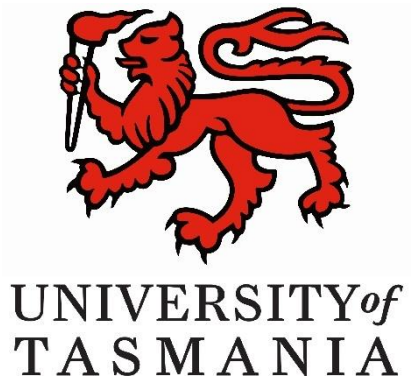

The Influence of Video Game Reward Structure on Player Risk-Taking

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A report submitted as a partial requirement for the Bachelor of Psychological Science with Honours degree (M4Y) at the University of Tasmania, 2021

Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

Signed:

_____

Nicholas James D'Amico,

October 14th, 2021

Acknowledgements

This research would not have been possible without the guidance and support of my primary supervisor, Dr. Jim Sauer. His unwavering enthusiasm, encouragement, and optimism were essential to my wellbeing and engagement throughout this year. I am truly grateful to him for supporting me as an emerging academic. It has been a privilege to work collaboratively on research we are both passionate about. I am also grateful for the contributions of Dr. Aaron Drummond, as a collaborator on this work and for assisting me through endless questioning.

My research was conducted alongside my lab partner, Callan Waugh. I am so grateful to have shared in this year with you. To see the personal growth and progress we have both achieved in such a short time together is a journey that I will not soon forget. Thank you for supporting me, I have learned so much from you and I'm blessed to be your friend.

I struggle to consider where I might be without the support of my friends and colleagues in the Honours cohort. The collaboration, connection, and encouragement I have felt from this group has been a highlight of my education. It's been a privilege to learn and grow alongside my close friends Brea, Cal, Georgia, Grace, and Zachary in our collective endeavour of completing this year. I am truly blessed to have met you all, you inspire me to be a better person and I'm excited to see where our futures take us. I'm so proud of each of you for all that you've achieved this year.

I'd also like to thank my family, friends, and housemates for supporting me through what has been an immense year. You have kept me afloat and aided me in staying sane on this journey.

And finally, to my dog Mikey, for consistently reminding me that love exists wherever you wish it, whenever you choose it.

I could not have done this without you all.

Thankyou.

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ID: 548555

Word Count: 9973

Abstract

There is speculation that engagement with gambling-like in-game rewards might be a risk factor for future gambling. No empirical data exists on this proposed relationship. We test one possible mechanism that might support this pathway: the effects of engaging with gambling-like reward mechanisms on risk-taking. We hypothesised that gambling-like rewards (i.e., randomised rewards delivered via a loot box) would produce an increase in risk-taking compared to a fixed, and no reward condition. 153 participants (M_{age} = 24.8, SD = 6.09) completed twenty minutes gameplay followed by a gamified, online version of the Balloon Analogue Risk Task. Gambling and loot box engagement self-reports were collected via the Problem Gambling Severity Index, and Risky Loot-Box Index. Bayesian t-tests comparing effects on risk-taking between reward groups indicated moderate to strong evidence in favour of the null hypothesis (BF = 4.05-10.64). These effects were not moderated by players' gambling symptomatology. A Spearman correlation between past loot box engagement and self-reported gambling severity (r_s = 0.35, p < .001) aligned with existing literature. Findings suggest the need for additional exploration into shared characteristics of gambling behaviour and loot box engagement. Future research may benefit from targeting individuals with elevated gambling symptomatology and loot box use.

Key Terms: Loot Boxes, Monetisation, Variable Ratio Reinforcement, Problem Gambling, Bayesian Analysis

The structure of rewards in video games has generated concern for their psychological impact on player behaviour. In the US and Australia, at least two-thirds of the population play video games (Brand et al., 2019; The Entertainment Software Association, 2021) and the global gaming market is predicted to reach a value of $314 billion (USD) by 2026 (Mordor Intelligence, 2020). The exponential growth of video gaming has prompted an increase in research into the positive and negative impacts of the activity. Increasingly, evidence suggests that video game engagement can reach problematic and addictive levels, causing psychological distress to individuals (Billieux et al., 2015; Kneer et al., 2014).

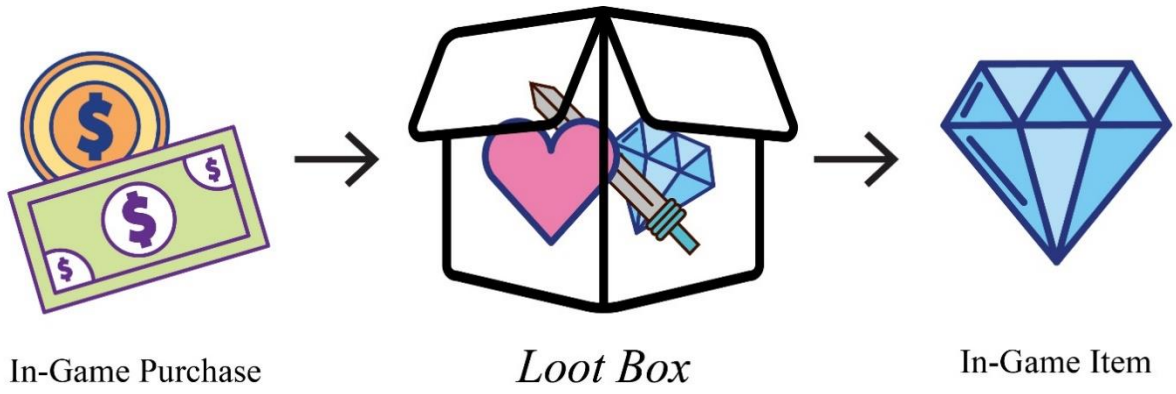
As the gaming industry grows, game publishers are innovating with new ways to increase the longevity and profitability of their game titles. In turn, these innovations are designed to capture player attention, maintain engagement, and generate income as more and more competing game titles emerge (Drummond & Sauer, 2018), creating a saturation of the market. Some researchers attribute the growth of video gaming and gaming-related revenue to innovations in reward design and monetisation strategies, which now include the ability to purchase randomised in-game items for cash or virtual currency. Game design such as this has generated media controversy (Abarbanel et al., 2017; Kelly, 2019), with some scientists regarding the monetisation of rewards as "predatory" to consumers (D. L. King & Delfabbro, 2018; Shen, 2021). One popular method of acquiring in-game rewards - known as a *loot box* - has been likened to gambling due to similarities in both surface-level appearance, and in the shared psychological mechanisms the two activities rely on. Some researchers and policy makers have speculated that, given these similarities, loot boxes might serve as a gateway to future gambling (Quirk, 2021; Zendle & Cairns, 2018). Although this seems unlikely, in this research we test one causal pathway through which engagement with loot boxes might increase the risk of the future gambling: via increased risk-taking.

Loot Boxes

A loot box is a digital container of rewards within a video game, often purchasable with real money (Figure 1).

Figure 1

Example of a Loot Box



The rewards in a loot box are acquired at random, with rarer (and more desirable) rewards awarded less frequently than common (and less desirable) ones. Rewards from loot boxes are sometimes relevant and valuable to the gameplay experience. These rewards vary from game to game but commonly offer a competitive in-game advantage, and/or a cosmetic change for the player (i.e., a character or item skin) (Drummond & Sauer, 2018; Garea et al., 2021). Other rewards exclusively offer cosmetic changes to the gameplay (e.g., altering the appearance of in-game characters), but can nonetheless be desirable to players based on their scarcity or esteem in the gaming community (Larche et al., 2021). Loot boxes are increasingly prominent on mobile, console and PC game platforms. Zendle et al., (2020) studied loot box prevalence rates among mobile app stores and found that a majority of the top 100 games (56%) across Android and iOS contained loot boxes. Total install counts were also measured for each game. For games with an age rating of 7 years and older, almost a billion installations of games containing loot boxes were recorded in U.S. app-stores. Another

analysis of the most played games on the PC platform *Steam* from 2010 to 2019 observed an increase in exposure to loot boxes from 5.3% of players in 2010, to 71.2% by 2019 (Zendle, Meyer, et al., 2020). Thus, loot box exposure is increasing across age groups and - given their ubiquity across platforms - across broader gaming demographics.

In response to their growing popularity, research has emerged concerning the way loot boxes function as part of the broader gameplay experience, and how they influence player behaviour.

Video Game Monetisation

As a design feature, including loot boxes in a video game is a monetisation strategy. That is, loot boxes leverage in-game content to generate profit for game developers (Zendle, Meyer, et al., 2020). Monetisation strategies in video games are increasingly prolific, as reflected in growing revenue trends for game publishers (D. L. King & Delfabbro, 2018). The monetisation of in-game content has increasingly fragmented, with many modern games now hosting marketplaces for individual item sales (Petrovskaya & Zendle, 2020) known as *microtransactions*. The success of microtransactions as a revenue source has led to the normalisation of player spending as part of the gameplay experience, including the use of real money to purchase rewards, often in the form a loot box. Currently, some games offer rewards exclusively through loot boxes, requiring players to pay for the random chance of receiving a desired item that is otherwise unavailable (Petrovskaya & Zendle, 2020). This raises ethical concerns (Neely, 2021), as players are often unaware of, or fail to understand (Xiao & Newall, 2021) the odds of receiving a given reward. They also cannot control the cost of their wager on this outcome, and therefore may not be able to make informed decisions about their gaming-related spending.

The increase in loot box implementation has coincided with the financial gain made in the video-game industry, as game developers are incentivised to include these monetisation systems by the profits accrued through their purchase and use (Garea et al., 2021). Currently loot boxes are a primary feature in many modern games (Zendle, Meyer, et al., 2020), and generate billions of dollars in post-sale revenue for the gaming industry (Drummond & Sauer, 2018; Greer et al., 2019; D. L. King & Delfabbro, 2018). The monetisation of rewards in video games is not a new phenomenon, games such as Pokémon contained virtual currencies and rewards as early as 1996 in the form of games corners and virtual casinos (Laato, 2020). Problems arise however, with the spending of real money (cf. virtual currency earned exclusively in-game) in purchasing rewards. Some researchers argue that the ability to buy loot boxes with real money is a key distinction from other forms of in-game rewards, and places loot boxes closer to conventional gambling activity (Drummond & Sauer, 2018; Garea et al., 2021).

Video Gaming and Gambling

Although the focus of this thesis is not on digital gambling itself – and more on gambling-like reward mechanisms in games – it is worth considering digital gambling and its convergence with video gaming in order to better appreciate the emergence of gambling-like systems in games, and the way they operate.

Digital Gambling

Consumers can now gamble on a range of devices including computers, smartphones, tablets, gaming consoles and televisions (Gainsbury et al., 2014). Consequently, the same devices can now be used to both game and gamble. Like video games, digital gambling often employs virtual currency instead of real money to simulate gambling activities. Additionally, many gambling activities are embedded in modern video games as mini-games, in which the winnings can be used to make other in-game purchases (Gainsbury et al., 2014; Griffiths,

2015; Zendle, Meyer, et al., 2020). These gambling-games are increasingly accessible on social media sites, phone apps and gaming consoles (Abarbanel et al., 2017) and appear similar to traditional forms of gambling in the psychological processes they interact with, such as variable-ratio reinforcement (Ferster & Skinner, 1957), risk-reward evaluation (Rachlin et al., 2015) and the sunk cost bias (Griffiths, 2015). A lack of regulation in this area has resulted in few, if any age restrictions on who accesses this gambling content. This has raised concern among researchers and policymakers in understanding the effects of gambling-gaming products on adolescents (Griffiths, 2015, 2019; Hayer et al., 2018). The long-term consequences of exposure to digital gambling is unclear (Armstrong et al., 2018; Hayer et al., 2018; Laato, 2020). In traditional gambling, children who are exposed early in life are likely to develop gambling behaviours as adults (Hodgins et al., 2010; Newall et al., 2020). Similarly, some researchers have speculated that digital gambling might act as a gateway to future gambling behaviour (Armstrong et al., 2018; Griffiths, 2015; Hayer et al., 2018), but the literature does not provide a rigorous test to this claim. This concern is particularly relevant in considering the convergence of gambling and video gaming, as players are engaging in gambling-like activity with in-game items.

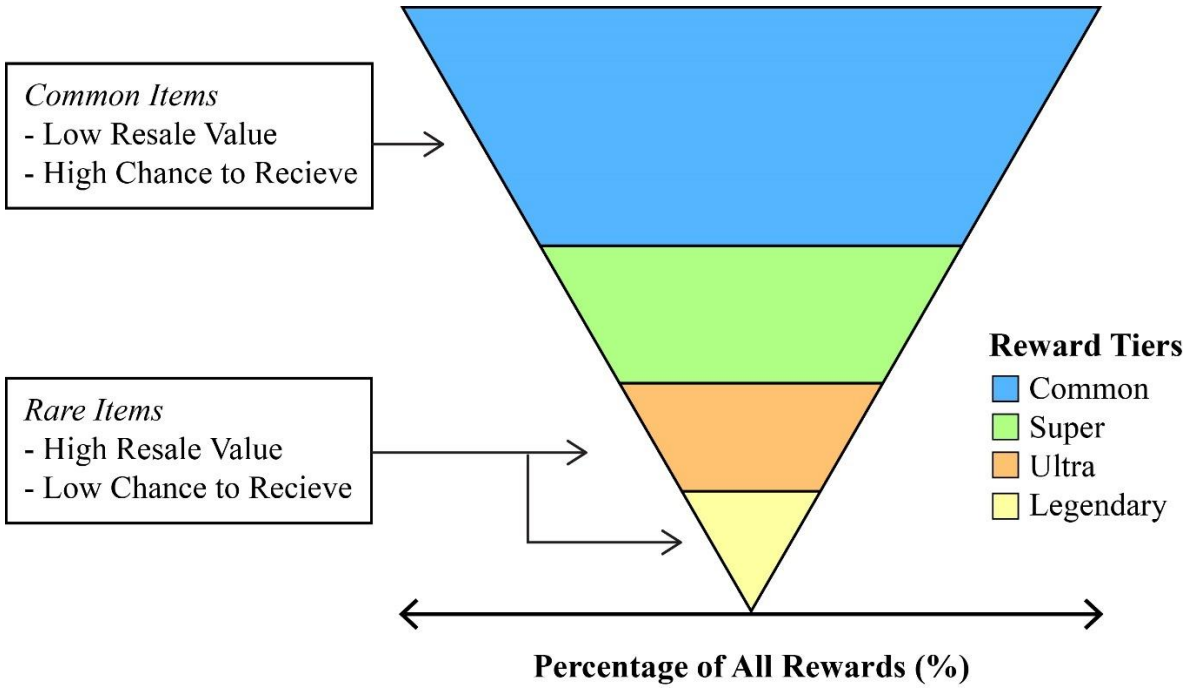
Digital Gambling and In-Game Content

In-game rewards are increasingly monetised and randomised, and the value of some loot box items extends beyond their purchase price. Across the gaming industry there is a reasonably consistent price for loot box purchase, with an average cost of around $2-3 USD (Castillo, 2019; Kelly, 2019). Items won from some loot boxes can be sold in online marketplaces, and sale prices can far exceed the cost of purchase (Macey & Hamari, 2019). Conversely, many items from loot boxes have a resale value lower than the loot box purchase price, meaning that players receive an item which incurs a financial loss (Drummond et al., 2019). Due to the random nature of acquiring rewards through loot boxes, players are more

likely to receive common items than rarer ones after purchase. This hierarchy of reward-likelihood (Figure 2) creates a system of value and rarity for in-game items that might not exist were they available for direct purchase (Neely, 2021), with rarer items becoming extremely valuable to the relevant gaming community (Liu, 2019; Macey & Hamari, 2018).

Figure 2

Hierarchy of Reward Likelihood



Note. Conceptual representation, reward tier labels are fictional (though indicative of actual labels).

Within this system, cosmetic items which generally only offer an aesthetic change and provide no functional advantage accrue monetary value based on their rarity or popularity. These rewards may disproportionately appeal to vulnerable people, with reports of individual spending exceeding $10,000 on loot boxes (Kelly, 2019).

Due to their demand, third-party online marketplaces emerged allowing the payment of cash for the resale of in-game items, with some individual prices exceeding thousands of

dollars (Greer et al., 2019). Some of these items became placeholders or “de facto currency” (Haskell, 2017, p.126) used to bet on the outcomes of sports matches, roulette games and other gambling activities. In 2015, an estimated $2.3 billion (USD) in in-game rewards from the game *Counter Strike: Global Offensive* were sold through resale sites and used as virtual currency (Haskell, 2017). In this instance, in-game content was used to facilitate actual gambling, resulting in a prompt ban due to a lack of regulation and protection for consumers.

Digital gambling and in-game content are increasingly intertwined, and some researchers consider loot boxes to be a product of the “gamblification of gaming” (Brooks & Clark, 2019, p. 26). This is partly due to the concurrent rise of gambling-like gaming products, the ability to gamble on video games, and the monetisation of in-game rewards. Loot boxes represent a unique nexus of these developments, in which player rewards, gambling-related activities, and the spending of real money converge. The prominence of loot boxes, and their proximity to other gambling activities surrounding video games has generated concern for the safety of consumers (Quirk, 2021; Zendle et al., 2019). This concern has resulted in an analysis of the psychological structure, and impact of loot box use on the players that engage with them.

The design of loot boxes appears psychologically similar to traditional forms of gambling, and this is reflected in trends of player behaviour with loot boxes (Drummond & Sauer, 2018; Garea et al., 2021). Drummond & Sauer (2018) utilised Griffiths (1995) framework to show that most loot boxes in popular games met the psychological criteria for gambling. These criteria include: the exchange of money, an unknown future event in the exchange, the element of chance involved in the outcome, the capacity to avoid loss by opting out, and the option to “cash out” winnings.

The Psychology of Loot Boxes

These psychological criteria for gambling that most loot boxes meet, and the mechanisms they exploit may contribute to their success as a revenue source and their increasing prevalence in modern video games. Broadly, it is argued that loot boxes condition players to play for longer, to spend money and to buy additional loot boxes (Brooks & Clark, 2019; D. L. King & Delfabbro, 2018). Specifically, the randomisation of loot box rewards results in variable ratio reinforcement, a feedback mechanism that increases behaviour acquisition and repetition, and attenuates behavioural extinction (Drummond & Sauer, 2018; Ferster & Skinner, 1957). It is speculated that this reward schedule underpins the success, and continued implementation of loot boxes in modern video games (Garea et al., 2021; D. L. King & Delfabbro, 2018; Zendle, Meyer, et al., 2020). These reinforcement features are central to classical and operant conditioning and underpin the psychology of many traditional gambling activities.

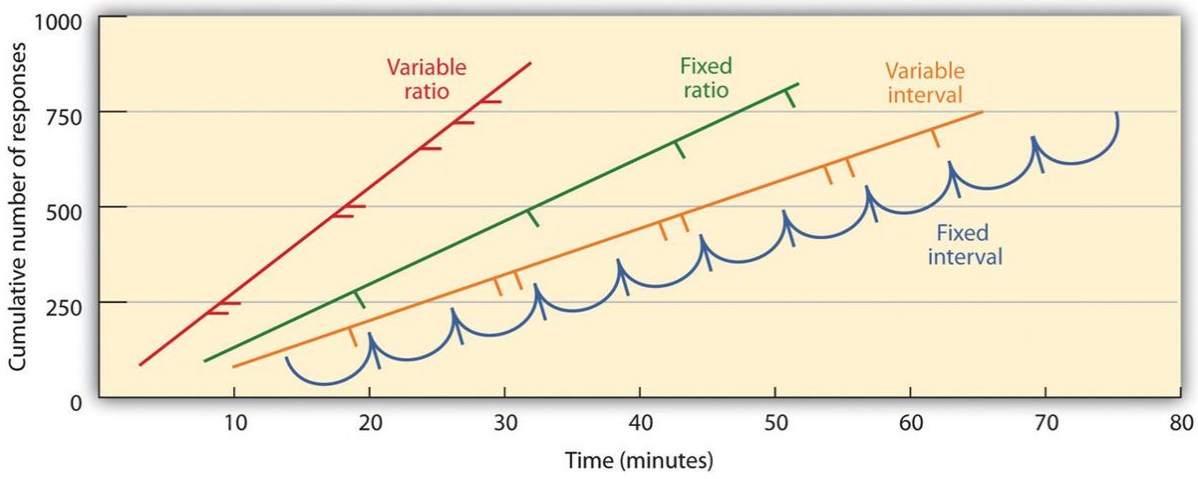
Reinforcement, Randomisation and Gambling

Reinforcement can be positive or negative, with positive reinforcement often constituting a reward or desirable outcome. Basic operant conditioning and reinforcement principles entered behavioural psychology in the mid-20th century. Ferster & Skinner (1957) differentiated between different schedules of reinforcement of behaviour in animals, and how each resulted in varied rates of behaviour acquisition, repetition, and retention. The schedule on which behaviour is reinforced can vary between a *ratio* or an *interval*, with rewards delivered at fixed or varied ratios and intervals. Rewarding behaviour every time it is produced is a *fixed*, 1:1 ratio schedule. Additionally, a reward at every second, fifth or tenth behaviour follows ratios of 1:2, 1:5 and 1:10 respectively. Extending or reducing this ratio has varied effects on a subject response rate, known as “stretching” or “thinning” reinforcement (Ferster & Skinner, 1957). The larger the ratio, the less likely behaviour will

be reproduced, as the rewards may be spaced too far apart for consistent association. An interval relates to the time of reward relative to a behaviour. Delivering rewards at predictable, repeated time intervals (e.g., immediately, 1 second, 2 minutes) results in behaviours closely aligning with these intervals. Conversely, *varied* intervals reward behaviour at random times, creating inconsistencies between behaviour and reward timing. Early work suggested that variable (random) ratio reinforcement results in the strongest behavioural response (i.e., most rapid acquisition and most frequent repetition) compared to other schedules (Ferster & Skinner, 1957) (Figure 3).

Figure 3

Variation in Response Over Time per Reinforcement Schedule



Note. Retrieved from (Walters, 2020).

The random timing of rewards is thought to increase overall engagement, rather than rewarding specific behaviours. In other words: when rewards are randomised, the subject is more likely to persist in their behaviour for reward. This may occur because each time the behaviour fails to generate the reward, the subject believes they are one step closer to the next reward (Belisle & Dixon, 2016).

In practice, these reward schedules can be seen in real world contexts, as researchers apply these same mechanisms to our understanding of problem gambling and loot box use. Gambling and loot box use require a wager on an unknown result, and a financial risk is inherent to the activity. Neither a win nor loss is guaranteed, with the outcome largely determined by chance, and wins distributed intermittently and at random. In this way, virtually every gambling activity (Sharpe & Tarrier, 1993), and every loot box purchase both relies on and feeds into operant conditioning and variable reinforcement schedules.

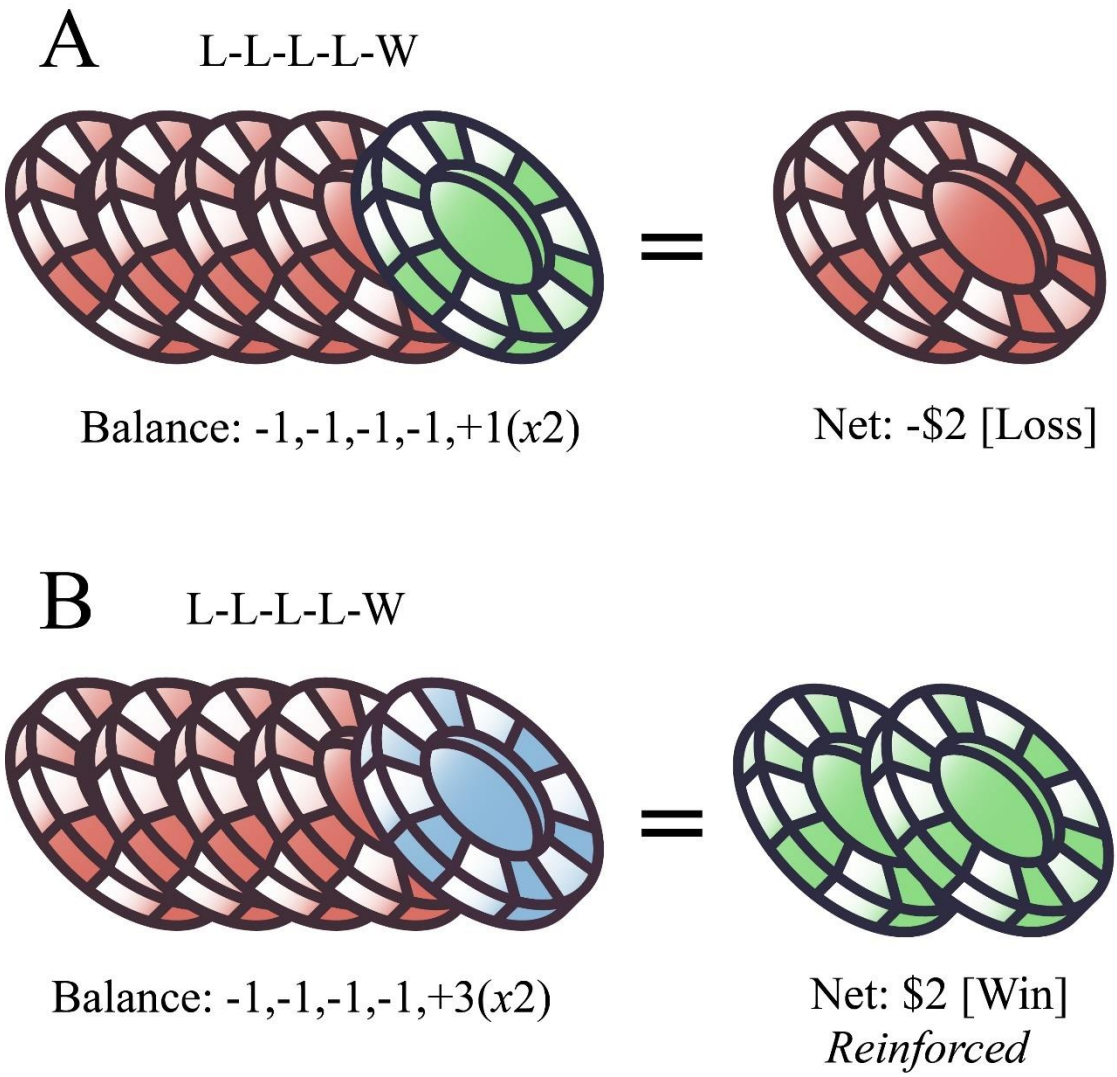
The Risk of Gambling

Each time a player places a bet, wager, or gamble on an outcome, they risk the chance of losing their bet. Repeated gambles place consumers at higher risk of addiction, as they are reinforced to continue playing irrespective of win or loss (Rachlin, 1990). If a gambler persists after an initial loss, this repeated gambling behaviour creates a pattern of reinforcement that results in increased risk-taking (Rachlin, 1990; Rachlin et al., 2015). Rachlin describes gambling behaviour as a sequence or *string*, and these strings of behaviour relate to win-loss ratios that parallel operant conditioning. For every loss, the risk - of breaking even or making a profit from winnings - increases. As loss accumulates, the required value of the reward to recover, or break-even also increases. Framed this way, every time a gambler loses: their hypothetical “next win” becomes more valuable, while the *risk* of obtaining that win only increases as they make another gamble. Take for example: a gambler who places four bets and wins on the fifth, with every bet worth one dollar, and a payout of two dollars. At the end of the fourth bet, she has lost four dollars. Assuming she wins on her fifth bet, her net loss will still be two dollars, and so the win is merely a reduction in loss (Figure 4, A). To convert this string to a win, the gambler would need to increase the value of the bet to at least three dollars. Her probability of loss is the same, yet the risk of loss has increased from a ratio of 1:1, to 1:3. As mentioned, our gambler wins this bet, and so her net

gain is now two dollars (Figure 4, B). In effect, our gambler has been rewarded for her increased risk-taking, as her behavioural pattern of loss-loss-loss-loss-win has been reinforced with a win of two dollars.

Figure 4

Gambling as Winning or Losing Strings



In this example, the *ratio* of wins to losses is 1:4 (L-L-L-L-W), and this functions as a reinforcement schedule for this string. In this example, our gambler is rewarded at a win-loss ratio of 1:4 (see Table 1) and may pursue and expect a win after a future string of four consecutive losses (Lloyd et al., 2021).

Table 1

Similar Gambling Strings Leading to Varied Reinforcement

Gamble	String	Win-Loss Ratio	Risk:Reward at Win	Outcome of String	Reinforcement
A	L-L-L-L-W	1:4	X:1	-$2	Negative / Loss
B	L-L-L-L-W	1:4	X:3	+$2	Positive / Win

Note. X = probability (risk) of loss. The *risk* value is varied in real life contexts, but stable and arbitrary (X) in this example.

Over time and with repeated exposure and gambles, the ratio of risk to reward, and the ratio of wins to losses will fluctuate and vary on an intermittent schedule. On another occasion, our gambler may be rewarded with a win after a string of six losses (1:6), or any other combination of win-loss. In total, the ratio of her rewards and risks will vary at random, and this variation will comprise the overall reinforcement schedule she experiences whenever she gambles. As a result, Rachlin argues that the constructs of risk and reward are intertwined, and central to the maintenance of gambling behaviours, as gamblers are conditioned to continue from their first wager irrespective of win or loss (Rachlin, 1990; Rachlin et al., 2015). After an initial gambling experience, some individuals are more likely than others to continue gambling, and this may be due to differences in risk-taking. It is speculated that this same conditioning process occurs in loot box use (Zendle, Cairns, et al., 2020), but no evidence exists on the relationship between loot boxes and risk in video gamers. However, it is plausible that the guarantee of a reward (however varied) through loot box purchase may influence risk in a similar fashion to gambling (Lelonek–Kuleta et al., 2020).

Risk-Taking

Risk-taking refers to voluntary action performed under uncertainty, which carries some probability for negative consequences (Balogh et al., 2013; Magar et al., 2008), and this definition applies directly to the act of gambling, and loot box use. The development of risk-taking and risk assessment is well documented, increasing from childhood to young adulthood, with a peak and decrease in later adulthood (Figner et al., 2009). Importantly, developmental research suggests that higher risk-taking in youth is associated with addiction vulnerability later in life (Balogh et al., 2013; Figner et al., 2009; Figner & Weber, 2011) which may have implications for adolescent loot box use (Ide et al., 2021; Newall et al., 2020).

Not all risk-taking is problematic, as risk behaviours can be positive (i.e., rock climbing, bungee jumping) or negative (i.e., crime, drug use) (Hansen & Breivik, 2001). Risk-taking is not homogenous, and different approaches are used to measure the various dimensions, which are often used interchangeably (Frey et al., 2017). Risk *propensity* is a type of self-report measure used to identify an individual's risk preferences and likelihood. Like preference, risk *frequency* is another self-report method that describes risk behaviours such as drinking, gambling, or smoking. Risk *behaviour* measures are less concerned with an individual's self-reports and are designed to assess actual risk behaviours, also known as the "revealed-preferences" approach (Frey et al., 2017, p. 1). Behavioural measures are often designed to capture or demonstrate the cognitive processes underlying risk behaviours (Frey et al., 2017). In our research, we chose a commonly used risk behavioural measure to assess the influence of reward on player risk-taking: The Balloon Analogue Risk Task (BART) (Lejuez et al., 2002, 2003).

Risk and Reward

Risk-taking is influenced by the reward outcome of a decision, with some individuals displaying higher sensitivity to reward than others. The motivation to take a risk can be understood through two mechanisms: behavioural *activation* and *inhibition*. Behavioural activation refers to excitation in the presence of a reward, while inhibition governs the interruption of behaviour (Meyer et al., 1999). Individuals who are risk-averse may be better at inhibiting their thoughts and emotions, while a risk-prone person might have a stronger reaction to risk, with a lower capacity to inhibit their behaviour (Bembich et al., 2014; Noël, 2014). In children and adults, increased activation in brain regions associated with reward anticipation (e.g. the ventral striatum**)** is associated with risky behaviours (Rutherford et al., 2010). The neurobiology of these systems matures at different rates across adolescence (Balogh et al., 2013; Rutherford et al., 2010), with early exposure leading to stronger activation patterns and increased risk-taking in adulthood. Rutherford et al. (2010) found that youth who engaged in risk behaviours such as underage gambling had an imbalance between reward activation and inhibition, resulting in high scores on risk-taking measures. If loot boxes exploit similar psychological mechanisms to gambling, then risk may be an inherent part of loot box engagement. As such, loot box use is considered by some to be a form of risk behaviour (Brooks & Clark, 2019; Zendle et al., 2019).

Risk-Reward and Gambling

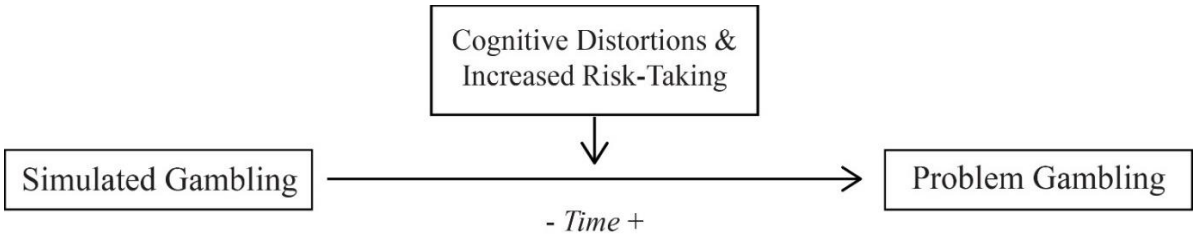
The link between gambling and risk is well established in the literature, as the act of gambling inherently involves risk-taking (Mishra et al., 2017; Rachlin, 1990; Rachlin et al., 2015). This link is particularly relevant to loot box use, as loot box exposure may function to *increase* risk-taking in the same way as gambling activities. Concerns have been raised that a large proportion of loot box users are children (Gilbert, 2020), with some studies reporting nearly half of young gamers having already engaged with loot boxes (Kristiansen & Severin,

2020), and others demonstrating that many popular game titles available to children include loot boxes that meet the psychological criteria for gambling (Drummond & Sauer, 2018).

Previous research on youth gambling highlights the vulnerability of young people in engaging with loot boxes (Liu, 2019; Newall et al., 2020). In an exploration of the transition from simulated gambling to real financial gambling, Armstrong et al. (2018) found that youth who engaged with virtual currency and simulated gambling were more vulnerable to later financial and problematic gambling. The authors argued that simulated gambling games are likely to increase risk-taking behaviour due to the cognitive distortions that occur from playing risk-free simulations (Figure 5).

Figure 5

Simulated Gambling Leading to Problem Gambling



They argue that a gambling simulation creates a *gamified illusion* that results in overconfidence and misconception about the risks (i.e., potential losses, addiction) associated with actual gambling. In consideration of these findings, it has been suggested that loot boxes distort perceptions of risk in a similar fashion to gambling activity (Brooks & Clark, 2019). This distortion may result in a *gateway* effect (Hayer et al., 2018; D. L. King & Delfabbro, 2018) in which engagement with loot boxes begins a sequence of behaviour that may increase player risk-taking, as a precursor to problematic gambling.

The Path to Problematic Gambling

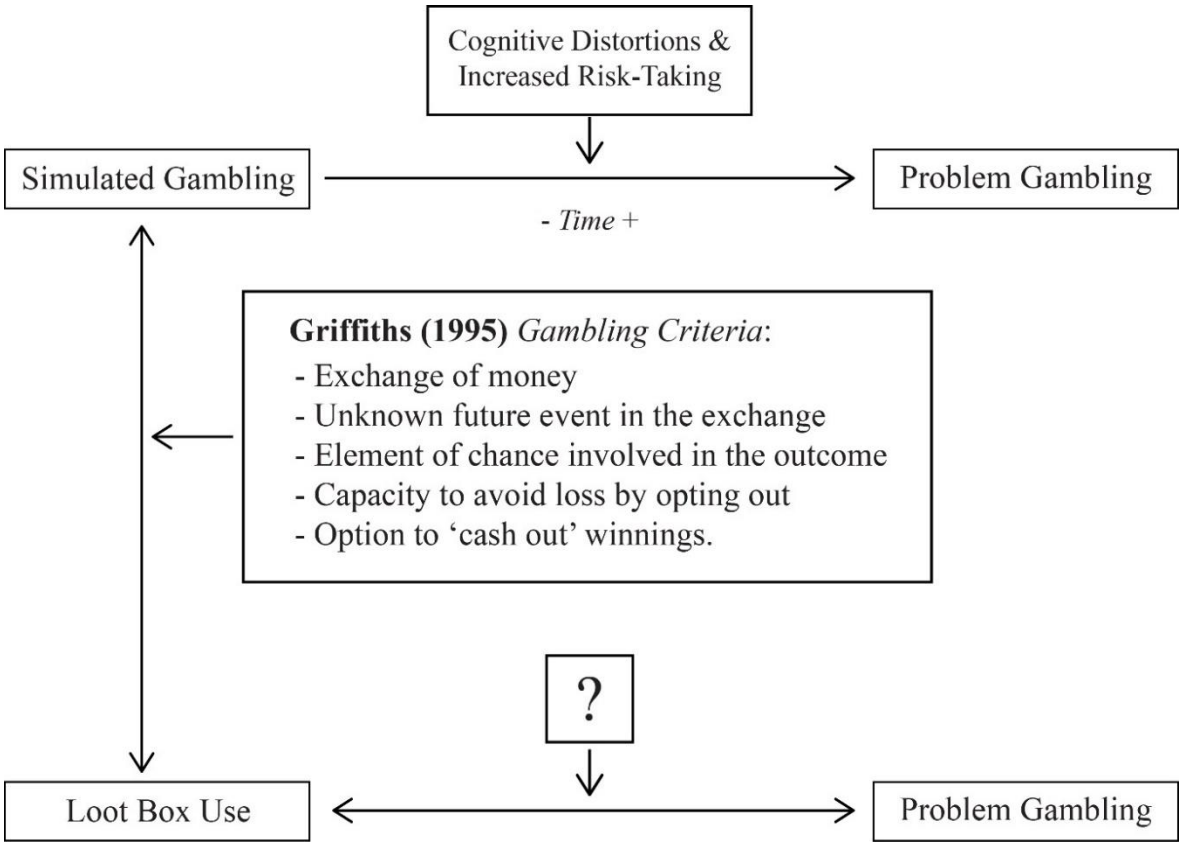
In their pathways model, Blaszczynski & Nower (2002) describe how operant conditioning creates habitual participation in gambling through a pathway of cognitive changes. Initial reinforcement occurs after a win which produces arousal and excitement in the individual. Immediately, the experience of a win is rewarded with the feeling of success. After repeated wins, this association is paired with the environment in which gambling takes place, such as a casino, online on a computer or, in the case of loot boxes: within a video game itself. This arousal also begins a sequence of cortical excitation, in which a cognitive desire is created to continue the behaviour in anticipation of a win or reward. If participation in this cycle continues, the potential for distorted cognitive schemas arises. Such schemas can include: the misattribution of success to skill, resulting in a distorted sense of control over outcomes; biased evaluations of individual contributions; superstitious thinking; and probability theories relating to wins and losses (Blaszczynski & Nower, 2002; Griffiths, 1995). Griffiths (1995) argues that these distortions solidify as gambling engagement increases, resulting in a cognitive entrapment for problem gamblers. Entrapment results in a committed endeavour to complete a goal after an initial investment of money (Arkes & Blumer, 1985). In a gambling context, entrapment behaviours relate to incurred losses and can include playing beyond one's financial means, playing for longer periods than intended, and continued wagers to make prior investments worthwhile (Brooks & Clark, 2019). Entrapment is also known as the *sunk cost bias*, in which prior spending (the sunk cost) motivates the present decision to continue gambling (Arkes & Blumer, 1985). After repeated exposure, individuals' perceptions of their own gambling habits, thoughts and behaviours may become warped, even as their behaviour reaches problematic and damaging levels.

Loot Boxes as Gambling

The theoretical and structural similarities of loot boxes to gambling activity has implications in this context and may be a cause for concern. Plausibly, these same effects could be occurring in loot box engagement as they often meet many of the same psychological criteria as gambling (Figure 6).

Figure 6

Gambling and Loot Box Associations



Engaging with loot boxes could act to condition players to further spending, risk-taking and longer play time as noted in Zendle (2019): "intermittent wins that characterise loot boxes may result in a process of conditioning in which loot box spenders learn to associate gambling-like experiences with excitement" (p.3). The excitation associated with this conditioning process can be seen in research comparing player brain activity during a

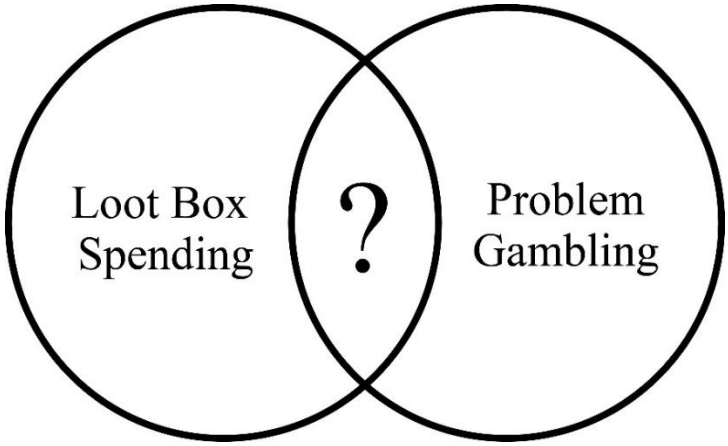
loot box opening to activity during gambling tasks. In a within-subjects design, Larche et al., (2021) showed that winning a reward from a loot box activates the same neurobiological reward responses as monetary wins from a slot machine, with rarer items in loot boxes eliciting stronger responses.

Additionally, players by nature are investing time and money into the experience of playing the game that loot boxes are nested within. Immediately, operant conditioning and the sunk cost bias may be operating, as the rewards from loot boxes may reinforce the gameplay experience, with some rewards necessary for in-game progression (Zendle, Meyer, et al., 2020). Like gambling, the time accumulated in-game and exposure to loot boxes may directly relate to increased loot box engagement.

Another study by Zendle (2019) measured player spending before and after the removal of loot boxes from a popular game title *Heroes of the Storm*. After loot boxes were removed, individuals with pre-existing gambling problems showed a greater reduction in total in-game spending compared to non-gamblers (Zendle, 2019). Results from this study and others suggest a unique appeal of loot boxes to gamblers compared to other in-game purchases (Zendle, Cairns, et al., 2020), as research has consistently shown a positive relationship between problematic gambling and loot box purchase (Figure 7) (Garea et al., 2021; Li et al., 2019). Similarly, some studies have found that loot boxes generate a disproportionate amount of their revenue from problem gamblers (Drummond & Sauer, 2018; Griffiths, 2019; Zendle et al., 2019).

Figure 7

Ven Diagram of Loot Box Spending and Problem Gambling

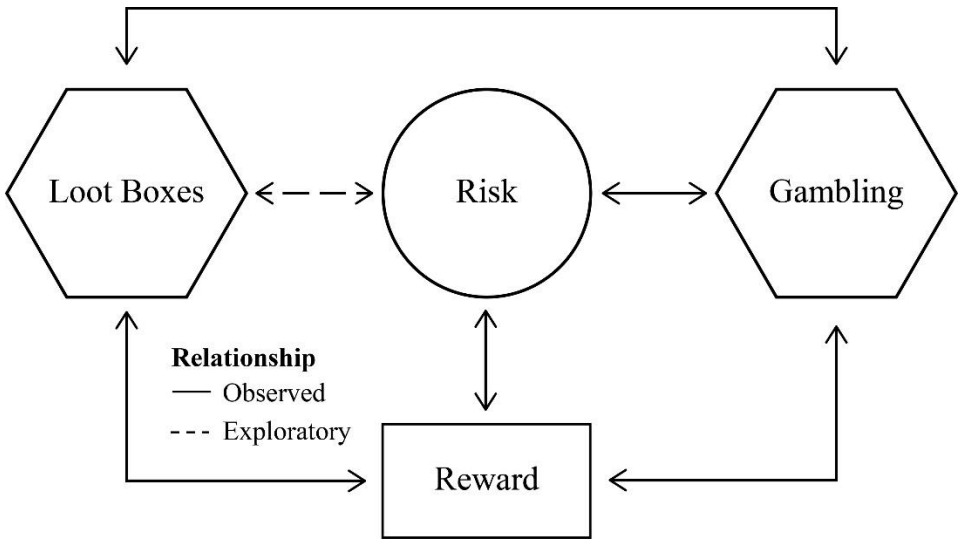


Within a sample of video gamers, Zendle & Cairns (2018) observed a positive relationship with loot box spending and elevated status on the Problem Gambling Severity Index (PGSI) when compared to other forms of in-game spending. The PGSI has been used consistently in comparing loot box purchases to problematic gambling tendencies, and in both individual studies, replications (Zendle & Cairns, 2019) and meta-analyses, the relationship between problem gambling symptomatology and loot box spending has been recurrent (Garea et al., 2021). In response to this, other measures have been developed to assess "risky" or problematic loot box use specifically. The Risky Loot-Box Index (RLI) was created to understand the use, purchasing habits, beliefs and behaviours about loot boxes and how they relate to risk and gambling, and correlates well with the PGSI and other measures of risk-taking (Brooks & Clark, 2019). These findings contribute to a broader treatment of loot boxes as gambling devices in recent research. Following, Drummond & Sauer (2018) highlight that access to loot boxes generally is not age restricted. Thus, children and young people who do not meet the age restrictions for conventional gambling activities can access them.

A consistent positive relationship between loot box purchasing and problem gambling symptoms is established in the literature (Garea et al., 2021; A. King et al., 2020; Molde et al., 2019; Zendle, Cairns, et al., 2020; Zendle & Cairns, 2019). Although this work does not imply a causal relationship between loot box spending and the development of problem gambling symptomatology – and may instead simply indicate that these mechanisms are disproportionately enticing to those at risk of problem gambling – there is concern in some circles that loot box engagement may have a causal influence on maladaptive behaviour, such as future gambling (Brooks & Clark, 2019; Kelly, 2019; Quirk, 2021). The factors underlying a directional influence between loot box use and risk-taking necessary to support a *gateway hypothesis* have not been established, or even tested for (D. L. King & Delfabbro, 2018). Regardless of our beliefs about the likelihood of a gateway mechanism in this context, the issue merits investigation because there are some plausible (though not necessary probable) theoretical pathways for the relationship (Figure 8), and because policy makers are making claims about the possibility of such a gateway (Quirk, 2021)**.** Thus, some empirical data on the relationship is required.

Figure 8

Relationships Between Risk, Reward, Gambling and Loot Boxes



Specifically, the temporal order of the links between loot boxes, gambling, and risk behaviour is yet to be understood. Zendle (2019) offers several speculations to understand the nature of this relationship: First, and by design, loot boxes may act as a gateway to gambling. Second, pre-existing gambling behaviours, tendencies or predispositions may drive higher loot box purchasing upon engagement. Third, individuals who have access to loot boxes may also be in digital proximity to online gambling products and are more likely to access them, resulting in a co-occurrence of loot box purchasing and gambling. This area of research is in its infancy, as most studies have relied on self-reports of loot box spending, behaviour frequencies, and problematic gambling tendencies. As such, there is limited research on the effect of loot box engagement on player *behaviour*.

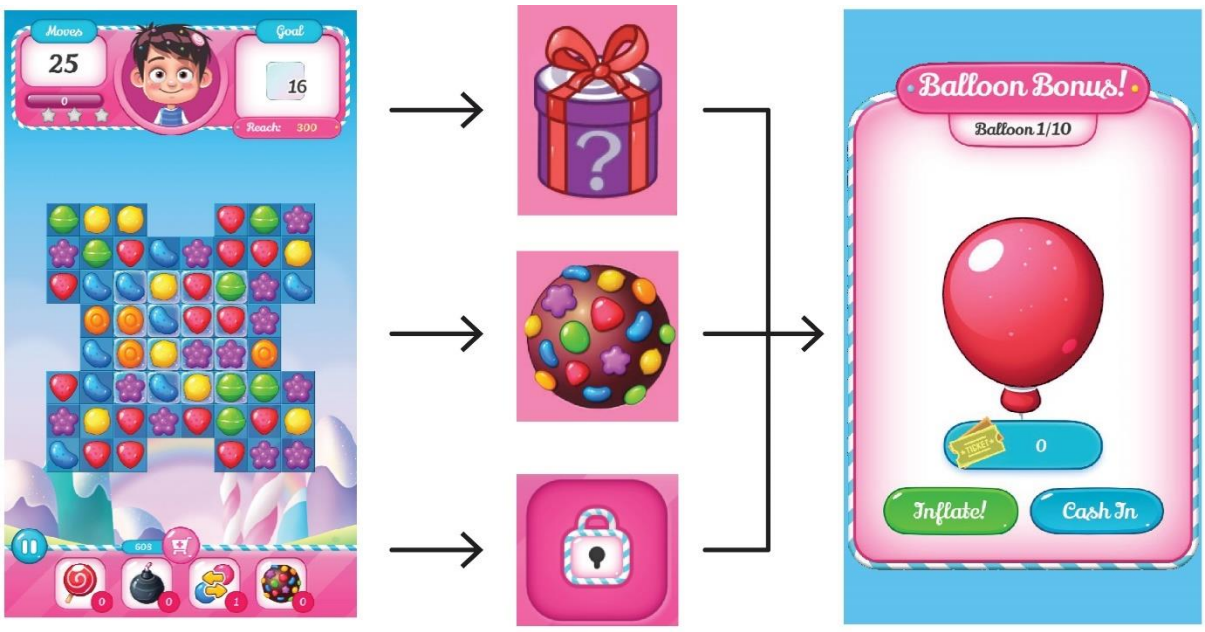
The Present Study

In our pre-registered study, we took a first step to address this gap, and test one mechanism that might support a gateway hypothesis by comparing individuals who interact with in-game loot boxes with those who do not, on an established behavioural measure of risk-taking: The BART (Lejuez et al., 2002).

Using a custom video game, this research was designed to reflect the existing literature on the interplay between video gaming, loot boxes, risk, and gambling. Specifically, we recruited participants to play a bespoke videogame (modelled on the popular Candy Crush™ game, to maximise participants' ability to "pick up and play") with one of three reward conditions (see Figure 9).

Figure 9

Experimental Components



Some participants were exposed to a reward mechanism which allowed them to purchase *randomised rewards* with currency earned in-game (Loot Box Condition); some participants were exposed to a reward mechanism which allowed them to purchase *visible rewards* with currency earned in-game (Fixed Reward condition); and other participants played the game without any reward mechanism (No Reward, control condition). After gameplay, participants completed the BART, and answered questions on the PGSI and RLI.

This design allowed to us investigate whether engaging with randomised in-game rewards, compared to fixed rewards or a no-reward control, affected later risk-taking behaviour. Given the inherent role of risk-taking in gambling, and the structural similarities between loot boxes and gambling activities: we hypothesised that engaging with loot boxes in-game - as a gambling-reward mechanism - would be associated with increased post-game risk-taking such that:

H1: Participants in the Loot Box (random reward) condition would have higher scores on the BART than participants in the No Reward (control) condition.

H2: Participants in the Loot Box condition would have higher scores on the BART than participants in the Fixed Reward (non-randomised) condition.

Due to the exploratory nature of this design, we also tested for differences in risk-taking between the No Reward and Fixed Reward condition (***H3***). This allowed us to explore whether in-game rewards in general increased risk-taking relative to the control condition.

Given the interrelationship between risk and gambling, previous gambling experience may have influenced the relationship between loot box engagement and risk-taking. Thus, we tested if differences in BART scores across the three reward conditions were moderated by participants' scores on the PGSI such that:

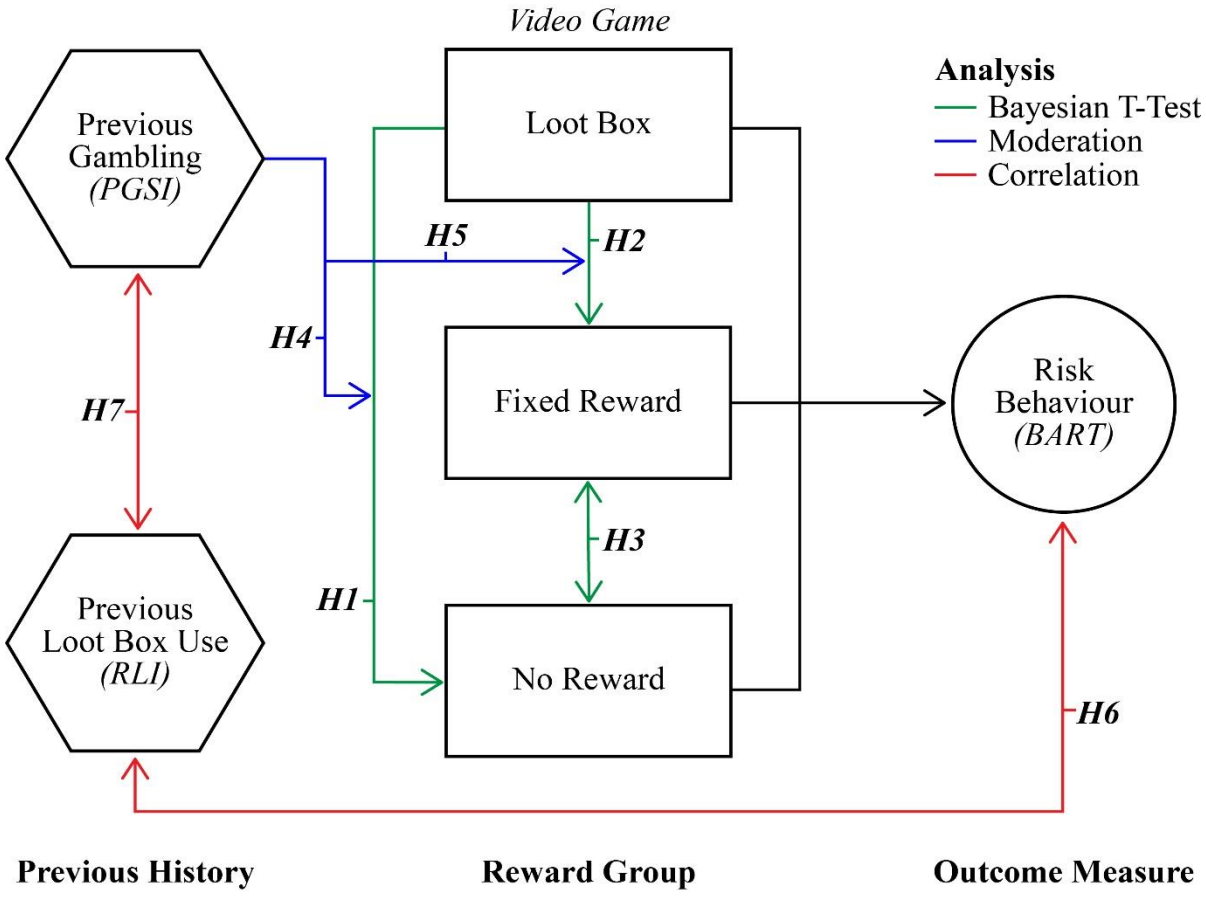
H4: Participants with higher PGSI scores would show greater differences in BART scores from the Loot Box to No Reward conditions than participants with lower PGSI scores.

H5: Participants with higher PGSI scores would show greater differences in BART scores between the Loot Box to Fixed Reward conditions than participants with lower PGSI scores.

The RLI is a relatively new measure of loot box engagement (Brooks & Clark, 2019). Thus, we had the opportunity to test if BART scores were correlated with participants scores on the RLI (***H6***) and as a replication of the original study, we tested if RLI scores were correlated with participant PGSI scores in our sample (***H7***). This hypothesis provided additional insight into the validity of the RLI for use in future loot box research. The hypotheses-analysis interplay is visualised in Figure 10.

Figure 10

Hypotheses-Analysis Flow Diagram



Note. Construct measures and experimental tasks are italicised.

Method

Ethics Approval

Ethics approval was granted for a minimal risk application (HREC Code: H0021748) on the 5th of May 2021 by the Tasmania Social Sciences Human Research Ethics Committee (see Appendix A).

Preregistration

To facilitate transparency, reproducibility, and to demonstrate good research practice (Yamada, 2018) this study was preregistered within the OpenScience framework and will be made available pending approval from primary researchers.

Participants and Design

A priori power calculations were conducted in G*Power for a one-tailed independent samples t-test comparing two means and suggested that 51 participants per condition (N=153) would yield .8 power to detect a moderate (*d* = .5) difference between any two conditions. This calculation was based on Frequentist analyses and used to guide recruitment cut-offs.

153 participants (91 males, 59 females, 3 others), aged 18 to 53 years (*M* = 24.8, *SD* = 6.09) were randomly assigned to one of the three experimental conditions in our between-groups design. The conditions included: Loot Box (n = 51), Fixed Reward (n = 51), and No Reward (control condition, n = 51). Participants were recruited from a variety of sources including the UTAS School of Psychological Sciences first year research participation pool, via established recruitment lists, through advertising around campus, and on social media platforms. All participants entered a prize draw for one of six $50 gift vouchers for completing the experiment.

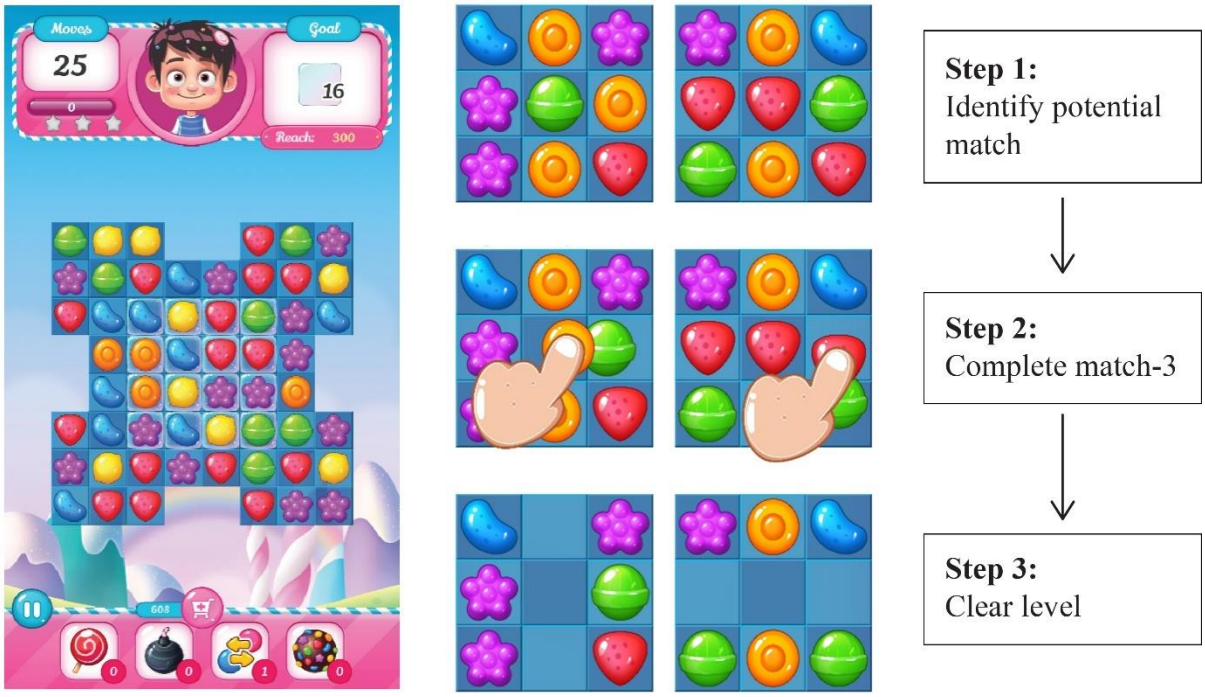
Materials

Our Game. The match-3 video game used in this research was designed to emulate the popular game Candy Crush™, which is well known to the general population and accessible (i.e., easy to play) for participants with no prior gaming experience. This software was developed for a previous study of a similar nature. The game requires participants to match coloured candies in rows or columns of three, with each level requiring candy-matches

of increasing frequency, or under varied conditions (Figure 11; for a complete explanation of the rules, see Appendix B). Participants completed this task online, on a personal computer. Play-time was limited to 20 minutes for all conditions, as a pop-up appeared automatically to proceed to the next task.

Figure 11

Experimental Video Game



In-Game Rewards. Reward presentation and availability varied across conditions. There were three rewards available, with different gameplay functions related to each reward (see Appendix C). Rewards were only available in the two Fixed and Loot Box conditions (Figure 12). In the Fixed Reward condition, rewards were presented in a marketplace-style buying window at the conclusion of each level. In the Loot Box condition, a single option was presented to participants to purchase a loot box containing a random item from the 3-item pool of rewards at the end of each level. Unlike the Fixed Reward condition, the

outcome of reward purchase in the Loot Box condition was unknown to players prior to purchase.

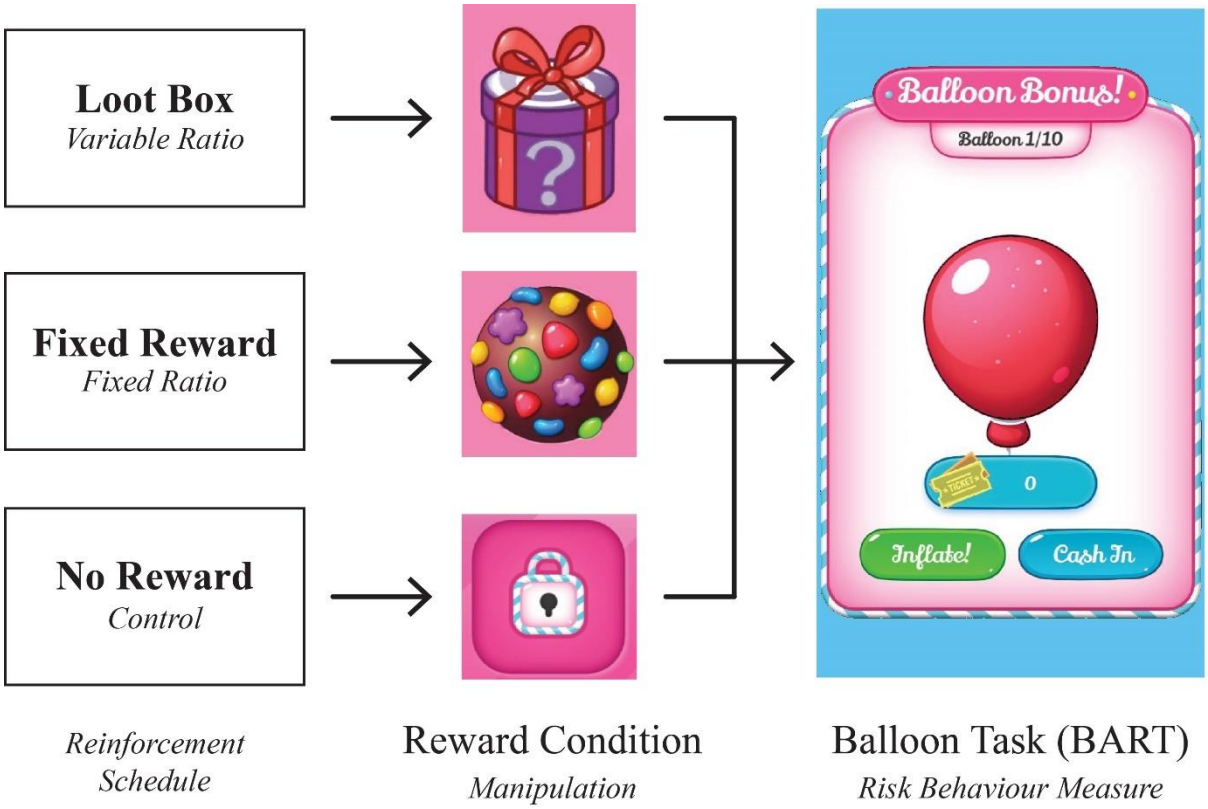
Figure 12

Reward Interface per Condition

In the No Reward (control) condition, rewards were unavailable, and their access was hidden. The game itself, however, was unchanged. Rewards were purchased using virtual currency earned through gameplay and items were equally valued across both Fixed Reward and Loot Box conditions (200 coins). Once purchased, rewards were available to use during gameplay at the players' discretion. The randomisation of reward in the Loot Box condition was a key experimental manipulation, as a variable ratio reward structure. This allowed for comparison with a fixed ratio reward structure, and a no-reward control (Figure 13).

Figure 13

Reward Comparison on Risk Outcome Measure



Measures

Balloon Analogue Risk Task (BART). We used the BART (Lejuez et al., 2002) as our outcome measure of risk-taking. The BART is a computerised task designed to measure individual risk-taking *behaviour*. Instructions for the BART were presented on-screen at the commencement of the task. In our study, 30 balloons (trials) were presented to each participant. Each trial required participants to simulate the inflation of a balloon, knowing that an undetermined number of inflations will pop the balloon. The value for the pop threshold varied between 2 and 14 inflations and was randomised for each trial. With each inflation, participants accumulated tokens, and if the balloon popped the tokens were lost. Thus, the risk of loss accumulates with each additional inflation of the balloon. After each inflation, participants can either cash-out their tokens or inflate again. Choosing to cash out

shifts the tokens accumulated for that trial into a bank, ending the current trial, and commencing the next. Banked tokens are safe and cannot be lost in subsequent trials. Importantly, this task is designed such that risk is correlated with reward (Steiner & Frey, 2021). Performance on this task was measured as the adjusted average number of pumps on unexploded balloons (i.e., the average across participants, of pumps where the balloon did not explode), with higher scores indicative of greater risk-taking behaviour (Lejuez et al., 2002, 2003). This task was created alongside other measures of risk behaviour, including drug and alcohol use, and gambling activity, as well as self-reports of risk frequency (Lejuez et al., 2002), and is a prominently used behavioural measure (Frey et al., 2017; Steiner & Frey, 2021).

The Problem Gambling Severity Index (PGSI). The PGSI (Ferris & Wynne, 2001) is a nine-item survey asking the frequency with which participants engage in a variety of gambling-related activities over the past 12 months (e.g., "Have you needed to gamble with larger amounts of money to get the same feeling of excitement?", "Have you borrowed money or sold anything to get money to gamble?") (Appendix D**)**. The items of the PGSI have shown "good internal reliability and single factor loading" and correlation with other gambling measures (Orford et al., 2010, p. 31). It is a standardised measure, and heavily used within the gambling and loot box literature (Garea et al., 2021; Griffiths, 2015; Orford et al., 2010). Recent validation studies of the PGSI have recommended collapsing the gambling categories from four groups into three, by rescoring the groups as *low-risk* (1—4), *moderate-risk* (5—7), and *problem gambler* (>7) as recommended by Currie et al., (2013). This recalibrated variation is commonly used in loot box research (e.g., Zendle, 2019; Zendle & Cairns, 2018) and was employed in this study.

The Risky Loot-Box Index (RLI). The RLI is a five-item scale designed to examine risky engagement with loot boxes (Brooks & Clark, 2019). Participants are asked to indicate

the extent of their agreement with statements like: "The thrill of opening loot boxes has encouraged me to buy more" and "I have put off other activities, work, or chores to be able to earn or buy more loot boxes" on a Likert scale ranging from 1 (*strongly disagree*) – 7 (*strongly agree*) (See Appendix E). The RLI was created and validated alongside the PGSI, and other gambling measures (Brooks & Clark, 2019).

Additional Measures. The NEO Personality Inventory-Revised (NEO PI-R) (Costa & McCrae, 1992) was also completed at the end of this experiment as part of a concurrent honours project. Items from this measure were not included or analysed in this study.

Procedure

Participants were recruited and allocated to conditions in temporal order of arrival (i.e., first: control, second: loot box condition, etc.). After allocation, participants were invited to join an online video-conferencing session with the researcher. At the beginning of the session, participants were provided with information and consent forms (see Appendix F) which were also available online at the opening window of the experimental webpage. The specific research aims and hypotheses were not disclosed, however, a brief explanation of the research and participant contributions were provided by the researcher and information sheets. Participants were guided in the registration process for the experiment and provided with gameplay and reward information relevant to their condition. Participants were then invited to play the game freely for the allotted twenty minutes, before proceeding with the BART. At the completion of the two tasks, participants completed demographic questions, followed by the RLI, the PGSI and other items related to the parent study. At the conclusion of these items, participants were thanked for their time and debriefed by researchers (see Appendix G).

Statistical Analysis

Data cleaning and consolidation was conducted in Microsoft Excel. Analysis and transformations were conducted in jamovi (2021). Bayesian t-tests were conducted using the *jsq* add-on, and moderation analysis through the *medmod* add-on. Bayes factors are interpreted in line with Wagenmakers, Love, et al. (2018, Table 2).

Table 2

Bayes Factor Classification Scheme

Bayes Factor	**Evidence Category**
> 100	Extreme evidence for $\boldsymbol{H_1}$
30-100	Very strong evidence for $\boldsymbol{H_1}$
10-30	Strong evidence for $\boldsymbol{H_1}$
3-10	Moderate evidence for $\boldsymbol{H_1}$
1-3	Anecdotal evidence for $\boldsymbol{H_1}$
1	No evidence
1/3 - 1	Anecdotal evidence for $\boldsymbol{H_0}$
1/10 - 1/3	Moderate evidence for $\boldsymbol{H_0}$
1/30 - 1/10	Strong evidence for $\boldsymbol{H_0}$
1/100 – 1/30	Very strong evidence for $\boldsymbol{H_0}$
< 1/100	Extreme evidence for $\boldsymbol{H_0}$

Given the exploratory nature of this research, Bayesian analyses were chosen to compare differences in reward effect and allow us to quantify evidence in favour of both the alternate and null hypothesis (Wagenmakers, Marsman, et al., 2018). In instances where the null is quantified, this data is useful in informing future research.

Results

Data Screening

A total of 166 participants completed the experiment between May and September 2021. 13 participants were removed due to incomplete datasets resulting from software issues, leaving 153 participants for analysis. Our preregistered exclusion criteria included participants who failed to respond to at least 75% of the PGSI questions, and this did not apply to any of our remaining data.

Primary Analysis

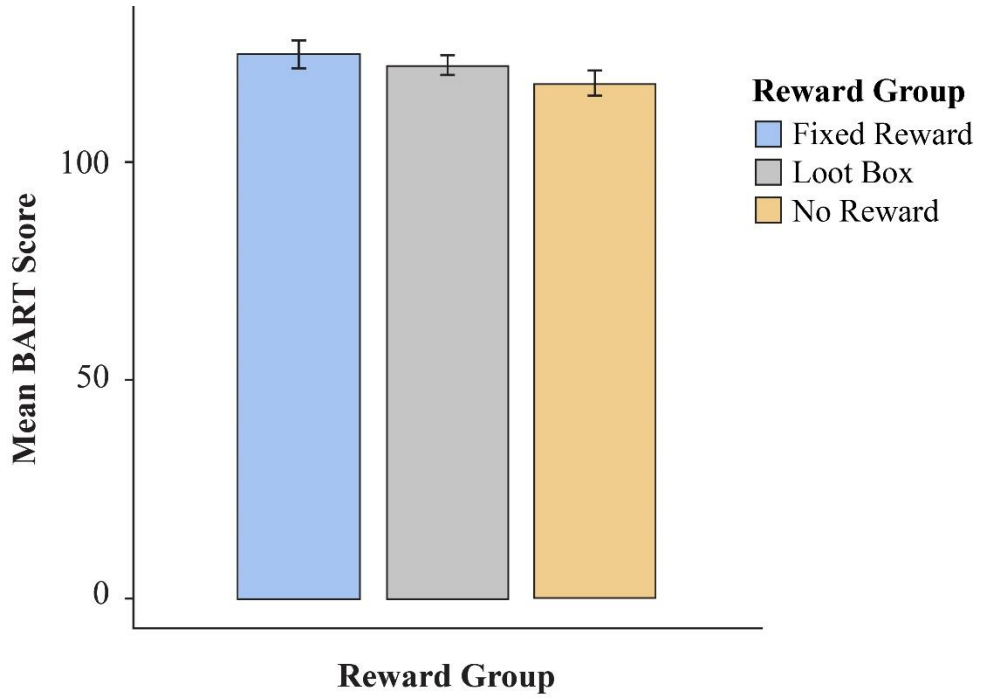
All hypotheses, Bayesian and Frequentist analyses, transformations and exclusions were preregistered.

Bayesian T-Tests

We hypothesised that differences would emerge in participant risk-taking depending on the reward structure they engaged with. Overall, mean risk-taking scores on the BART were similar across reward conditions (Figure 14).

Figure 14

Mean Distribution of BART by Reward Condition



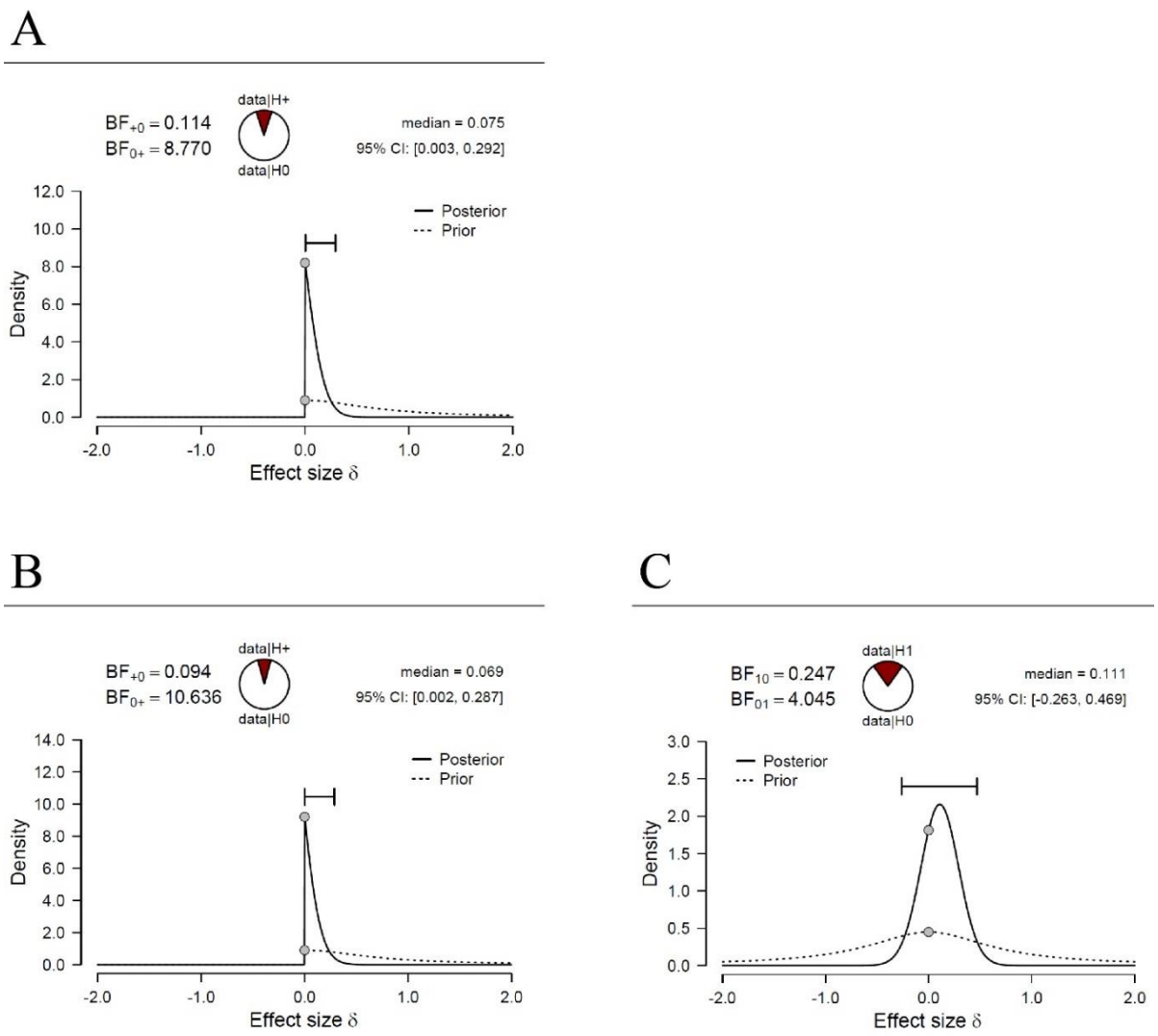
Note. Error bars represent standard error of mean (SEM).

Specifically, and in line with the existing literature we hypothesised that participants engaging with rewards would score higher on the BART than those with no rewards (H1, H3) and that differences would exist between fixed and randomised reward groups in subsequent risk-taking (H2). Bayesian one-sided independent samples t-tests compared mean BART scores between groups. A priori hypotheses for H1 & H2 specified a directional prior distribution for an alternative hypothesis in which Group 1 > Group 2 (Loot Box > Other Groups). Given the exploratory nature of these reward group comparisons, we did not have justification to deviate from the default Cauchy prior distribution (0.707) (Wagenmakers, Love, et al., 2018).

Our results showed *moderate* evidence in favour of a null hypothesis, suggesting no difference between Loot Box and No Reward conditions on the BART task (H1) (BF_{0+} = 8.77 indicating that the data are 8.77 times more likely under the null than the alternative hypothesis) (Figure 15, A).

Figure 15

Prior and Posterior Plots for Bayesian T-Tests



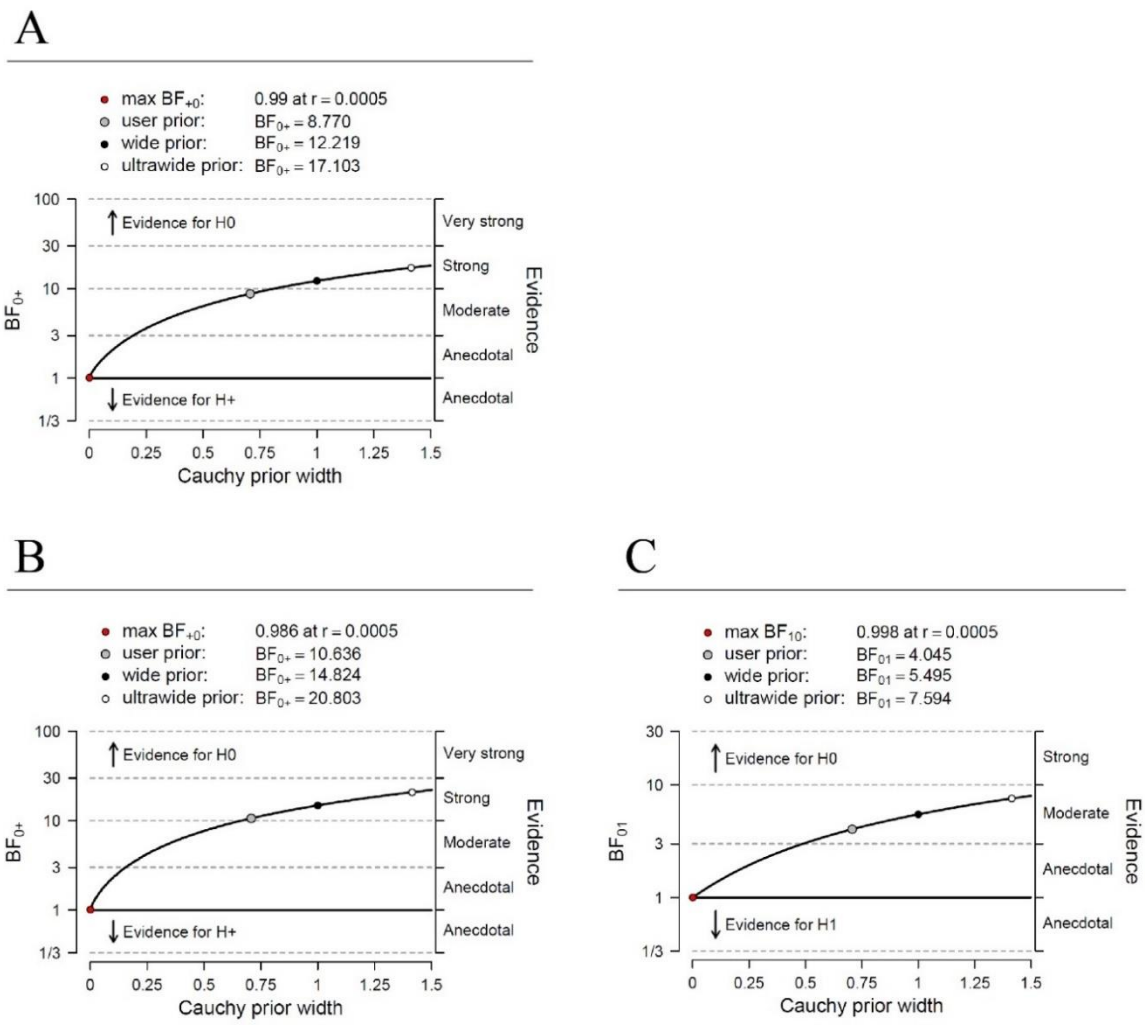
Additionally, *strong* evidence in favour of a null hypothesis was observed between reward conditions, indicating no meaningful difference in BART scores between Loot Box and Fixed Reward groups (H2) (BF_{0+} = 10.64) (Figure 15, B).

An exploratory two-sided Bayesian t-test was employed to assess mean differences between the Fixed Reward and No Reward groups (H3). Results indicate no difference between groups, with *moderate* evidence (BF_{01} = 4.05) in favour of a null hypothesis (Figure 15, C). Consistent with the observed evidence for null effects, median effect sizes were very small (see *median* values in Figure 15, A-C).

Robustness checks for all three t-tests suggest that the data provides *moderate* to *strong* evidence in favour of a null hypothesis across a wide range of plausible prior distributions (Figure 16, A-C).

Figure 16

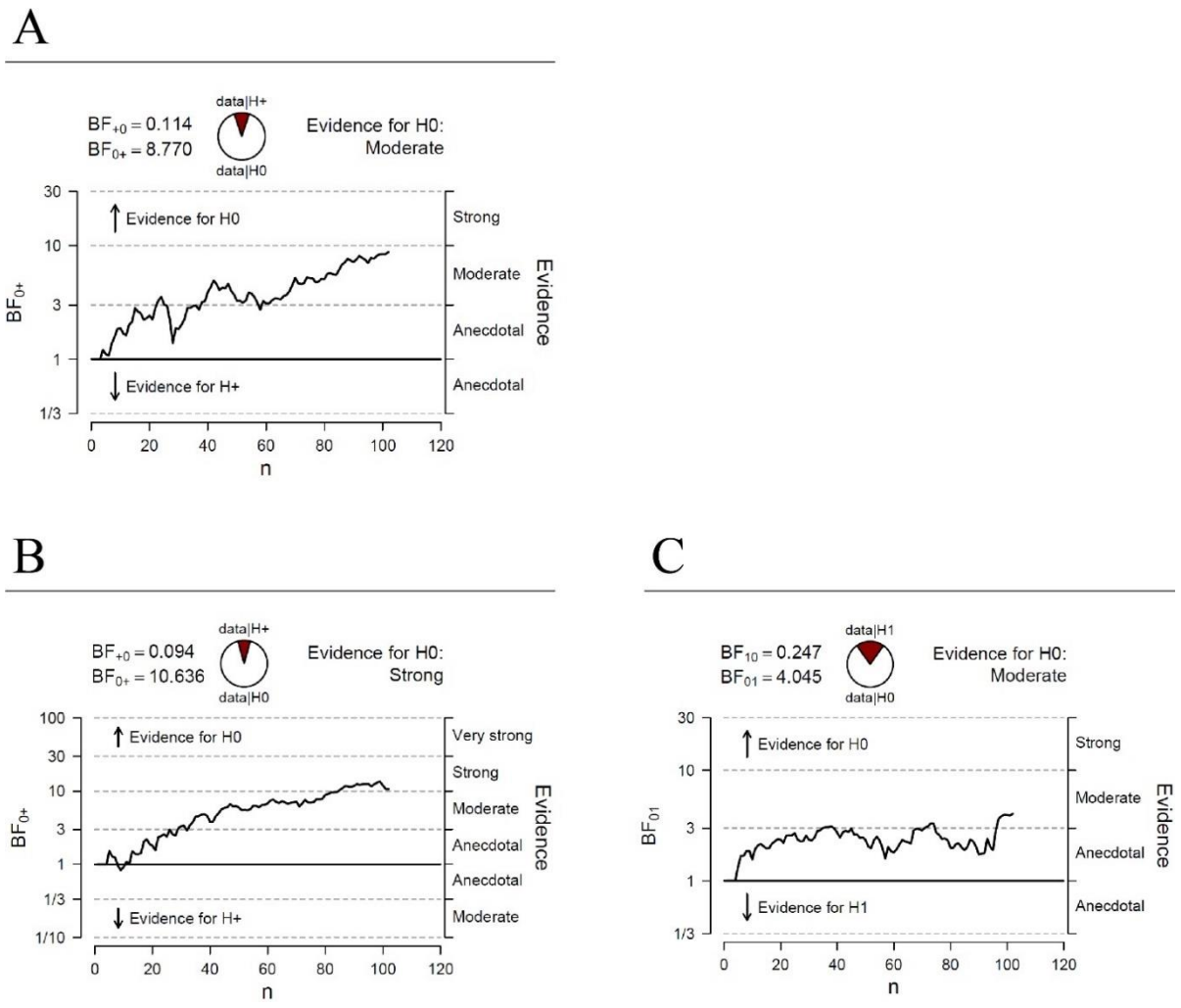
Robustness Checks



Sequential analyses highlight the importance of adhering to sampling plans by plotting the relative Bayes factor of group comparisons as data accumulate (Wagenmakers, Love, et al., 2018). For H2, evidence transitioned from an alternate to null hypothesis at approximately n = 10 (Figure 17, B). Evidence for H1 and H3 accrued consistently in favour of the null (Figure 17, A, C).

Figure 17

Sequential Analyses



Counter to our predictions based on the idea that exposure to gambling-like rewards might increase subsequent risk-taking, we observe evidence that our reward manipulation did not affect subsequent risk-taking.

Secondary Analysis

Moderation

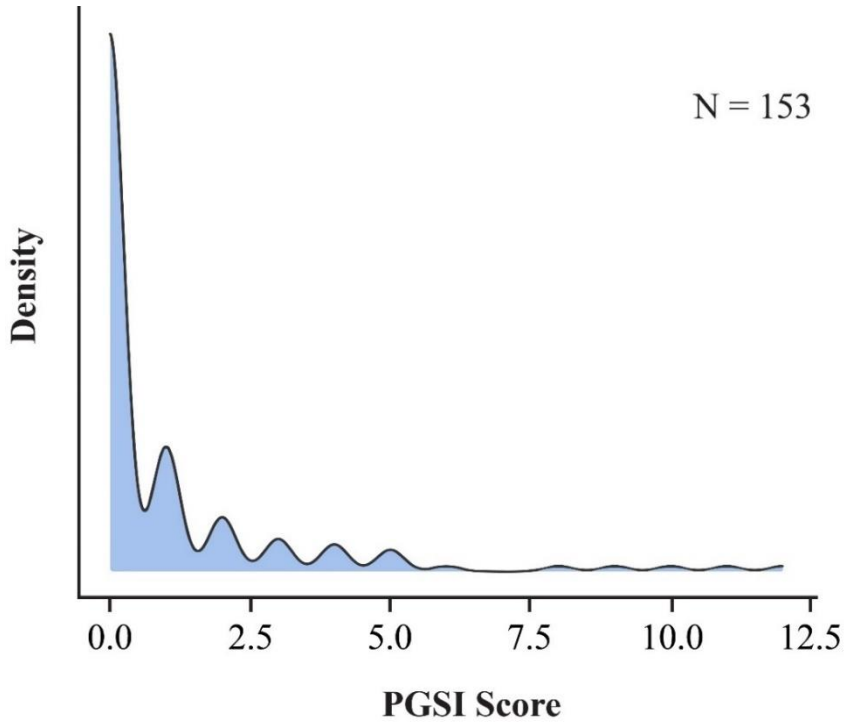
Existing literature suggests that previous gambling history may influence individual risk-taking. As such, we hypothesised that higher scores on the PGSI would moderate differences in BART scores between our Loot Box and No Reward condition than lower scores on the PGSI (H4). Specifically, that differences between conditions might increase as participants' PGSI scores increased. Additionally, we hypothesised that a similar effect of prior gambling on risk-taking would occur between our Loot Box and Fixed Reward conditions (H5). We employed Frequentist moderation as an inferential analysis of the influence of PGSI score across BART scores in our sample.

Dummy coding was used to transform reward conditions into categorical predictors for use in the analyses for H4 & H5. For H4, the Loot Box and No Reward conditions were coded as 0 and 1 respectively. Similarly, for H5 the Loot Box and Fixed Reward condition were coded as 0 and 1. Given the absence of accessible Bayesian tools for moderation, we reverted to a Frequentist, null hypothesis significant testing approach. Estimate robustness was increased by bootstrapping to 1000 samples.

Between Loot Box and No Reward conditions (H4) there was no main effect of group on mean scores on the BART (b = 3.97, 95% CI [-4.19, 11.96], p = 0.347). PGSI score was negatively associated with BART score between these groups (b = -0.17, 95% CI [-1.85, 1.35]) and this effect was non-significant (p = 0.843). Consequently, no significant interaction or moderating effect of PGSI scores was detected between groups in BART scores (b = 0.32, 95% CI [-3.40, 3.50], p = 0.854). This may be due in part to the distribution of PGSI scores in our sample, which was positively skewed towards 0, indicating a small proportion of gambling activity (Figure 18).

Figure 18

Density Plot of PGSI Score Distribution



For the Loot Box and Fixed Reward groups (H5) there was no effect of group on mean scores on the BART (b = 7.13, 95% CI [-2.61, 17.16], p = 0.150). PGSI score was positively associated with BART score between conditions (b = 0.73, 95% CI [-2.62, 4.00]) and this effect was non-significant (p = 0.663). Similarly, no differences in BART score as moderated by PGSI scores were detected between groups (b = 2.11, 95% CI [-4.0, 8.85], p = 0.530). Simple slope analyses were included to visualise the effect of PGSI scores between reward groups (Figure 19, 20).

Figure 19

Moderation Simple Slope Analysis for H4

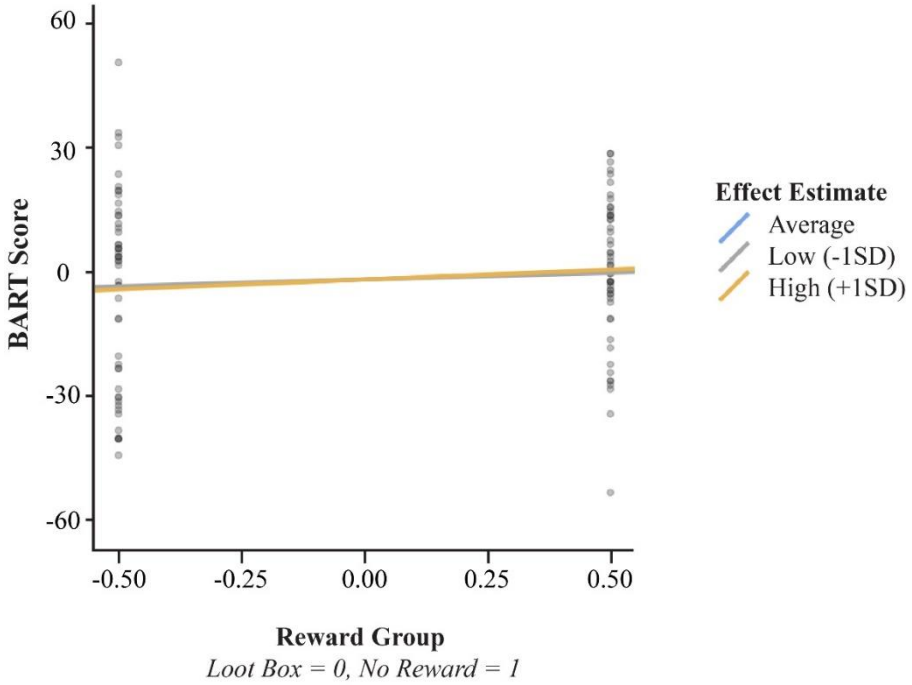
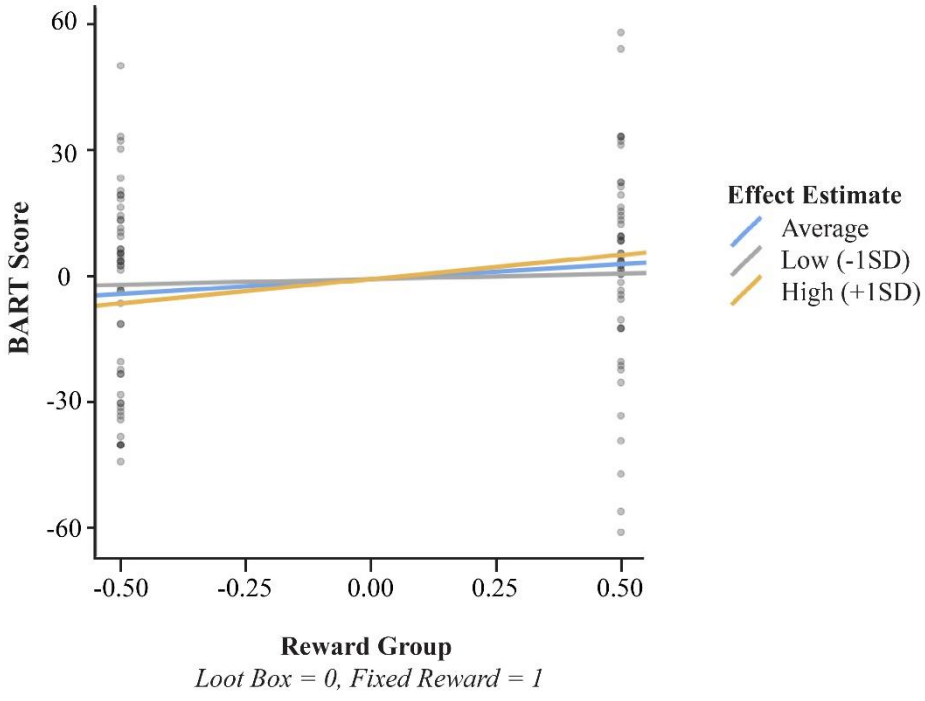


Figure 20

Moderation Simple Slope Analysis for H5



Correlations

We also explored whether risk-taking was correlated with risky loot box use, as measured by the RLI in our sample (H6). Additionally, and as a replication of previous research (Brooks & Clark, 2019), we explored correlations between the PGSI and RLI (H7). BART and RLI scores showed negligible, non-significant correlation (r = -0.058, p = 0.923). Conversely, a significant positive correlation was observed between the PGSI and RLI (r = 0.36, p < .001). PGSI data was highly skewed (above, Figure 18; skewness = 3.04), as such a Spearman's rho was calculated (per the pre-registered transformation criteria) and significance remained when correlated with the RLI (r_s = 0.35, p < .001).

Discussion

Loot boxes are psychologically akin to traditional gambling activities (Drummond & Sauer, 2018), and increased loot box engagement is positively associated with problem gambling severity (Garea et al., 2021). We examined the behavioural influence of engaging with loot boxes on subsequent risk-taking when compared to fixed and no reward gameplay conditions. No meaningful differences emerged between conditions in player risk-taking as measured by the BART. Additionally, problem gambling symptomatology did not moderate the effect of reward on player risk-taking in our study, though this may be because our sample showed little evidence of prior gambling behaviour. Participants' RLI scores were also not associated with BART scores in our sample.

Our last hypothesis was informed by our choice to use the same two measures as Brooks & Clark (2019) - the PGSI and the RLI - as questionnaire items for our sample. They created the RLI through exploratory factor analysis, in which they found positive correlations between the PGSI and RLI across two samples. This association was present in our sample, and to a similar magnitude (Table 3), providing additional validity for the RLI as a measure of *risky* loot box use as correlated with problem gambling severity.

Table 3

Correlations Between the PGSI & RLI in the Literature

Study	N	Correlation (*r*)
Brooks & Clark (2019) Study 1	144	.491***
Brooks & Clark (2019) Study 2	113	.315***
Our Study	154	.354***

Note. *** = $p < .001$

This recurrent correlation underlies the rationale for the present research: that elevated loot box use co-occurs with problem gambling pathology. While we did not observe any differences in risk-taking, this phenomenon was present in our study and is encouraging with respect to comparable sample sizes in the literature.

Theoretical Implications

Few studies have investigated the behavioural correlates of loot box use beyond financial spending, but some researchers speculate that loot box engagement might lead to future gambling (A. King et al., 2020; D. L. King & Delfabbro, 2018; Zendle & Cairns, 2018). We sought to test one potential mechanism associated with gambling, in understanding the *temporal order* of loot box influence on players. Risk is inherent in gambling, and in engaging with loot boxes. If engaging with loot boxes increases subsequent risk-taking, it might also increase the risk of engaging in future gambling behaviour. By exposing players to rewards at the beginning of our experiment, we tested whether loot boxes would have a real-time effect on player risk-taking after gameplay. We found evidence in opposition to this mechanism: randomised rewards did not increase subsequent risk-taking.

We also tested several exploratory hypotheses. Theoretically, loot boxes employ the same variable ratio reinforcement schedule as gambling. We expected that this structural

similarity would result in a more pronounced effect on risk-taking when compared to a Fixed Reward condition (where players could choose the reward they purchased, and the chance-based/randomisation element central to gambling was removed) and a No Reward condition. However, we found no meaningful difference *between* these reward groups on risk-taking. These findings have multiple interpretations**,** identified here, and elaborated on throughout this discussion. First, loot box engagement may not affect subsequent risk-taking. Second, an effect was obscured by pre-existing differences between groups. This is unlikely given the randomisation of our participants across reward conditions. Third, aspects of our design may have constrained the relationship between reward-type and risk such that (a) rewards might not have been salient, valuable, or important enough to generate effects; (b) gameplay might not have been long enough for participants to reach the level of engagement required to generate effects; (c) the virtual currency might have been too easy to earn which meant it wasn't perceived as valuable and engagement with loot boxes wasn't a "risky" behaviour because participants felt they had nothing to lose; or (d) the BART may not have been a sensitive measure to detect risk in this context.

We also sought to understand the relationship between prior loot box use and risk-taking behaviour. The RLI measures self-reported loot box behaviours, and we hypothesised that higher reports of past risky loot box use would be associated with increased actual risk-behaviour (measured by the BART). We did not observe this correlation in our sample. Despite its name, the Risky Loot-Box Index includes questions related but not limited to risk-taking as adapted from the financial subscale of the DOSPERT (Weber et al., 2002). In contrast, the BART is a more generalised risk-taking behavioural measure, and may not adequately capture the same risk-related influence of loot box engagement as the RLI. Another consideration is the lack of variation in RLI scores, and lack of previous loot box

engagement within our sample, which may have constrained the correlation between measures.

Strengths, Limitations and Future Directions

Strengths

At the time of writing, we are the only research group to collect behavioural data on the constructs underlying loot box engagement in gamers. Our hypotheses, methodology and analyses were preregistered with the intention of maintaining good, transparent open science practices and to increase the integrity of our findings.

The use of Bayesian analyses has allowed us to explore and quantify preliminary data in favour of a null hypothesis: that variations in reward structure as implemented in our experiment did not yield a difference in player risk-taking on the BART. In turn, we have reason to consider the implications of this null hypothesis beyond simply a rejection of the alternative, and this will benefit future research involving loot boxes.

As outlined, the existing literature surrounding this topic relies almost exclusively on self-report measures of loot box engagement. To overcome this, we created an engaging and novel experimental task (the video game), which allowed us to design, manipulate and implement reward systems directly informed by current literature and to measure our behavioural outcome of interest. The limitations in simulating the real-world experience of loot box engagement in our experiment are discussed below, however, participant feedback on the game task was positive (i.e., the game was genuinely enjoyable), and encouraging for future work.

Limitations

Our behavioural measure of risk-taking may not completely capture the influence of reward structure on players' risk behaviour. The construct of risk is undergoing a major

conceptual revision, as divisions have emerged within the literature in measuring self-reported risk propensity, risk frequency and actual risk behaviour (Frey et al., 2017). In a large-scale psychometric assessment of many prominent risk measures (N = 1507), the BART (and other behavioural tasks) correlated poorly with risk propensity and frequency measures, demonstrating low test-retest reliability in a follow-up study (Frey et al., 2017). In contrast to self-reported risk propensity or preference, measuring risk behaviour may lend itself to the observation of a risk state, rather than general or stable risk-related traits (Frey et al., 2017; Lauriola et al., 2014). As a result, the BART may have been relatively insensitive to the cognitive processes underlying and influencing loot box and reward engagement in our experiment. This may explain the evidence for the null hypothesis in our between-groups analyses. Additionally, the RLI could be considered a self-report measure of risk propensity related *specifically* to loot box engagement. This conceptual difference may have resulted in the BART measuring a different domain of risk-taking (i.e., propensity vs behaviour), resulting in a lack of correlation with the RLI.

However, although the BART has its flaws, we thought it suitable for this initial exploratory study because (a) it has been validated (Lejuez et al., 2002, 2003) and used widely in the literature on risk-taking (Frey et al., 2017, 2021; Steiner & Frey, 2021), (b) it offers a behavioural measure of risk-taking, which is of interest to the behavioural outcomes of loot box use and (c) we were able to gamify the task, which we felt allowed it fit neatly into our paradigm and maintain the focus on risk-taking in a video game context.

Another limitation is the use of virtual currency to buy rewards in our experiment. Employing variable ratio reinforcement for any behaviour carries a potential risk for participants (Balogh et al., 2013; Griffiths & Wood, 2001), and this research was designed to minimise the potential for psychological harm. We anticipated that some participants might score within the *problem gambler* range (>7) on the PGSI (Skromanis et al., 2018), and to

avoid a risk of harm and potential gambling exposure we implemented virtual currency instead of real money for reward purchases. Inherently, this may have undermined the value and salience of in-game rewards and subsequent reinforcement, and the risk associated with purchasing rewards, as the virtual currency had no genuine monetary worth. Several of our participants (n = 5) scored in the problem gambler range of the PGSI. Thus, precautions may have been warranted. Emulating the problematic, gambling-like characteristics of loot boxes makes them a sensitive thing to measure in a research context. We could not expose participants to predatory, potentially illegal reward mechanisms as the risk of harm may be genuine, irrespective of the fact that many loot boxes exist with additional problematic features in the current video game market (Drummond & Sauer, 2018; Petrovskaya & Zendle, 2020; Zendle, Cairns, et al., 2020; Zendle, Meyer, et al., 2020). Thus, prioritising participant safety while emulating a real-world effect was a delicate balance to achieve. In this first attempt, to observe a basic effect we reduced the phenomena to a single dimension: a randomised reinforcement schedule. This simplification in measurement may have limited the depth of our findings.

Future Directions

At present, we have preliminary evidence of the absence of an effect of reward structure on player risk-taking. Yet, we have observed a correlation between self-reported problem gambling symptomology, and risky loot box engagement in line with existing findings. The recurrence of this trend in past, and present research warrants further investigation. Following the constraints of this research, I recommend four future directions in exploring an underlying construct of gambling and loot box engagement.

First, the allotted gameplay (and subsequent reward exposure) *time* may have been inadequate to properly establish a perception of reward value or purchase risk in our participants. Future work using experimental gameplay may benefit from increasing the

perceived value of rewards (i.e., making them more essential to game progression) and/or increasing the perceived value of the in-game currency to create a genuine sense of risk, loss, and risk-reward ratio in purchasing loot boxes.

Second, considering recent developments in risk conceptualisation there may be a more appropriate and sensitive measure of risk-taking behaviour than the BART; one that more closely aligns with the mechanisms involved in loot box engagement such as the Problem Video Game Playing Test (PVGT) (Biegun et al., 2021). Additionally, measuring risk *preference* related to loot box engagement may be more informative in line with current risk-taking literature (Frey et al., 2021; Steiner & Frey, 2021).

Another consideration is the single exposure-phase in this experimental design. In reality, players' experience and engagement with loot boxes is typically repeated over multiple gaming sessions (Zendle, 2019; Zendle, Meyer, et al., 2020). Future work may consider a longitudinal design, allowing players more time to become invested in the game and to value the rewards in the context of that investment. It is plausible that our short gameplay window simply wasn't enough time to invest players in our in-game rewards.

Finally, while our study was primarily interested in differences at a group level, we observed correlations at the individual level between gambling symptomology and risky loot box engagement. This finding may inform future research in targeting individuals with elevated scores on both the PGSI and the RLI, as this may provide valuable insight into the nature of any shared underlying characteristics that guide these behaviours.

Conclusion

Consumers, academics, and policy makers are concerned that loot boxes are adversely influencing gamers through predatory design and implementation. Some researchers speculate that loot boxes engage cognitive processes that promote gambling behaviour. Our

research was the first to study the directionality and temporal order of this loot box/gambling relationship. We found evidence against one possible mechanism that would support this relationship. Based on our data, engaging with loot boxes did not increase risk-taking behaviour. However, we must be cautious not to overgeneralise this conclusion because (a) ours is the first study of loot boxes and risk-taking, and (b) our design, for all its strengths, had some important limitations.

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Appendices

Appendix A: Ethics Approval Letter

Ethics Approval Letter

05/05/2021

To: Dr Sauer

Project ID: 21748

Project Title: Videogames: Rewards and Risks

The amendment received in support of the above named project has been approved by the Tasmania Social Sciences Human Research Ethics Committee on the 5 May 2021.

Approval has been granted to add two new Honours students to the project (Nick D'Amico and Callan Waugh) and to add two additional individual differences measures to the project, and for the following documentation:

Submission Document Name	Submission Document File Name	Submission Document Type	Submission Document Date	Submission Document Version
Questionnaire Items	Questionnaire Items.docx	QUESTIONNAIRE	28/04/2020	1
SAUER Recruiting Ad	SAUER Recruiting Ad.pptx	ADVERTISING MATERIAL	15/07/2020	1
eGift and GiftPay Information	eGift and GiftPay Information.docx	OTHER PROJECT-RELATED DOCUMENTATION	29/07/2020	1
Project Description v3	Project Description v3.docx	PROTOCOL	28/04/2021	3
SAUER PIS and IC forms Amendment A2 Clean	SAUER PIS and IC forms Amendment A2 Clean.docx	PARTICIPANT INFORMATION AND CONSENT FORM	28/04/2021	A2
SAUER PIS and IC forms Amendment A2 track	SAUER PIS and IC forms Amendment A2 track.docx	PARTICIPANT INFORMATION AND CONSENT FORM	28/04/2021	A2
IGD-20 andIPIP NEO 5 items	IGD-20 andIPIP NEO 5 items.docx	QUESTIONNAIRE	28/04/2021	1
SAUER Debrief text v3 Track	SAUER Debrief text v3 Track.docx	OTHER PROJECT-RELATED DOCUMENTATION	28/04/2021	3
SAUER Debrief text v3 Clean	SAUER Debrief text v3 Clean.docx	OTHER PROJECT-RELATED DOCUMENTATION	28/04/2021	3

Please ensure that all investigators involved with this project have cited the approved versions of the documents listed within this letter and use only these versions in conducting this research project.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approvals of other bodies or authorities are required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

In accordance with the National Statement on Ethical Conduct in Human Research 2007 (updated 2018), it is the responsibility of institutions and researchers to be aware of both general and specific legal requirements, wherever relevant. If researchers are uncertain they should seek legal advice to confirm that their proposed research is in compliant with the relevant laws. University of Tasmania researchers may seek legal advice from Legal Services at the University.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the National Statement on the Ethical Conduct in Human Research 2007 (updated 2018).

Therefore, the Chief Investigator's responsibility is to ensure that:

(1) All investigators are aware of the terms of approval, and that the research is conducted in compliance with the HREC approved protocol or project description.

(2) Modifications to the protocol do not proceed until **approval** is obtained in writing from the HREC. This includes, but is not limited to, amendments that:

(i) are proposed or undertaken in order to eliminate immediate risks to participants;
(ii) may increase the risks to participants;
(iii) significantly affect the conduct of the research; or
(iv) involve changes to investigator involvement with the project.

Please note that all requests for changes to approved documents must include a version number and date when submitted for review by the HREC.

(3) Reports are provided to the HREC on the progress of the research and any safety reports or monitoring requirements as indicated in NHMRC guidance.

Guidance for the appropriate forms for reporting such events in relation to clinical and non-clinical trials and innovations can be located under the ERM "Help Tab" in "Templates". All adverse events must be reported regardless of whether or not the event, in your opinion, is a direct effect of the therapeutic goods being tested.

(4) The HREC is informed as soon as possible of any new safety information, from other published or unpublished research, that may have an impact on the continued ethical acceptability of the research or that may indicate the need for modification of the project.

(5) All research participants must be provided with the current Participant Information Sheet and Consent Form, unless otherwise approved by the Committee.

(6) This study has approval for four years contingent upon annual review. A Progress Report is to be provided on the anniversary date of your approval. Your first report is due on the anniversary of your approval**,** and you will be sent a courtesy reminder closer to this due date. Ethical approval for this project will lapse if a Progress Report is not submitted in the time frame provided.

(7) A Final Report and a copy of the published material, either in full or abstract, must be provided at the end of the project.

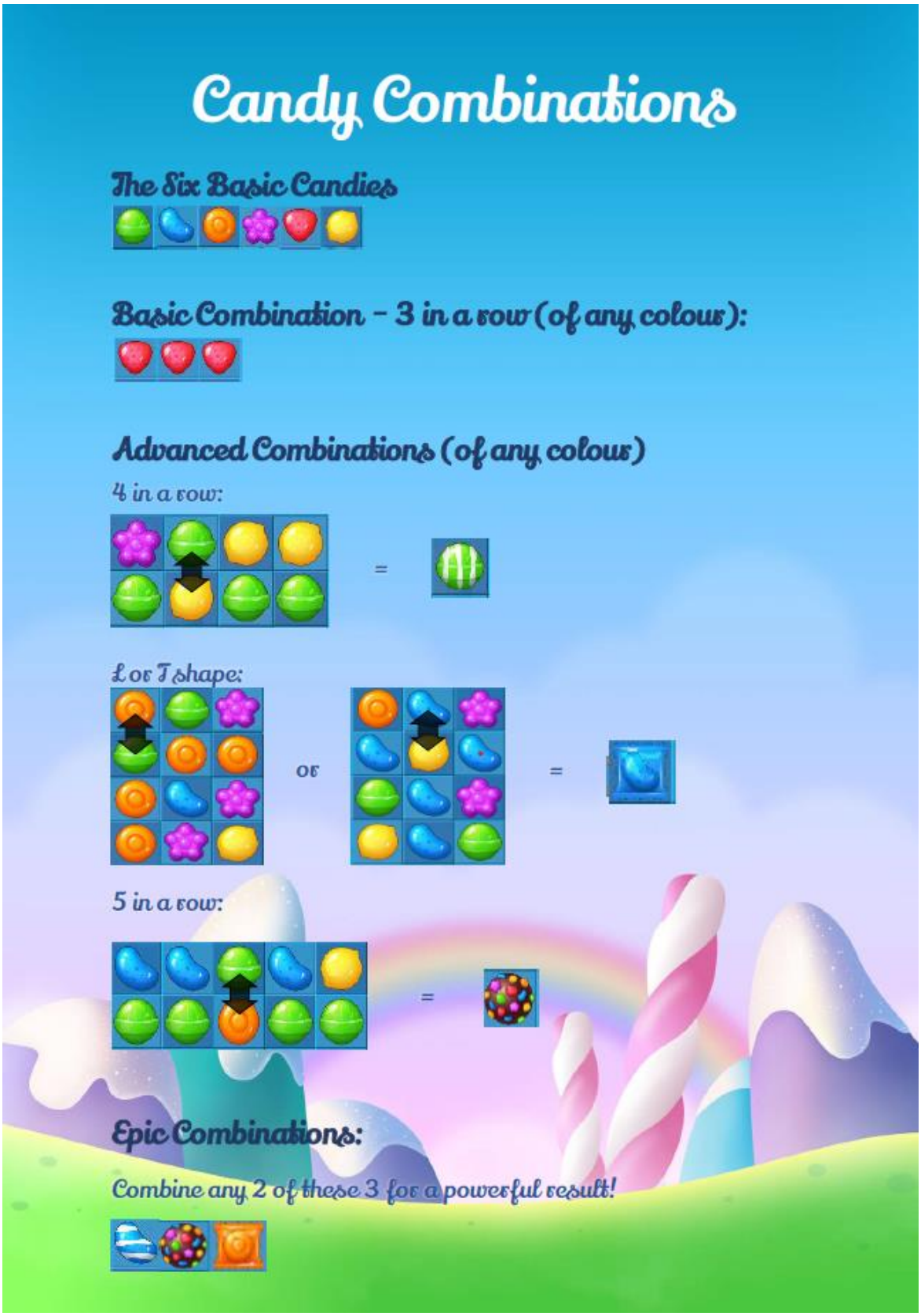
(8) The HREC is advised of any complaints received or ethical issues that arise during the course of the project.
(9) The HREC is advised promptly of the emergence of circumstances where a court, law enforcement agency or regulator seeks to compel the release of findings or results. Researchers must develop a strategy for addressing this and seek advice from the HREC.

Kind regards,

Ethics Executive Officer

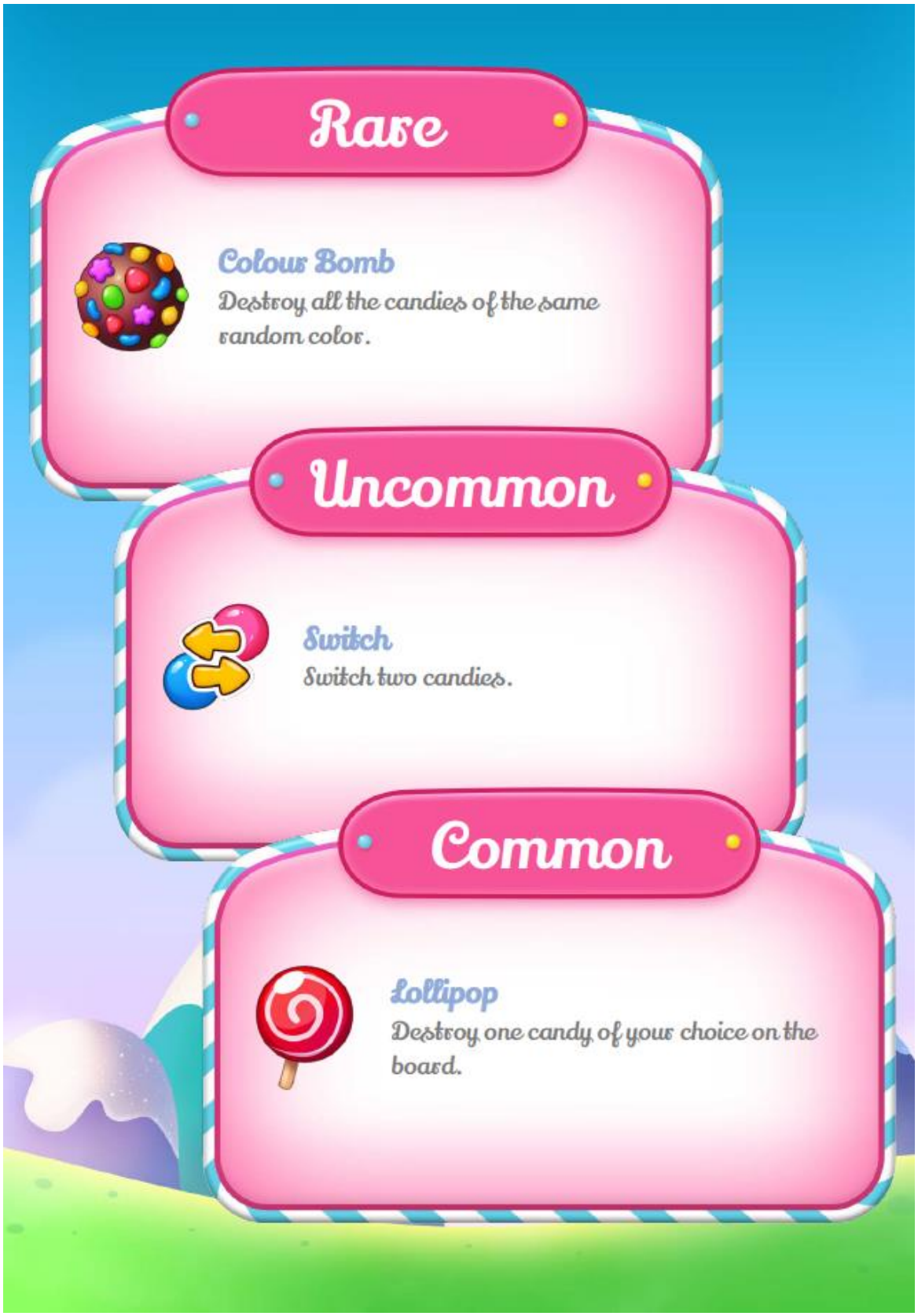
UNIVERSITY of TASMANIA

Appendix B: Video Game Instructions



Appendix B: Video Game Instructions (Continued)

Appendix C: In-Game Rewards



Appendix D: The Problem Gambling Severity Index (PGSI)

The Problem Gambling Severity Index (PGSI)

1) Thinking about the last 12 months... Have you bet more than you could really afford to lose?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

2) Still thinking about the last 12 months, have you needed to gamble with larger amounts of money to get the same feeling of excitement?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

3) When you gambled, did you go back another day to try to win back the money you lost?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

4) Have you borrowed money or sold anything to get money to gamble?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

5) Have you felt that you might have a problem with gambling?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

6) Has gambling caused you any health problems, including stress or anxiety?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

7) Have people criticized your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

8) Has your gambling caused any financial problems for you or your household?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

9) Have you felt guilty about the way you gamble or what happens when you gamble?

   0 = Never. 1 = Sometimes. 2 = Most of the time. 3 = Almost always.

Appendix E: The Risky Loot-Box Index (RLI)

Risky Loot-Box Index

Please indicate how much you agree with each statement below.

1) The thrill of opening loot boxes has encouraged me to buy more.

1 = Strongly disagree	2 = moderately disagree	3 = mildly disagree	4 = neither agree or disagree	5 = mildly agree	6 = moderately agree	7 = strongly agree

2) I frequently play games longer than I intend to, so I can earn loot boxes.

1 = Strongly disagree	2 = moderately disagree	3 = mildly disagree	4 = neither agree or disagree	5 = mildly agree	6 = moderately agree	7 = strongly agree

3) I have put off other activities, work, or chores to be able to earn or buy more loot boxes.

1 = Strongly disagree	2 = moderately disagree	3 = mildly disagree	4 = neither agree or disagree	5 = mildly agree	6 = moderately agree	7 = strongly agree

4) Once I open a loot box, I often feel compelled to open another.

1 = Strongly disagree	2 = moderately disagree	3 = mildly disagree	4 = neither agree or disagree	5 = mildly agree	6 = moderately agree	7 = strongly agree

5) I have bought more loot boxes after failing to receive valuable items.

1 = Strongly disagree	2 = moderately disagree	3 = mildly disagree	4 = neither agree or disagree	5 = mildly agree	6 = moderately agree	7 = strongly agree

Appendix F: Information Sheet and Consent Form

UNIVERSITY of TASMANIA | FACULTY OF HEALTH

Videogames: Rewards and Risks

Note: This document presents the relevant information, but formatting will vary when presented online.

PARTICIPANT INFORMATION SHEET

Research team	Jim Sauer, School of Psychological Sciences Aaron Drummond, School of Psychology, Massey University (NZ) Kristy De Salas, School of Technology, Environments and Design Ian Lewis, School of Technology, Environments and Design Breanna Bannister, School of Psychological Sciences Nick D'Amico School of Psychological Sciences Callan Waugh School of Psychological Sciences Jim.Sauer@utas.edu.au

1. Invitation

You are invited to participate in a research study examining the role of specific design features in video games and their role on playing behaviours. This study is being conducted in partial fulfilment of Nick D'Amico and Callan Waugh's Honours degree and being overseen by the supervision of Dr. Jim Sauer, and the rest of the research team identified above.

2. What is the purpose of this study?

This study aims to investigate how players react to video game design features. To reduce the influence of prior knowledge altering your behaviour, the aims and hypotheses of this study will be withheld from you until after the data collection period has concluded.

3. How is the study being funded?

This study is being funded through a UTAS honours support fund.

4. Why have I been invited to participate?

You may have been invited because you have previously registered your interest in participating in research in our lab, you may have contacted us after seeing a poster

advertising the research, or you may have signed up via SONA, or via an online recruiting platform such as Prolific Academic or MTurk.

Your participation in this study is completely voluntary, and there are no consequences should you decline to participate. Should you choose to withdraw from this study, you may do so any time up until the completion of the study without providing a reason, and without a penalty. Once the study is completed, your data will be added to the dataset. At this point, your data will be non-identifiable and it will not be possible to withdraw your data.

If you choose to participate, all information provided, and all the data collected shall remain anonymous. No single participant's data in this study will be individually identifiable.

5. What will I be asked to do?

As part of your participation in this research, you will be required to sign-in to a Zoom meeting with one of the researchers prior to participation to (a) provide a briefing about the requirements of the research and (b) ensure all aspects of the task requirements are understood.

If you consent to participate you will be given a link to an online data collection suite. Once you click this link, you will be asked to complete three tasks. First, you will play a videogame. Second, you will complete another gamified task. Finally, you will complete a questionnaire collecting basic demographic information, and information on your gaming habits. You will be free to skip any questions you do not wish to answer.

The first videogame in this case is 'Match-3', a game that shares similarities to the game 'Candy Crush™'. This game involves matching 3 similar 'blocks' to achieve certain in-game objectives, such as scoring enough points or removing certain blocks from the level. You will be asked to play this game approx. 20 minutes. You will play a second game that requires anticipating how far a digital balloon can be inflated before it pops. Following your gameplay, you will be asked to fill out a quick questionnaire regarding your experiences with the game, some questions about yourself, and some other videogame related measures.

The research should take **no longer than an hour** and will take place online.

6. Are there any possible benefits from participation in this study?

You will receive research credit for your participation.

You will also go into the draw to receive a $50AUD voucher. Everyone receives one entry in the draw for participating, but you can receive additional entries based on your performance on one aspect of the task.

As a general benefit, all participants will assist in furthering the scientific understanding of memory and the conditions under which memory performance can be improved.

7. Are there any possible risks from participation in this study?

There are no identified major risks that can occur from participation in this study.

8. What if I change my mind during or after the study?

If you change your mind during the study, you are free to withdraw at any time prior to the completion of the study, and you may do so without providing an explanation. Once you have

completed your participation, you will be unable to withdraw your data because it will be anonymised.

9. What will happen to the data when this study is over?

To determine the number of entries you receive in the prize draw and to contact the winner of the prize draw, we will need to link your performance on one aspect of the task to your username. These data will be kept in password-protected files accessible only to the primary researcher and research supervisor.

All other data are fully deidentified and, following the destruction of the file linking your username to the number of entries in the prize draw, ALL data will be fully deidentified (there will be no way to link data to you). Prior to publication, your data will be kept private and inaccessible to anyone but the research team listed above. After publication, deidentified raw data will be stored online in the Open Science Framework and will be accessible for researchers worldwide to access and use for further analyses.

10. How will the results of the study be published?

Deidentified data will be published in an Honours thesis, and in an academic, peer-reviewed article. All data obtained in this study will be anonymous, with no individual participant being identifiable at the time of publication. Please feel free to contact us if you would like to be informed of the results.

11. What if I have questions about this study?

If you have any queries, concerns or issues with this study, please feel free to contact the supervisor of this study, Dr. Jim Sauer via email: jim.sauer@utas.edu.au

This study has been approved by the Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, you can contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 2975 or email (ss.ethics@utas.edu.au). The Executive Officer is the person nominate to receive complaints from research participants. You will need to quote H0021748.

12. How can I agree to be involved?

To participate, simply indicate your consent by clicking the onscreen button to begin the study. Please make sure that you have read and understood what you will need to do.

Thank you for your time

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Videogames: Rewards and Risks

PARTICIPANT CONSENT FORM

Research team

Jim Sauer, School of Psychological Sciences

Aaron Drummond, School of Psychology, Massey University (NZ)

Kristy De Salas, School of Technology, Environments and Design

Ian Lewis, School of Technology, Environments and Design

Breanna Bannister, School of Psychological Sciences

Nick D'Amico School of Psychological Sciences

Callan Waugh School of Psychological Sciences

Jim.Sauer@utas.edu.au

By signing below, I confirm that I have read and understood the information sheet and in particular:

- I understand that my involvement in this research will include playing a video game and then answering a series of questions about my experience.
- I have read and understand the information sheet that has been provided to me
- I understand my participation in this study proposes no foreseeable risks
- I understand that all research data will be securely stored on the University of Tasmania premises indefinitely following the publication of study results
- I agree to have my study data archived. (data will be stored anonymously.)
- I agree to my data being used to support future research
- I understand that the results of the study will be published so that I cannot be identified as a participant
- I understand that my participation in this research is voluntary
- I understand that I am free to withdraw at any time, without explanation or penalty, up until the conclusion of the study.
- I understand that, although I can discontinue my participation at any time during the study and my data will be withdrawn, I cannot withdraw my data after participating

(i.e., once the study is concluded) because my data will not be identifiable in the dataset.

- I agree to participate in the study

To be signed by participant

Name	
Signature	
Date	

Statement by Researcher

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the researcher has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Name	
Signature	
Date	

Appendix G: Debrief Form

UNIVERSITY of TASMANIA

Video Game Design and Subsequent Behaviours

Note: This information will displayed on-screen. Thus, the formatting will change.

Thank you for participating in our research. This research is being conducted as part of Nicholas D'Amico and Callan Waugh's Honours theses, under the primary supervision of Dr. James Sauer, and investigates the effects of structural characteristics within video games on participants' gameplay and risk-taking behaviour.

Particularly, we are interested in how in-game reward features, and the ways these in-game rewards are delivered, influence participants' playing behaviour and subsequent risk-taking. Researchers have noted some similarities between some in-game reward systems and more conventional gambling activities. We're interested in whether and how these similarities affect players' playtime and risk-taking.

The questionnaire measures you completed help us understand how these effects might vary depending on (a) players' previous gameplay experience and (b) players' previous gambling behaviours.

If you know somebody who is considering participating in this study **please do not share the contents of this form with them** as it may affect the way they approach the task, and jeopardize their results.

We would like to thank you for participating in this research and contributing to our understanding of the ways in which in-game reward systems influence player behaviour.

If you have any further queries about this study, don't hesitate to contact the research supervisor at:

jim.sauer@utas.edu.au

You can also found out the results of the study by contacting the research supervisor after October 15th, 2021.
Thankyou.

If any of the questions in this research has raised concerns for you about any gambling-related behaviour, you may wish to contact services like Gambling Help Online (ph: 1800 858 858) Lifeline (ph: 13 11 14) or for information or support.

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