occurs when players are given the chance to wager in an adventure-style videogame, and to find out whether the degree of loss aversion was affected by various factors such as the amount of the wager or people's gender, age, gambling propensity, or player type.

3.1 Custom Game

We developed a *Zelda*-like game called *Small Adventure* using Unity 2019 and WebGL (see Figure 2 and video figure). The game presents a series of levels where players battle monsters, collect gold, and have the opportunity to wager some of their gold. The game begins with the player in a shop, learning that there are different swords – with different levels of attack power – available for purchase. The player starts the game with only a single gold piece, and so is only able to buy the basic sword (+1 attack) before moving to the first of the game's levels.

In each level, players used the keyboard to move their character around the map and fight waves of monsters who engage in both melee and ranged attacks. Each level started with an exploration phase, where players could familiarise themselves with the level, learn the game mechanics, and acquire initial items that would be needed later (e.g., the player picked up a bow for ranged attacks in the second level). The game then moved to a battle phase where players had to fight and kill two waves of monsters. Monsters would get progressively stronger and require more hits to defeat in later levels, ranging from two to ten hits. Defeated monsters would drop loot (gold coins), life points (hearts), and arrows (see Figure 2). If the player was defeated in battle, the game would restart the level, with the player maintaining the same amount of money they had when they first entered the level. After all enemies were defeated, players could open a treasure chest on the map that would give them additional gold (used to equalise player wealth for each round, as described below).

Figure 2: Example game level with player fighting a monster during the battle phase.

Players completed each level by entering a shop and interacting with a purple treasure chest called the "trickster's treasure chest". Opening this chest presented players a 50% chance of winning gold, and a 50% chance of losing some of their gold (see Figure 3). The amounts that players could win or lose were clearly specified in the dialogue and were controlled by our design of the loss-aversion manipulation (explained below). Players could choose to open the chest or leave it alone; once they had made their selection, the outcome was presented (if they chose to wager).

The more-powerful swords were displayed in each store but not available for purchase until the end of the game, and with their cost hidden. Each shop had a shopkeeper, and his dialogue set the swords up as a clear goal for the player (see Figure 4): if they could accumulate enough gold, they would be able to buy the mid-tier sword (+5 attack) or the high-tier sword (+10 attack). A progress bar shown above the dialogue indicated the player's relative progress toward the goal of being able to buy the swords.

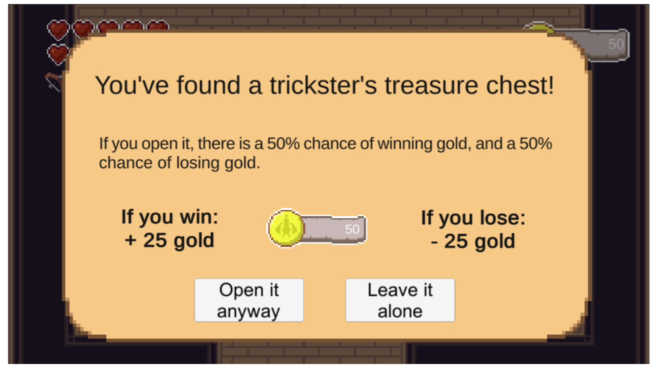

Figure 3: Screenshot of the game depicting a decision point, where players have the option to open the treasure chest (i.e., gamble) or leave it alone (i.e., not gamble).

After the outcome of the players' decision was presented, players would be able to leave the shop and move to the next level. At the start of a new level, the game asked players to rate their satisfaction with their progress in the game so far, presenting a 5-point scale that ranged from "Very Dissatisfied" (1) to "Very Satisfied" (5) (see Figure 5).

Figure 4: Example interaction with the shopkeeper; an open trickster's treasure chest is shown in purple above the dialogue.

The game consisted of 18 levels, each with a shop and a decision about the trickster's treasure chest. In the final shop, however, players were told that this was the last round and that they now had enough gold to buy the mid-tier sword, but would have to engage in a final wager to afford the high-tier sword. The final wager ensured that players were able to complete the goal that was set up at the start of the game. After leaving the last shop, players proceeded to an extra level where they could use their new sword to defeat the last monsters of the game.

Figure 5: Satisfaction questionnaire given after each level.

3.2 Design of the Wagers

The trickster's treasure chest sets up a wager with 50% chance of both winning and losing, and each wager has different win and loss amounts that can be either favorable (i.e., win more than lose) or unfavorable (lose more than win). By tracking the number of players who accept each wager, we can look for the presence of loss aversion by examining the rate at which people take different wagers, and by comparing the rate of refusing unfavorable wagers to the rate of accepting equivalent favorable wagers. For example, if 80% of players refuse a win:loss ratio of 0.25 (e.g., win 250, lose 1000) but only 50% accept a ratio of 4.0 (e.g., win 1000, lose 250), people are biased towards avoiding losses.

We set up the game so that the player's gold would have a clear utility – that is, the gold was useful because it would eventually allow the player to purchase a more powerful sword. The game was also designed to give players a sense of ownership over their gold, because much of the gold was "earned" through fighting and defeating monsters. However, the gold had only a future utility because players could not use gold in the levels to buy other items such as health packs or powerups.

The wagers embodied by the trickster's treasure chest provided nine different win:loss ratios, each seen twice – once in the first half of the game, and once in the second half – which meant that each ratio was seen with a lower amount and a higher amount. The outcomes of the wagers were the same for all participants, in order to increase control over the scenario. Ratios and outcomes of the game's 18 wagers are shown in Table 1. As shown in the table, the player's wealth before the wager increased at each round. We ensured that all players had the same amount of gold when entering the shop by manipulating the value of the treasure chest that the player opened after defeating the monsters (players were unaware of this manipulation).

After the player made a decision on a wager and saw the outcome, the NPC shopkeeper told the player how far they were from buying a new sword and provided additional motivation, with the statements becoming progressively more encouraging after each decision point (See Figure 4). For example, at level seven, the shopkeeper stated "Not yet, my soon-to-be valued customer – but you are well on your way to being able to afford these fearsome swords."

Table 1: Wager Details at Each Decision.

Decision	Starting Wealth	Win:Loss	Ratio	Outcome
1	50	25:25	1.0	Loss
2	200	80:100	0.8	Win
3	500	375:250	1.5	Loss
4	1200	2400:600	4.0	Loss
5	2000	666.67:1000	0.667	Win
6	3800	3800:1900	2.0	Loss
7	5000	625:2500	0.25	Win
8	8200	5125:4100	1.25	Loss
9	10,000	2500:5000	0.5	Win
10	18,000	6000:9000	0.667	Loss
11	22,000	44,000:11,000	4.0	Win
12	70,000	70,000:35,000	2.0	Loss
13	80,000	10,000:40,000	0.25	Win
14	100,000	40,000:50,000	0.8	Loss
15	150,000	93,750:75,000	1.25	Win
16	520,000	130,000:260,000	0.5	Win
17	820,000	615,000:410,000	1.5	Loss
18	1,000,000	500,000:500,000	1.0	Win

A progress bar was also displayed above the dialogue box to encourage the player's progress towards the goal of being able to afford the new swords.

The use of wagers and the choices of the win:loss ratios were based on previous work by Tversky and Kahneman on loss aversion, decision making, and prospect theory [67–69, 120, 121]. We used "lottery choice" wagers (coin-flip bets with different amounts of gain or loss) which are commonly used in loss aversion measurements [25, 39, 130]. Previous studies typically do not provide participants with the outcome of each wager (e.g., participants are only able to learn the outcome of one of their wagers and only at the end of the study), but this is an infeasible approach for a game, so our study includes the player learning the outcomes of each wager they decide to accept. We designed the game to avoid strong influence of earlier outcomes in two ways: first, participants have to battle and earn money before engaging in a new wager, which means that the memory of the previous outcome is not immediate and that the gold earned from fighting monsters in the new level offsets the feeling that a previous win is a "windfall gain." Second, players always enter a new decision point with more money than they had in the previous one (whether or not they decided to gamble), reducing the likelihood that they will feel the need to make up for a previous loss.

Finally, the potential losses were fixed at 50% of the player's current wealth, in order to make wagers feel substantial, to enable game procession in a controlled fashion regardless of wager outcome, and to avoid scenarios where people are reluctant to engage in risks that could result in them losing everything.

3.3 Measures

Our primary measure to explore loss aversion was player decisions about whether to accept each of the 18 wagers in the game. We also measured several demographic variables to look at whether different groups had different degrees of loss aversion. A questionnaire at the start of the study asked the following:

- Gender, age, gaming experience, and preferred platform;
- BrainHex player type [86] (Socialiser, Mastermind, Seeker, Daredevil, Survivor, Achiever, Conqueror).

After the game ended, we asked participants about their gambling tendency using the Problem Gambling Severity Index (PGSI, [59]), which categorises respondents as non-problem (0 points in total), low-risk (1-2), moderate-risk (3-7), or high-risk gamblers (8+);

We also asked two types of player-experience questions (set during level transitions so as to not interrupt gameplay): players rated their satisfaction with their own progress after each level (see Figure 5), and at the end of the study, we measured players' enjoyment, effort, perceived competence, and tension using the Intrinsic Motivation Inventory (IMI) [82]. We do not report analyses by IMI responses as we did not see any differences.

3.4 Participants and Procedures

We used Amazon's Mechanical Turk (MTurk) platform to recruit participants for the study. MTurk has been shown to be a reliable tool for HCI and games user research [18, 24, 34], with many researchers showing that it is at least as reliable as data obtained from traditional methods [26, 56, 71, 92], including when collecting behavioral/decision-making data [42, 60, 81, 91]. We obtained ethical approval from the research ethics board at University of Saskatchewan, and participants were asked to give their consent before proceeding to the experiment. To comply with ethical guidelines, participants were all from the USA and were older than 18. We carried out an initial screening study to ensure that participants were familiar with adventure-style games and that their computers could display the game correctly. The screening task took 5-10 minutes, and participants were paid $0.70 USD.

Participants who successfully completed the screening study were invited to the main study, which took on average 44 minutes and paid $10 USD. Participants completed an informed consent form and a demographics questionnaire, and then played the game as described above. After the game finished, participants completed the IMI and PGSI questionnaires. A total of 114 people finished the study. We excluded participants who failed to provide answers to questionnaires (3 people), selected questionnaire items faster than 1.5 sec/item (14 people), or had >3s.d. variance on two or more questionnaire subscales (1 person).

This resulted in 96 participants: 65 men, 29 women, two non-binary; ages 19-65 (mean 34); playing 0-40 hours of videogames per week (mean 11.4). All participants were familiar with desktop and mobile apps, and most chose PC as their favorite platform (55%), followed by console (27%) and mobile (11.5%). Participants self-identified as Seeker (35%), Achiever (26%), Survivor (11%), Socialiser (9%), Mastermind (7%), Conqueror (5%), and Daredevil (5%).

4 RESULTS

Of the 96 players, 93 wagered at least once during the 18 rounds of the game, and the average number of wagers accepted per player was 6.6 (37%). In the sections below, we analyse our main research questions about whether loss aversion occurred and how it differed by player groups.

4.1 Did Loss Aversion Occur in the Game?

Figure 6 shows the percentage of players accepting the wager at each win:loss ratio. As can be seen from the chart, willingness to accept unfavorable wagers is low, but increases as the win:loss ratio improves, reaching 50% when the ratio reaches 1.0. However, at favorable wagers (where players stood to win more than they lost), people were no more likely to accept a wager until the ratio became strongly favorable at 4.0 (i.e., where the win amount is four times the loss amount). To look for loss aversion, we compared the

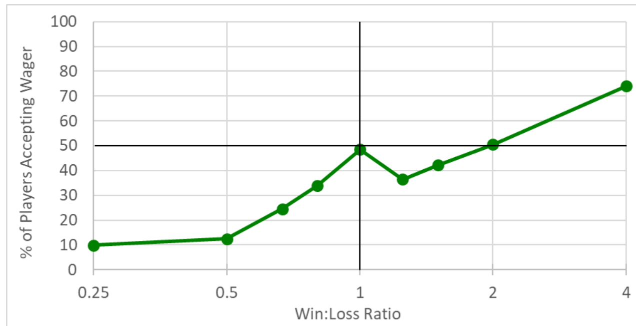

Figure 6: Overall acceptance of wagers, by win:loss ratio.

rate at which players accepted and refused equivalent favorable and unfavorable wagers. 'Equivalent wagers' are pairs of bets that are an equal distance from the win:loss ratio of 1.0 (where the player would win or lose the same amount). Our pairs of equivalent win:loss ratios are 0.25 and 4.0, 0.5 and 2.0, 0.6667 and 1.5, and 0.8 and 1.25 (see Table 1 for corresponding values). If loss aversion is occurring in the game, we should see more players rejecting (for example) the 0.25 ratio than accepting the 4.0 ratio. Figure 7 shows these comparisons, and clearly shows that players were much more likely to reject unfavourable wagers than to accept equivalent favourable wagers. We used paired Wilcoxon rank sum

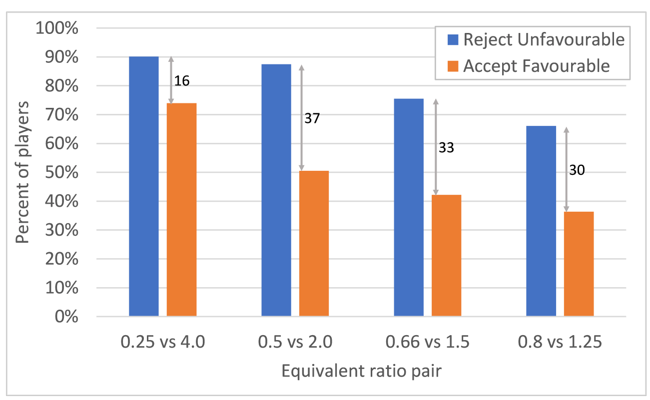

Figure 7: Rates of rejecting unfavourable ratios vs. accepting equivalent favourable ratios.

Table 2: Wilcoxon tests comparing reject rate for unfavourable ratios vs accept rate for favourable ratios.

Unfav. Ratio	Reject Rate	Favor. Ratio	Accept Rate	V	p
0.25	90.1%	4.0	74.0%	1504	**<.0001**
0.5	87.5%	2.0	50.5%	5096	**<.0001**
0.66	75.5%	1.5	42.2%	6353	**<.0001**
0.8	66.1%	1.25	36.4%	7373	**<.0001**

tests (two-tailed) to compare the accept/reject rates in each pair. Results are shown in Table 2: for each pair, the difference was highly significant, providing evidence that loss aversion was occurring at all wager ratios.

4.1.1 Effect of prior outcomes. As a further check on the effect of prior outcomes, we compared pairs of decision points where the two decisions had different previous outcomes (i.e., pairs of wagers with the same win:loss ratios, where the player had in one case just had a loss, and the other just had a win). A t-test on players' willingness to wager showed no significant difference between prior loss and prior win (p=0.14).

4.2 Is loss aversion affected by wager amount?

Each win:loss ratio in the game was seen by players twice: once at a lower amount and once at a higher amount (see Table 1). We grouped these into two categories (Low and High) for further analysis. Overall, Low wagers were accepted more often (40% of the time overall) than High wagers (30% overall); see Figure 8.

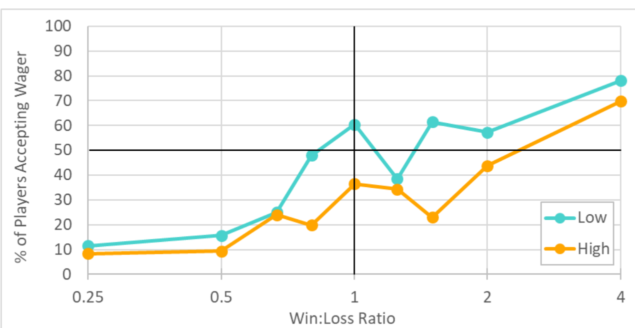

Figure 8: Acceptance of wagers by amount of the wager.

We carried out a similar analysis of equivalent wagers for Low and High amounts. These data are shown in Figure 9, and Wilcoxon rank sum tests (two-tailed) are reported in Table 3. Although loss aversion was evident for both Low and High amounts, the effect was much larger at High amounts.

4.3 Are There Differences Across Player Groups?

We examined whether there were differences arising from several intrinsic factors in our players, including gender, age, player type, and gambling propensity. We note that because we cannot carry out

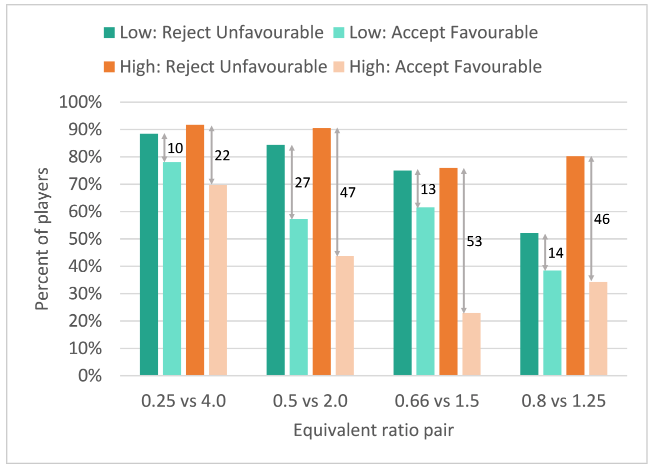

Figure 9: Rates of rejecting unfavourable ratios vs. accepting equivalent favourable ratios, by wager amount.

Table 3: Wilcoxon tests comparing reject/accept rates for equivalent ratio pairs, by wager amount.

Unfav. Ratio	Reject Rate	Favor. Ratio	Accept Rate	V	p
Low Amounts					
0.25	88.5%	4.0	78.1%	275	=.061
0.5	87.5%	2.0	50.5%	1033	=**.00032**
0.66	75.0%	1.5	61.5%	952	=.080
0.8	52.1%	1.25	38.5%	1360	=.11
High Amounts					
0.25	91.7%	4.0	70.0%	504	=**.00040**
0.5	90.6%	2.0	43.7%	1560	=**<.0001**
0.66	76.0%	1.5	22.9%	2394	=**<.0001**
0.8	80.2%	1.25	34.4%	2409	=**<.0001**

multi-factor analyses to look for interactions, our analysis first considers overall differences in willingness to wager, and then considers possible differences in loss aversion through simple inspection.

4.3.1 Effect of gender. Previous literature suggests that gender is a significant factor when assessing loss aversion [25, 39, 85]. In total, 94 of 96 players identified as either "woman" or "man" in our demographic questionnaire. Overall, women accepted 41% of the 18 wagers, and men 35%; however, Wilcoxon tests comparing willingness to accept wagers showed no effect of gender at any ratio (all p>0.05). Figure 10 shows the proportion of men and women who accepted wagers at each win:loss ratio. To look for differences in loss aversion, we carried out a similar comparison of equivalent wagers for the two genders: results are shown in Figure 11. Wilcoxon tests indicated that all differences between reject-unfavourable and accept-favourable were significant at p<0.05. As can be seen in Figure 11, the difference between rejecting unfavourable wagers and accepting favourable ones was similar for the first pair, and larger for men in the other three pairs. This stands in opposition to prior research suggesting that women are more loss averse than

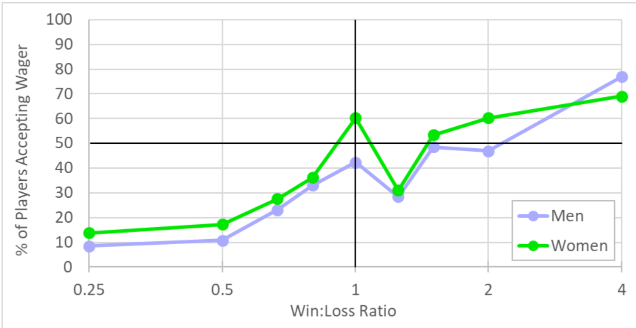

Figure 10: Acceptance of wagers by gender.

men: in our data, this pattern was not seen (if anything, the reverse was true).

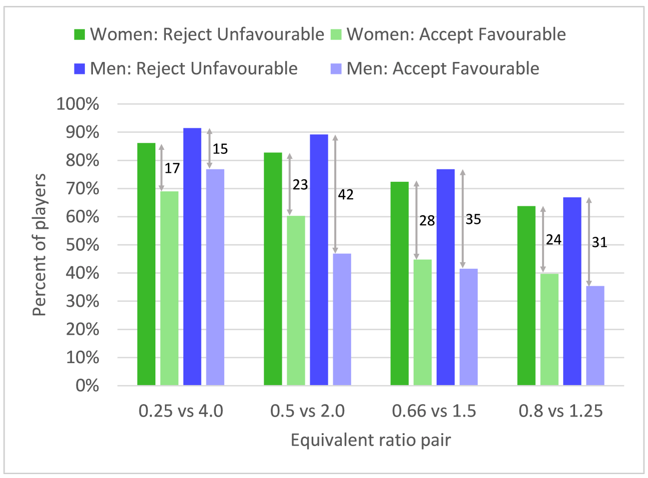

Figure 11: Rates of rejecting unfavourable ratios vs. accepting equivalent favourable ratios, by gender.

4.3.2 Effect of age. We grouped our participants into five age categories: 19-25 (16 people, 39% of the 18 wagers accepted); 26-35 (44 people, 40%); 36-45 (26 people, 30%); and over 45 (10 people, 30%). Figure 12 shows these age groups' willingness to accept wagers at each win:loss ratio. Kruskal-Wallis tests (Bonferroni-corrected) at each ratio showed only one significant difference by age group (at ratio 2.0, p=0.0029, see Figure 12); for all other ratios, p>0.05. There was also no clear evidence of difference in loss aversion (although the difference at ratio 2.0 may suggest a trend for players over 35 to be more loss-aversive than players under 35).

4.3.3 Effect of player type. We asked players to self-identify as one of the player types in the BrainHex model [86]. Participants chose Seeker (34 people), Achiever (25), Survivor (11), Socialiser (9), Mastermind (7), Conqueror (5), and Daredevil (4). Kruskal-Wallis tests at each ratio showed no effect of player type on willingness to wager (all p>0.02). In addition, the data show no clear evidence of any differences in loss aversion by player type; see Figure 13.

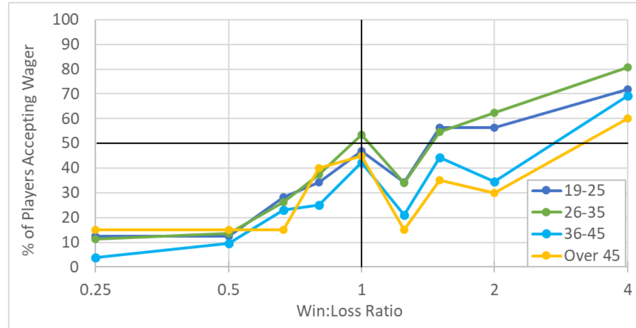

Figure 12: Acceptance of wagers by age group.

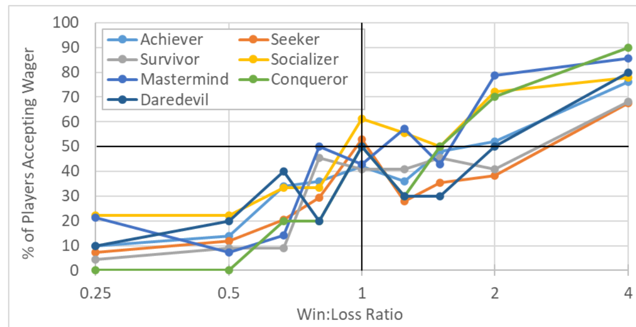

Figure 13: Acceptance of wagers by player type.

4.3.4 Effect of gambling propensity. Participants completed the PGSI questionnaire to estimate their gambling propensity [59], with participants categorised as non-problematic (60 people, accepted 32.5% of the 18 wagers), low-risk (17 people, 43%), moderate-risk (13 people, 46%), and high-risk gamblers (6 people, 44%). Bonferroni-corrected Kruskal-Wallis tests at each ratio showed no effect of PGSI risk group on willingness to wager (all p>0.02), although Figure 14 suggests that the high-risk group may behave differently than other groups both in terms of willingness to wager and loss aversion (however, as there were only 6 players in this group, a larger sample is needed for further investigation of this issue).

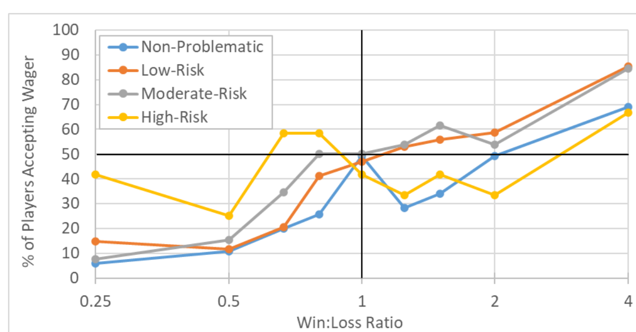

Figure 14: Acceptance of wagers by gambling risk group.

4.4 Player Attitudes Toward Gold in the Game

Participants reported on their attitudes toward gold in the game through a series of 'yes' or 'no' questions. Our expectation was that the majority of players would reflect a degree of hedonic or utilitarian value. In our sample of 96 people, the majority of participants reported: feeling attached to their gold (65 people, 67%), feeling that their gold in the game had purchasing power (63 people, 65%), that they were hoping to save enough money to buy the sword upgrades (95 people, 98%), and that they avoided using the Trickster's treasure at any point (87 people, 90%). These results suggest that many players did see the utility of gold in the game, which may have played a role in their willingness to wager.

4.5 Player Satisfaction

As a second analysis of loss aversiveness, we looked at player responses to the question "How satisfied are you with your progress?" that was given after the player had interacted with the shopkeeper (and if they had taken the wager, after the outcome was revealed). There were an equal number of wins and losses at different win:loss ratios (pre-determined, as outlined earlier), and we assessed the influence of losing and winning on perceived progress by comparing responses to those of people who did not bet. Figure 15 shows the results: a loss led to a reduction of 0.53 on the 5-point perceived-progress scale, whereas a win only led to an increase of 0.28. This result suggests that the effect of a loss was larger than the effect of a win – in line with previous work suggesting that "losses loom larger than gains."

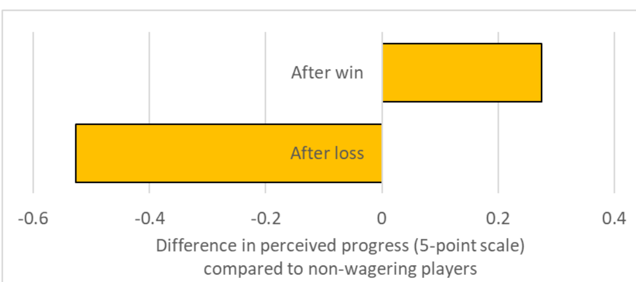

Figure 15: Relative change in perceived progress after a win or a loss, compared to players who did not wager.

5 DISCUSSION

Our study provides five main results:

- Loss aversion did occur in the game: players were significantly biased towards avoiding the losses from unfavorable wagers;
- The overall likelihood of accepting a wager only notably exceeded 50% when the wager's win amount was more than double the loss;
- The values involved in the wager had a significant effect on the likelihood of acceptance: players accepted fewer wagers involving larger amounts than those with smaller amounts, despite the wagers having equivalent win:loss ratios;
- Contrary to previous research, there was no significant difference in willingness to wager by gender, nor for several other demographic variables (player type, age, and gambling propensity);
- Losses had more of an effect on subjective satisfaction than wins – satisfaction decreased more when players lost a wager than it increased after a win.

In the following sections, we consider explanations for these findings, discuss the implications of our results for game designers, and outline potential limitations and avenues for further research on loss aversion in game contexts.

5.1 Explanation for Main Results

Our study clearly showed the presence of loss aversion: players were much more likely to refuse unfavorable wagers than they were to accept equivalent favorable ones; wagers with favorable win:loss ratios were frequently declined; and wagers were only notably accepted when the win was more than double the loss. To explain these results, we return to the questions raised at the start of the paper regarding players' decisions in games.

Three factors suggested that loss aversion may be reduced in games: the "magic circle" that allows players to engage in activities that they would not undertake in their ordinary lives; the virtual nature of game assets (i.e., wagers in the game are not "real money"); and the idea that gambling may be primarily hedonic rather than utilitarian. In contrast, the idea that game assets often have a clear utility for reaching a goal within the game argues that loss aversion may still occur, although it will be re-calibrated to the reward structure of the game.

Our results align with the last of these explanations – it appears that players saw their gold as having a clear utility (i.e., for purchasing a more powerful sword). Further evidence for this interpretation can be seen in the players' responses to questions about whether they felt that their gold had purchasing power (65% of participants said yes) and whether they were trying to get enough gold to purchase the better sword (98% said yes).

However, the results also suggest that loss aversion in the game may differ from that in the physical world. First, people who stated that they do not take financial risks in the physical world (81.25% of participants) still accepted 6.5 of the 18 wagers in the game on average, and even people who reported that they do not take financial risks in games (34% of participants) still accepted 4.5 of the 18 wagers on average. Furthermore, our results for wagers with an equal win and loss (ratio 1.0) showed acceptance at ~50%. In contrast, results from behavioural economics suggest that these wagers would be reduced in the physical world [68].

Given these results, a remaining question is why we did *not* see stronger effects of the magic circle, the virtuality of game assets, and the hedonic nature of gambling. Our interpretation is that although these factors may have played a role in altering players' willingness to gamble overall, the utility of a player's gold in reaching a game objective outweighed any influences towards risk-taking, allowing people's natural loss aversion to dominate. Thus, despite the game's lack of reality, players maintained a sense of what was valuable in the game. This is not surprising – designers have long known that players are keenly aware of minor differences in the power of different characters or weapons – but players' ability to understand utility relationships in games means that designers could beneficially account for biases like loss aversion when thinking about reward structures and decision points (discussed further below).

We also found that gambling behaviour was significantly affected by the amount of the wager. Previous work has shown conflicting results in this regard (e.g., [51]), but many of these studies differ from our game in that large-value prospects offered to participants are only theoretical (i.e., they ask participants whether they would take certain wagers, but do not show an outcome, and do not either pay out to or collect from the participant). Players in our game, in contrast, really saw the outcomes of the wagers, and were clearly affected by these outcomes (as shown by the satisfaction measures), which may have accentuated their loss aversion with higher amounts. Further study is needed, however, to determine whether the effect of amount is relative to the cost of the goal (e.g., the sword in our game) or to the difficulty of acquiring more of an asset (e.g., if gold was rare in our game, it might change players' sensitivity to wager amount).

Finally, we found no significant effect of gender on willingness to wager – although results seemed to indicate than men were more loss aversive than women on equivalent wagers. This finding contrasts with loss aversion literature that instead suggests that, in general, women are more loss averse than men (e.g., [25, 39, 102]). However, the literature on the subject is far from conclusive, and several studies have also found no significant difference in gendered tendencies towards loss aversion [1, 36, 57]. Durant et al. [36] provides a possible explanation for this, suggesting that personality traits – such as extraversion and neuroticism – have a bigger role influencing loss averse behavior than gender. Our results may also be attributable to slight variations in the definition of 'loss aversion', which have been found to radically influence results concerning gender susceptibility to loss aversion [23]. As the literature regarding gender influence on loss aversion is still inconclusive, further study–especially that which considers personality variables alongside gender, as well as work towards the consolidation of a loss aversion definition in light of gender effect – is recommended.

5.2 Implications for Game Design

Games often seek to create conflicting decision points for players through the use of mechanical and moral dilemmas. For example, in a first-person shooter such as *Counter-Strike: Global Offensive*, a player may need to choose between the high-risk, high-reward sniper rifle, and the more reliable – but less powerful – assault rifle. In a narrative-based roleplaying game à la *The Witcher* series, a player may need to decide whether to spare or execute a villainous NPC. Decisions, risks, rewards, and losses are inherent to gameplay, and yet are rarely considered through the lens of cognitive biases like loss aversion.

Game designers often need to balance player autonomy and sense of control. Unfavourable win:loss ratios, in addition to high amounts, could be employed by designers to dissuade players from taking certain actions. In effect, loss aversion could be used to guide players toward an intended path. But beyond the creating of interesting decision points, game designers may also be able to take advantage of loss aversion by giving players a resource that suffers attrition or decay. To avoid the negative sense of loss, players could be extrinsically motivated to engage in behaviours to mitigate that loss. This design paradigm is already in effect in games such as *Overwatch*, where players' skill ranking decreases if they do not play a ranked game for several days. While forcing players to behave a certain way to avoid losses may seem to work against player interests, this technique could be employed in contexts that help to promote positive player experiences (e.g., by preventing toxicity in multiplayer games). As an example, multiplayer games could assign players a 'community standing' resource, seeded with a relatively high value, with code of conduct violations penalised by decrementing the value.

Speculatively, loss aversion may also have implications for why some people stop playing a game; either within a play session, or permanently. If players reach a point where progression in the game puts their resources at risk, or forces a loss onto the player, it may be more rational to stop playing before the loss is realised, rather than realizing the loss and experiencing the hedonic consequences. For example, if a player is on a win streak, continuing the play session may threaten to interrupt the streak – making it preferable to stop playing while the player is 'ahead'.

5.3 Limitations and Opportunities for Further Research

This research focused on the investigation of a purpose-built *Zelda*-like adventure game. As player experiences differ notably between genres and gameplay, further study is needed to generalise findings to other genres, play formats, and perspectives. For example, it may be that games that offer more immersive experiences – such as narrative-based roleplaying games – induce greater loss aversion due to the player's involvement in the game world, narrative arc, or connection to the player-character. Likewise, the occurrence and magnitude of loss aversion may differ in multiplayer games due to players' concerns about how their actions are perceived by others, such as fearing 'losing face' or appearing irrational.

Although there are variables other than wager amount, such as fatigue and familiarity, that could affect a player's decision to accept the wager, we do not capture these explicitly from participants and thus cannot model their potential influence. Our game's design meant that wager amounts increased, just as fatigue and familiarity do, so future work may want to account for these potentially latent factors.

While efforts were taken to ensure that our bespoke game had a high degree of ecological validity, the game did not include a save feature. In games where players have the option to save before risks, 'save scumming' (cheating behaviour where players reload the game if they receive a non-favorable outcome) could undermine effects of loss aversion. Investigating the impact of cheating behaviours on loss aversion was outside the scope of this investigation, but may be an area for future work.

This research explored the presence and influence of loss aversion in games through wagering currency. While this allowed for more direct comparison with loss aversion literature (in which wagering is often the experimental manipulation), there is a variety of both decision types and 'assets/valuables' that could be studied in gameplay. For example, many popular multiplayer games – such as *Fortnite*, *League of Legends*, and *Apex Legends* – prominently feature a persistent kill-death ratio attached to a player's public profile. Loss aversion may influence a player's in-game behaviour with these assets as well, prompting them to avoid situations that might adversely affect their kill-death ratio.

Our experimental method involved a sequence of 18 wagers, with participants immediately seeing the outcome of any wager they accepted. It is therefore possible that the outcome of their last accepted wager may have influenced their subsequent decision. While our method is consistent with many other studies, cautions have been raised regarding the cross-condition contamination that can occur in decision series [115]. Future work could examine this as a potential influence on player decision, including the possibility and influence of recency and serial position effects.

Furthermore, it is also possible that players considered the effect of wagering on their overall wealth – and that the current totality of their assets influenced their likelihood to accept or decline a wager. While it is ideal to be mindful of this, literature generally suggests that participants do very little asset integration (i.e., the degree to which people consider their current assets) when evaluating a prospect or a wager [3, 17, 80]. As such, we make the assumption that the win:loss ratio has more effect on a participant's decision to wager than their current accumulated wealth.

While our results suggest that the majority of players valued their gold, it is possible that our MTurk participants prioritised a quick completion of the experiment, and that they were therefore less likely to experience the game in a representative way. Future research may benefit from the exploration of loss aversion in a commercial game, and – with it – the utilization of a real playerbase. It is possible that loss aversion is moderated (potentially increased) by an intrinsic motivation to play.

Future work may also benefit from considering various aspects of play that strengthen player involvement, connection, or immersion. For example, a player who feels more connected to or represented by their player-character may also engage in more loss averse behaviours. Allowing a player to customise a player-character to best represent themselves may result in an increase of utility and value evaluation of game currency.

Finally, the fact that players do appreciate the utility of assets in games allows us a new opportunity to test hypotheses that have been difficult to explore in physical-world studies of loss aversion. For example, asset integration studies have only been able to ask participants what they *would* do, rather than have them actually risk valuable assets. In games, we can now simulate these dilemmas and explore them in an accessible, modifiable, and economical context. This allows researchers to shift the context of asset integration and loss aversion studies from hypothetical and smaller sums to a representative exploration of loss aversion in high-value scenarios.

6 CONCLUSION

This work represents an initial step toward understanding whether and to what extent loss aversion occurs in digital games. Our study involved the design of a *Zelda*-style game that made use of wagering to test loss aversion across a set of 18 decision points. The wagers' win:loss ratios were chosen so that we could examine whether or not people would be willing to take bets with different levels of loss or gain, with 50% odds throughout.

Our results were consistent with loss aversion. First, we showed that the majority of players declined wagers until the win:loss ratio became highly favourable (that is, that the player stood to gain substantially more than they would lose). Second, participants were significantly less likely to take a wager that used a high monetary value, despite the ratio of the wagers remaining consistent. Third, demographic factors of gender, age, player type and gambling risk did not significantly influence loss aversiveness. Finally, we found that players' satisfaction with their progress was reduced more from losing a wager than it was increased from winning a wager. Taken together, these findings offer support for the existence of loss aversion in games.

In response to arguments around loss aversion being improbable as players would view their money as "play money", we also found evidence that the majority of players valued their gold in game. In particular, we found that the majority of players reported feeling attached to their gold and feeling that their gold had purchasing power.

Loss aversion has many implications for designing and understanding games – especially games that contain permadeath, that reward survival time, or that invoke a loss upon player failure states. Through greater consideration of loss aversion, game designers can realise increased authorial control, and both designers and researchers may be able to discreetly influence a range of player behaviours. Our increased understanding of loss aversion offers a wealth of opportunities, both in terms of exploration for future work in this area, and in the development of better player experiences.

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