

The gamblers of the future? Migration from loot boxes to gambling in a longitudinal study of young adults

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Abstract

Cross-sectional studies have established a robust correlational link between loot box engagement and problem gambling, but the causal connections are unknown. This longitudinal study tested for ‘migration’ from loot box use to gambling initiation 6-months later. A sample of gamers (aged 18-26) was stratified into two subgroups at baseline: 415 non-gamblers and 221 gamblers. Self-reported engagement with video game microtransactions distinguished loot boxes and ‘direct purchase’ microtransactions (DPMs). Loot box expenditure and the Risky Loot Box Index (RLI) were tested as predictors of self-identified gambling initiation and spend at follow-up. At baseline, gamblers spent significantly more than non-gamblers on microtransactions. Among baseline non-gamblers, loot box expenditure and RLI predicted gambling initiation (logistic regressions) and later gambling spending (linear regressions). DPM expenditure did not predict gambling initiation or spend after correcting for multiple comparisons, underscoring the key role of randomized rewards. Exploratory analyses tested whether baseline gambling predicted loot box consumption (the ‘reverse pathway’): among loot box non-users, gambling-related cognitive distortions predicted subsequent loot box expenditure. These data provide empirical evidence for a migration from loot boxes to gambling. Preliminary evidence is also provided for a reverse pathway, of loot box initiation by gamblers. These findings support regulatory steps directed toward young gamers and those who gamble.

Keywords: Randomized Reward; Problem Gambling; Behavioural Addiction; Monetization; Microtransaction; Longitudinal

1. Introduction

Loot boxes are a form of video game microtransaction, ubiquitous throughout modern gaming, and regularly described as a gambling-like feature (Drummond & Sauer, 2018; Drummond et al., 2020; Zendle et al., 2020). These virtual items, when ‘opened’, produce a randomly generated in-game reward that may have cosmetic (e.g., avatar stylization) or functional (e.g., player enhancements; Zendle et al., 2020) value in the game. Opening a loot box is often accompanied by enticing audio-visual displays that heighten the anticipation and receipt of prizes (King & Delfabbro, 2019), in ways that often further resemble gambling products like slot machines. Irrespective of between game variation, their underlying mechanism is a chance-based reward system, where the most desired items are the rarest, and many other prizes hold limited value to the gamer (e.g., duplicates of already-obtained items). The likenesses to gambling have prompted concern that loot boxes could introduce and encourage involvement in conventional gambling among gamers (Spicer et al., 2022).

1.1 Associations Between Loot Boxes and Gambling

A key empirical finding that underscores the link between loot boxes and gambling is evidence of a positive correlation in cross-sectional surveys between measures of loot box engagement (e.g., spending) and problem gambling symptoms. First shown by Zendle & Cairns (2018) in a large sample ($n = 7,422$) of gamers recruited through Reddit, this finding has been widely replicated in adult (Brooks & Clark, 2019; Li, Mills, & Nower, 2019) and adolescent samples (Kristiansen & Severin, 2020; Zendle, Meyer, & Over, 2019). The effect size of this detected association was small-to-moderate ($r = .260$) in a meta-analysis by Garea et al. (2021). Erroneous gambling beliefs (e.g., the gambler’s fallacy), a cognitive variable implicated in the development of gambling problems, are also positively correlated with loot box expenditure and

the Risky Loot Box Index (RLI; Brooks & Clark, 2019; Spicer et al., 2022). Rarer, more desirable, loot box rewards have been seen to elicit behavioural markers of reward reactivity (post reinforcement pauses), and increased physiological arousal (skin conductance level) has been detected prior to loot box outcomes (Larche, Chini, Lee, Dixon, & Fernandes, 2021).

The cross-sectional relationship between loot box engagement and problem gambling is generally interpreted in terms of two possible pathways, with researchers quick to note that neither causal interpretation can be inferred from the basic correlation (House of Commons Digital, Culture, Media, and Sport Committee, 2019; Spicer et al., 2022). One possibility is that loot boxes form an exposure to randomized reward mechanics that may increase the prospect of future gambling (Macey & Hamari, 2022). We refer to this pathway, from loot boxes to gambling, as ‘migration’ (see also Kim et al. 2015). Uncertain rewards can recruit the dopamine system and a process of incentive sensitization that is implicated in addictions (Zack, St. George, & Clark, 2020). Epidemiological data indicate that earlier age of onset of gambling (typically during adolescence) is a risk factor for adult gambling problems (Kessler et al. 2008). The regulatory implication here is that youth, for whom conventional gambling is an age-restricted activity, may be introduced to gambling via the variable-ratio rewards of loot boxes. An alternative possibility is that when experienced gamblers play video games, their familiarity with randomized rewards renders loot boxes highly appealing (Brooks & Clark, 2019; Spicer et al., 2022; Zendle & Cairns, 2018). This ‘reverse pathway’ points to distinct regulatory responses, primarily targeting gamblers as a vulnerable group to reduce financial harms when gaming. These causal directions are not mutually exclusive, and other explanatory factors have been noted; for example, Sidloski et al. (2022) found modest support for the hypothesis that gamers may actually be referring to consequences of their loot box use when they complete problem

gambling screening measures, although they noted that the strength of these effects was unlikely to fully account for the relationship between loot boxes and problem gambling.

1.2. Investigating Causal Pathways

To date, few studies have sought to disentangle these causal pathways. Specifically, there is a need for longitudinal research examining gamers around the typical age range for gambling onset. Using a cross-sectional design that relied on retrospective judgments of each activity, Spicer et al. (2022) recruited 1,102 individuals who endorsed using both loot boxes and gambling products. Participants were asked about their ages of onset for each activity, and to judge whether either one influenced their decision to engage in the other. Overall, 19.6% endorsed a migration-type effect (that Spicer et al. label a ‘gateway effect’) in which loot boxes promoted subsequent gambling, while 20.1% endorsed the reverse pathway. These two subgroups were characterized by higher levels of youth loot box purchases, higher scores on the RLI, and greater endorsement of gambling-related cognitions. Nevertheless, the reliance on retrospective data requires that participants were aware of the causal influence of one behaviour upon the other, and able to recall such information accurately. Using a brief longitudinal approach, Zendle (2019) tested players of the game *Heroes of the Storm* before and after the game designer removed loot boxes (but not other microtransactions) from the game. Players who were classified as at high-risk of problem gambling at baseline significantly reduced their in-game expenditure when loot boxes were removed, whereas spending levels were unaffected in those without gambling problems. This was interpreted as support for the reverse pathway, that the presence of loot boxes in a game specifically encourages spending in those with gambling problems. These studies provide glimpses into possible directionality, but also highlight the need for additional longitudinal research to guide these causal interpretations.

The two pathways, and the ensuing discussion about the appropriate regulatory responses to loot boxes, emphasize the role of randomized reward mechanics, while also noting that financial over-spending is the main route to harm (Langham et al., 2016). It is pertinent here that modern video games also offer other, non-randomized microtransactions, including ‘direct purchase microtransactions’ (DPMs) where the gamer pays directly for a desired in-game item -- conceivably the same item that could be won in a loot box. In Zendle & Cairns (2018), DPM expenditure was not associated with problem gambling (e.g., $\eta^2 = 0.004$ vs. $\eta^2 = 0.054$ for loot boxes), but subsequent studies have produced mixed results (Close, Spicer, Nicklin, Lloyd, & Lloyd, 2022; Drummond, Sauer, Ferguson, & Hall, 2020; Zendle & Cairns, 2019). In Close et al. (2022), loot box users had a significantly greater rate of gambling participation than those who made other game-related transactions (46.0% vs. 28.1%), but spending across the two modalities was also somewhat correlated. This comparison between DPM and loot box spending remains a powerful way to test the appeal, and impact, of reward randomization.

1.3. The Present Study

We conducted a longitudinal study with the primary goal of testing ‘migration’ from engagement with loot boxes to later (conventional) gambling at six months. We recruited a group of young adult video gamers, stratified into two subgroups, with and without gambling experience at baseline; the tests for migration were conducted within the subgroup of non-gamblers. The analysis plan was pre-registered (*AsPredicted* #54443), and our effect size and expected attrition was informed by Kim et al. (2015) that tested migration from social casino games¹ (SCGs) to gambling over a similar six month window. These authors found that spending

¹ Social casino games are free-to-play online gambling games that are often found on social networking platforms. Money is not required to play, and wagers are typically made with game-provided credits. However, players may purchase additional credits to continue playing beyond the free number of rounds, or to unlock other features.

within SCGs uniquely predicted subsequent gambling ($OR = 8.16$). We also established some exploratory predictions to assess the specific role of randomized rewards, and the reverse pathway. First, we hypothesized that DPM expenditure would not predict gambling migration and tested this by entering DPM expenditure into our regression models, both alone and simultaneously with loot box expenditure. Second, we re-categorized our participants to identify a subgroup who reported no loot box expenditure in the year prior to baseline assessment (loot box non-users), then tested whether their gambling involvement at baseline predicted the initiation of loot box spending at 6-month follow-up.

2. Methodology

2.1. Sample & Procedure

Participants were recruited from the United States, United Kingdom, and Canada, using Prolific, a crowdsourcing platform designed for research participation. Of our eligibility criteria, five were established using Prolific's participant filters: i) a Prolific approval rating of 95% and ≥ 50 previous submissions; ii) regular video gaming, defined as ≥ 3 hours per week; iii) country of residence; iv) a minimum age above the legal gambling age for their country of residence (i.e., UK = age 18, Canada = age 19, USA = age 21); and v) age ≤ 25 on their Prolific account at the time of pre-screen completion. We focused on young adults because we reasoned that our target variable, initiation of gambling, would begin to plateau beyond this age (see Kessler et al., 2008). We used a further pre-screen survey to establish two additional criteria: vi) familiarity with either loot boxes or DPMs (assessed by endorsement of two binary Yes/No questions); and vii) proficiency with English. For data robustness, the eligibility criteria were repeated in the baseline survey. To ensure an adequate sample of non-gamblers for our primary tests of migration, the pre-screen stratified participants into the non-gambler and gambler subgroups via a Yes/No

response to the question, “*Do you currently gamble?*”, with a target N of 392 per subgroup.

These subgroups were recruited concurrently. Informed consent was obtained via a consent form presented at the beginning the pre-screen, baseline, and follow-up surveys. Study approval was provided by the University of [Redacted for Author Anonymity] Ethics Board.

The baseline survey was titled as ‘*Video Game Spending – Part 1*’ and took approximately 30 minutes to complete. The 6-month follow-up was titled ‘*Video Game Spending – Part 2*’ and took about 12 minutes to complete. Participants were compensated £5.00 (currency of Prolific) for baseline and £2.50 for follow-up. Four attention check items were used to maintain data quality (recommended by Goodman et al., 2013): i) consistent entry of the participant’s age across two sections; ii) did not endorse playing a fictional slot machine; iii) did not endorse playing a fictional video game; and iv) selection of a specified answer for a question. Participants who failed more than one attention check were excluded (as specified in *AsPredicted* #54443). Exclusion also occurred for inconsistent responses across key variables (e.g., endorsed current gambling but denied any history of gambling), if nonsensical statements were provided for open text responses, or for extremely fast or slow survey completion (3.0 *SDs* from median).

A total of 712 participants completed baseline. Of these, additional participants were excluded because: i) Qualtrics flagged one participant as a potential bot; ii) 34 indicated no English proficiency on the repeated exclusionary item in the baseline survey; iii) 15 indicated no current gaming activity (likely due to outdated Prolific account data); iv) 6 were not a resident of one of the three target countries (again likely due to incorrect information associated with their Prolific account); v) 4 entered an age less than our minimums (indicating inattention or an incorrect age on their Prolific account); vi) 9 took excessively long to complete the survey. Of those

remaining, all passed 3+ attention checks, and an additional seven were removed for inconsistent responses across the survey. Following exclusions, data from 636 participants (415 non-gamblers; 221 gamblers) were included in baseline analyses. An additional 8 participants were removed at follow-up assessment for indicating insufficient English (suggesting inattention because sufficient English was reported at baseline), and none failed the attention checks. Two retained participants reported an age of 26, possibly due to a birthdate between pre-screen and baseline completion. Overall, 291 non-gamblers (29.9% attrition) and 155 gamblers at baseline (also 29.9% attrition) completed follow-up. The pre-screen launched and completed in November 2020, the baseline survey launched on 16 December 2020 and completed on 23 December 2020, and follow-up launched on 23 June 2021 and completed 20 July 2021. More information about the timeline of data collection and survey structure is provided in the Supplementary Methods. The baseline survey included a number of subsidiary measures for exploratory research questions that are not reported here.

2.2. Measures

2.2.1. General Descriptives

This included general demographics, degree of video game engagement (e.g., hours per week), and estimated age of video game onset. We also presented some items to assess the impact of the COVID-19 pandemic upon participants' video game use.

2.2.2. Microtransaction Descriptives

A series of questions assessed: 1) Participant exposure to, and engagement with, loot boxes and DPMs; 2) expenditure on loot boxes and DPMs; 3) familiarity with loot box item odds; 4) reasons for selling loot box items; and 5) preferred games to use these features in.

2.2.3. Beliefs and Behaviours about Microtransactions

We assessed a range of loot box and DPM-related beliefs and behaviours. This included the Risky Loot-box Index (RLI), a five-item, five-point Likert scale that assesses self-perceived excessive use of loot boxes (Brooks & Clark, 2019). The RLI demonstrated good internal consistency at baseline ($\alpha = .840$) and follow-up ($\alpha = .843$).

2.2.4. Gambling Descriptives

Past and current gambling activity, expenditure on gambling, and perceptions about future gambling behaviour were assessed.

2.2.5. Gambling Cognitions

The Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004) was used to assess erroneous gambling cognitions at baseline. GRCS is a seven-point scale ('strongly disagree' to 'strongly agree') that measures illusion of control, interpretive bias, predictive control, gambling expectancies, and inability to stop gambling. Total score reliability was excellent ($\alpha = .916$).

2.2.6. Problem Gambling

The Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) is considered a gold standard screening instrument for problem gambling (Dowling et al., 2018). Nine items are scored from 0 ('never') to 3 ('almost always'), creating the risk categories of: Non-problem gambler (score = '0'); low risk ('1-4'); moderate risk ('5-7'); and problem gambler ('8+'; Currie et al., 2013). Participants were asked to not consider loot box use in their answers. PGSI reliability was good at baseline ($\alpha = .875$), and excellent at follow-up ($\alpha = .912$).

2.3. Power Analysis

A power calculation assumed a medium effect size for the continuous dependent variables (defined as $f^2 = .15$), with a single predictor power of .90, and $\alpha \leq .0125$ given the

Bonferroni correction for multiple tests (described in Section 2.5). Using G*Power 3.1.9.7. (Faul, Erdfelder, Lang, & Buchner, 2007), the recommended sample size was $n = 89$. Our attrition calculations for an online study using a 6 month follow-up assessment were based on Kim et al. (2015): assuming 75% attrition, and a further 10% oversampling for data cleaning, we sought to collect $n = 392$ at baseline, for both the non-gambler and gambler subgroups. Data collection for the subgroup of gamblers ran more slowly compared to the non-gamblers and was ultimately stopped before reaching this target (see Supplementary Methods).

2.4. Data Availability

Study data are available in the Borealis repository: <https://doi.org/10.5683/SP3/KXHCUN>

2.5. Analysis Plan

We first characterize the typical level and range of engagement with different forms of microtransactions across the two subgroups. Group differences among these variables are assessed with chi-squared and Mann-Whitney U tests (effect sizes for these tests are given by ϕ and derived r coefficients, respectively). We conduct an exploratory chi-squared test to assess whether endorsement of *any prior* loot box expenditure (answered Yes/No) predicted migration to current gambler status by follow-up. To assess our primary hypothesis (H1), we tested whether use of loot boxes at baseline in the non-gamblers predicted gambling behaviour at follow-up; this constitutes the narrowest test of ‘migration to gambling’. Non-gambler status was determined by a ‘No’ response to the question, “*Do you currently gamble?*” at baseline. Our pre-registered analyses operationalized loot box engagement using the two separate but related facets of 12-month microtransaction expenditure (overall engagement) and RLI score (risky use). Gambling engagement at follow-up was assessed via answering ‘Yes’ to “*Do you currently gamble?*” and 6-month gambling spend, to assess both self-identification as a gambler and

degree of gambling behaviour. Logistic regressions were used to assess whether: H1a) 12-month microtransaction expenditure or H1b) RLI score predicted conversion to current gambler status. Linear regressions were used to assess whether: H1c) 12-month microtransaction expenditure or H1d) RLI score predicted 6-month gambling spend at follow-up. Given the four comparisons, a Bonferroni correction was applied ($p < .0125$). DPM expenditure was entered into the model first, to assess the predictive capacity of loot box expenditure beyond microtransactions more generally. All expenditure data was converted to USD using the exchange rate at the midpoint date of data collection.

An exploratory hypothesis (H2; not pre-registered) sought to test the reverse pathway. We re-categorized our participants to identify a subgroup who reported zero expenditure on loot boxes during the 12-months prior to baseline. Using linear regressions, we tested whether gambling-related variables at baseline predicted loot box expenditure (and therefore onset of use) by follow-up. A Bonferroni correction ($p < .0167$) accounted for the three gambling-related variables being assessed (12-month expenditure, PGSI, and GRCS). For comparison, DPMs were also used to predict loot box expenditure.

We tested full sample bivariate correlations between gender, age, ethnicity, education, and self-rated degree of self-isolation during the COVID-19 pandemic against our predictors. None of these demographic variables were considered as control variables because none met our pre-registered threshold for consideration, a bivariate association of $r \geq .30$ (all $r \leq .197$ absolute value, see Supplementary Table 1). Following Field (2017), outliers were assessed with boxplots and cases above 1.5 times the interquartile range were noted. These datapoints were manually reviewed, those deemed to be non-sensical (e.g., a negative or improbably large dollar expense) were listwise excluded from analysis. All plausible outliers remained in the analysis and

bootstrapping (BCa, 5000 samples, run in IBM SPSS 28.0) was used to mitigate their effect in regressions. Normality was assessed with P-P plots. All expenditure variables (for loot boxes, DPMs, and gambling) were right skewed, as was PGSI and GRCS. These were log base 2 +1 transformed to improve normality, base 2 was used to facilitate interpretability of odds ratios.

3. Results

3.1. Demographics Information

Table 1 shows the participant demographics in the two subgroups of non-gamblers and gamblers, and the re-categorized participants based on loot box use at baseline.

[Table 1 About Here]

3.2. Loot Box and DPM Descriptives

Engagement with loot box and DPM features by gambling status at baseline are presented in Table 2. Among participants who made a microtransaction in the past year ($n = 541$), gamblers reported higher spending on loot boxes ($z = 4.68, p < .001$) and on DPMs ($z = 2.85, p = .004$.) than the non-gamblers. Gamblers were more likely to have bought loot boxes ($\chi^2 = 6.99, p = .008$), and sold loot box items ($\chi^2 = 6.72, p = .010$), relative to the non-gamblers. For both subgroups, the modal response to “*Do you look at the odds of receiving specific items before purchasing loot boxes?*” was “sometimes”.

[Table 2 About Here]

3.3. Chi-squared Analyses

Among the non-gamblers at baseline, a chi-squared analysis tested the relationship between having bought loot boxes at baseline (Yes/No) and gambling initiation (Yes/No) at follow-up (Table 3). An equivalent model tested the same effect for DPM purchases at baseline. Participants who initiated gambling between baseline and follow-up ($n = 33$) were more likely to have purchased loot boxes in the 12 months prior to baseline ($\chi^2 = 4.61, p = .032$); there was no difference in their DPM engagement ($\chi^2 = .670, p = .413$).

[Table 3 About Here]

3.4. Regression Analyses to Predict Gambling Behaviour

For the pre-registered H1, logistic regressions assessed whether the baseline predictors of (H1a) 12-month microtransaction expenditure or (H1b) RLI score predicted migration to current gambler status at follow-up. For the model using loot box expenditure, a hierarchical approach was used, where 12-month DPM expenditure was entered first. Overall, 291 non-gamblers at baseline completed follow-up, and 33 identified as current gamblers by follow-up. After Bonferroni correction, DPM expenditure did not significantly predict migration when entered alone ($OR = 1.15, p = .049$) or when added simultaneously with loot box expenditure ($OR = 1.04, p = .628$). Loot box expenditure predicted migration to current gambling status by follow-up ($OR = 1.25, p = .002$), see Table 4. The change in mean predictive probability for DPM spend across groups, when controlling versus not controlling for loot box spend, and the corresponding difference for loot box spend, when controlling versus not controlling for DPM spend, are illustrated in Figure 1. The RLI model also significantly predicted migration ($OR = 1.62, p =$

.008). Similar results were found in the linear regression models that predicted gambling spend. DPM expenditure did not significantly predict 6-month gambling spend when entered alone ($B = .093, p = .059$), or simultaneously with loot box expenditure ($B = .012, p = .804$). Loot box expenditure (H1c) predicted gambling spending at follow-up ($B = .182, p = .001$), when included in the model. The RLI model (H1d) also predicted ($B = .497, p = .001$) gambling spend at follow-up (Table 5; see Figure 2 for scatterplots).

[Table 4 About Here]

[Figure 1 About Here]

[Table 5 About Here]

[Figure 2 About Here]

3.4.1. Sensitivity analyses based on current gambling status

In exploring the data, we noted that non-gambling status at baseline could also be determined from a second item, answering ‘Never’ to the question “*In the past 12 months, have you gambled at all?*”. These responses did not show full agreement with our item “Do you *currently* gamble?” (italics added). Re-classifying our participants in this way shifted the subgroup sizes (non-gamblers: 291 in the original classification to 218; gamblers: 155 in the original classification to 228) with a further consequence that fewer non-gamblers migrated at follow-up (33 compared to 17). In the basic chi-squared analysis of migration, the effects were qualitatively unchanged using this alternative measure for gambling status (Table 3).

We re-ran our regression analyses using this alternative classification. Modelled simultaneously, DPM expenditure did not predict migration, while the effect of loot box spending was predictive ($OR = 1.27, p = .004$). RLI score did not predict migration ($OR = 1.12, p = .654$; Supplementary Table 2). In the linear regressions, neither loot box expense ($B = .096, p = .077$) nor RLI score ($B = -.001, p = .994$) significantly predicted gambling spending at follow-up (Supplementary Table 3). Correlation matrices of the predictor and dependent variables for both classification methods are found in Supplementary Table 4.

3.5. Tests of the Reverse Pathway

Exploratory analysis of the reverse pathway selected participants who reported no loot box expenditure during the 12-months prior to baseline (data on $n = 179$ available over both assessments) and used a series of linear regressions to test whether gambling-related variables at baseline (PGSI, GRCS, and 12-month gambling spend; DPM spend included for comparison) predicted loot box expenditure at follow-up. DPM expenditure ($B = .124, p = .005$) and GRCS ($B = .632, p = .002$) were significant predictors; notably, PGSI ($B = .360, p = .061$) and gambling spend ($B = .088, p = .041$) were not significant after correction for multiple comparisons (Table 6). See Supplementary Table 6 for a correlation matrix of these variables.

[Table 6 About Here]

4. Discussion

This study sought to explore the longitudinal relationship between loot box use and gambling behaviour, among young adult video gamers who were stratified into subgroups of gamblers and non-gamblers at the baseline assessment. In cross-sectional comparisons at

baseline, gamblers were more likely than non-gamblers to endorse buying and selling loot box items, and to have greater past year expenditure across both loot boxes and DPMs. Our primary (pre-registered) analyses tested whether loot box engagement among the non-gamblers at baseline predicted migration to gambling at follow-up. Over 4 regression models, we tested gambling initiation as the outcome in two logistic models and gambling spend in two linear regressions, using microtransaction expenditure and a self-report measure of risky loot box use (RLI) as predictors. We found supportive evidence for migration across models, with correction for multiple comparisons. Participants were re-classified using an alternative item to identify non-gambling status at baseline. Despite the loss of power from a reduced sample size, loot box expenditure but not DPM expenditure continued to predict gambling initiation. Lastly, we operationalized the ‘reverse pathway’ by re-sorting the dataset to create a subgroup of loot box non-users at baseline, and testing whether gambling variables predicted future loot box spending. Gambling-related cognitive distortions predicted later loot box expenditure, although PGSI and gambling spend did not, after correction for multiple comparisons.

Among both subgroups of gamers with and without gambling experience at baseline, nearly all participants reported having played video games that included loot boxes and DPMs, reiterating the ubiquity of these monetary systems in modern gaming (Xiao, Henderson, & Newall, 2022; Zendle, Meyer, Cairns, et al., 2020). More gamblers reported purchasing loot boxes than non-gamblers (71.5% vs. 61.0%), whereas the rate of DPM purchasing was similar (87.8% vs. 84.1%). Gamblers reported spending 2.50 times more on loot boxes over the past year than non-gamblers, and their spending was 1.40 times greater on DPMs. This pattern of data, though cross-sectional, is consistent with the notion that gamblers are attracted to loot box features and other forms of microtransaction when they play video games.

In optimizing our study design to test for migration, we recruited a sample of young adults (the mean age of the non-gambler subgroup at baseline was 22 years old), as a window above the legal age for gambling where we expected gambling initiation to still be high (c.f. Kessler et al., 2008). Sample retention was good between measurements with 291 of 415 (70.1%) completing follow-up. Using the pre-registered gambling classification approach (self-identification as a current gambler), 33 non-gamblers initiated gambling over the follow-up window. Loot box expenditure at baseline increased the odds of migration by 24.9% (per doubling of expenditure), when holding DPM expenditure constant. The RLI also predicted migration, with an odds increase of 61.6% per standard unit. In the linear regressions, loot box expenditure significantly predicted gambling spend at follow-up (Adjusted $R^2 = .046$), again controlling for DPM expenditure, as did RLI (Adjusted $R^2 = .041$).

These data establish a longitudinal link from loot box use to subsequent gambling, on both a binary measure reflecting self-identified gambling initiation and a continuous measure of gambling spend. Our findings extend the cross-sectional study by Spicer et al. (2022), in which 19.6% of gamblers retrospectively judged that loot boxes had shaped their subsequent decisions to gamble. Earlier age of initiation of gambling is known to predict later gambling problems (Kessler et al., 2008), and higher levels of gambling spend and losses are seen as a vector to gambling harm and problem gambling symptom severity (Langham et al., 2016; Markham, Young, & Doran, 2016). Nevertheless, with a short 6-month window, our data do not establish a direct link from loot box use to gambling *harm*. Testing for such effects would likely require longer follow-up periods or selection of higher-risk samples to capture the escalation in gambling harms or symptoms.

Our analyses also included engagement with non-randomized ‘direct purchase’ in-game payments (DPMs). DPM expenditure at baseline weakly (and non-significantly after correction for multiple comparisons) predicted migration to gambling at a univariate level ($OR = 1.15$), and the association was further reduced ($OR = 1.04$) when DPMs were entered simultaneously with loot box expenditure. A similar pattern was found in the linear regression models that predicted gambling spend. As might be expected, spending on loot boxes and DPMs was moderately correlated (see Supplementary Table 4), and this could be driven, at least partly, by disposable income or a willingness to spend money on virtual items (randomized or otherwise) in video games (Watkins & Molesworth, 2012). Our multivariate effects provide evidence that the randomized rewards offered by loot boxes drive the links with gambling. This, coupled with our evidence for migration effects, support regulatory action to reduce the exposure to loot box mechanisms among youth and young adults.

Prospective designs require clear categorization of the outcome variable (gambling) at baseline, and we note some fragility and divergence between our two operationalization methods. Clearly, individuals who do not endorse *current* gambling may have gambled at an earlier point in their lives, even among a young adult (aged 18-26) sample. For example, in the UK Young People and Gambling report, 14% of 11-16 year-olds reported past week gambling while 39% reported past year gambling (Gambling Commission, 2018). However, with the more rigorous definition (based on any gambling over the past 12 months), our absolute numbers converting to gambling were unsurprisingly lower, reducing our power to detect predictors of migration. Longitudinal designs that use more stringent criteria may again require larger samples or longer follow-up periods to capture adequate rates of migration.

This study also assessed the ‘reverse pathway’, where gamblers are thought to be attracted to loot box features (Spicer et al., 2022; Zendle & Cairns, 2018). We did so by an exploratory re-sorting of participants into a loot box non-user subgroup and testing the predictive capacity of gambling spend, PGSI, and GRCS for 6-month loot box expenditure at follow-up. Some support for this pathway was found: GRCS significantly predicted later loot box expenditure (Adjusted $R^2 = .056$). Erroneous gambling cognitions are typically correlated with problem gambling severity and implicated in the etiology of gambling problems. Certain gambling beliefs are also implicated in loot boxes, such as the belief that a desired prize is ‘due’ (the ‘gambler’s fallacy’) or illusory control over randomized outcomes. This is also consistent with the reverse pathway endorsed retrospectively by 20.1% in Spicer et al. (2022), and the differential reduction of microtransaction spend among problem gamblers after loot boxes were removed in *Heroes of the Storm* (Zendle, 2019). It is notable that the predictive value of GRCS did not generalize to PGSI and 12-month gambling spend. These latter variables might, *prima facie*, seem more conceptually relevant to excessive loot box spending. This may reflect the distributional properties of GRCS as a trait measure, compared to PGSI and gambling spend, which will necessarily contain many zero responses among non-gamblers. These exploratory results raise a neglected point that it is challenging to detect both causal pathways within the same study, as different design decisions are required to optimize sensitivity to the two effects.

Our longitudinal study design operationalizes causality in temporal terms, sometimes called Granger causality, providing evidence that higher levels of loot box engagement predict later gambling involvement. As naturalistic designs, our approach does not specify how this precedence occurs, and various unexplored ‘third variables’ may play a role. An indirect explanation could involve low parental supervision as a youth risk factor for excessive loot box

use, and then subsequently as a risk factor for gambling onset (Lee, Stuart, Ialongo, & Martins, 2014). An alternative approach to testing causality is via a randomized experiment, which can control for third variable explanations via the randomization. In D’Amico et al. (2022), participants were engaged in 20 minutes of video gaming in the lab, and were randomly assigned to either loot boxes, DPMs, or no rewards. The three groups all then completed the Balloon Analogue Risk Task. In that study, the loot box exposed group did not show any short-term elevation in risk taking, but given the shorter timeframe and compromises to ecological validity in both the independent and dependent variables that are necessary in the laboratory, it is difficult to compare this study with our evidence for migration. Both longitudinal studies and randomized experimental designs are likely to prove fruitful in advancing knowledge in this area.

4.1. Limitations

Our study suffers from a number of limitations. First, we used a crowdsourced sample collected via Prolific. Crowdsourced samples are not representative of young adults in terms of either gaming or gambling (Pickering & Blaszczynski, 2021; Russell, Browne, Hing, Rockloff, & Newall, 2022), and we make no claims about the population prevalence of these activities. Our design employed several selection criteria, through Prolific account settings and our own pre-screen survey, and included attention checks to maintain data quality. Second, we relied on a single item to identify non-gamblers, and non-gambler status did not fully converge when compared to a similar item, as discussed above. Our decision to also include gambling spend as a continuous measure was made to mitigate concerns about reliance upon this single item. Due to a slower rate of recruitment, we did not reach our target sample size in the subgroup of current gamblers, creating differential sensitivity in those comparisons. A third limitation was our short follow-up time-frame (six months): longer follow-ups provide a greater chance to capture the

onset of the target behaviour (e.g., initiation of gambling), but this trades off against sample attrition, which was our chief concern based on the relatively high six month attrition in Kim et al. (2015). We have also discussed the limitations of establishing causality through temporal precedence in naturalistic study designs. Our test of the reverse pathway was limited because we did not design our study to assess conversion to loot box use, and the ubiquity of loot boxes in video games meant our exploratory subgroup of loot box non-users was comparatively small. Accordingly, the non-significant effects for PGSI and gambling spend as predictors of loot box use are not interpreted as evidence for the null hypothesis.

5. Conclusions

The literature linking gambling and loot box use has steadily grown and increasing emphasis has been placed upon understanding the directionality of this relationship. In a recent study, Spicer et al. (2022) observed that about 1 in 5 participants retrospectively believed their loot box use influenced subsequent gambling. Our longitudinal study supports a migration pathway, that loot box engagement increases the likelihood of gambling initiation. Our data further indicate that the randomized rewards presented by loot boxes are integral to this relationship, as opposed to microtransactions more broadly. Combined with other research showing earlier age of onset of gambling is associated with adult gambling problems (Kessler et al., 2008), and loot box purchasing is commonly reported among adolescents (Montiel, Basterra-González, Machimbarrena, Ortega-Barón, & González-Cabrera, 2022), these effects underscore the need for loot box regulation to reduce youth and young adult exposure to these products. Such regulation could take a number of forms, including restricting underage access to either the loot box functionality within video games, or access to the games themselves; or mandating the availability of ‘limit setting’ tools or self-exclusion programs within video games, as predicated

upon responsible gambling strategy (Xiao & Henderson, 2021). Lastly, we recognize that the risk of migration is not restricted to underage youth and further consumer protection measures are warranted to reduce the effects of ‘predatory’ monetization tactics on young adults (King et al., 2019). We also note the risks of overspending with loot boxes are separate from any debates about their legal classification as gambling, and regulatory action could mitigate both gaming and gambling-related financial harms.

References

- Brooks, G. A., & Clark, L. (2019). Associations between loot box use, problematic gaming and gambling, and gambling-related cognitions. *Addictive Behaviors*, 96(March), 26–34.
<https://doi.org/10.1016/j.addbeh.2019.04.009>
- Close, J., Spicer, S. G., Nicklin, L. L., Lloyd, J., & Lloyd, H. (2022). Loot box engagement: relationships with educational attainment, employment status and earnings in a cohort of 16 000 United Kingdom gamers. *Addiction*, (July 2021), 1–8.
<https://doi.org/10.1111/add.15837>
- Currie, S. R., Hodgins, D. C., & Casey, D. M. (2013). Validity of the Problem Gambling Severity Index Interpretive Categories. *Journal of Gambling Studies*, 29(2), 311–327.
<https://doi.org/10.1007/s10899-012-9300-6>
- D’Amico, N. J., Drummond, A., de Salas, K., Lewis, I., Waugh, C., Bannister, B., & Sauer, J. D. (2022). No effect of short term exposure to gambling like reward systems on post game risk taking. *Scientific Reports*, 12(1), 1–12. <https://doi.org/10.1038/s41598-022-21222-3>
- Digital, Culture, Media, and S. C. Immersive and Addictive Technologies, United Kingdom House of Commons § (2019). Retrieved from
<https://www.parliament.uk/business/committees/committees-a-z/commons-select/digital->

- culture-media-and-sport-committee/inquiries/parliament-2017/immersive-technologies/
- Dowling, N. A., Merkouris, S. S., Manning, V., Volberg, R., Lee, S. J., Rodda, S. N., & Lubman, D. I. (2018). Screening for problem gambling within mental health services: a comparison of the classification accuracy of brief instruments. *Addiction*, *113*(6), 1088–1104.
<https://doi.org/10.1111/add.14150>
- Drummond, A., & Sauer, J. D. (2018). Video game loot boxes are psychologically akin. *Nature Human Behaviour*. <https://doi.org/10.1038/s41562-018-0360-1>
- Drummond, A., Sauer, J. D., Ferguson, C. J., & Hall, L. C. (2020). The relationship between problem gambling, excessive gaming, psychological distress and spending on loot boxes in Aotearoa New Zealand, Australia, and the United States-A cross-national survey. *PLoS ONE*, *15*(3), 1–16. <https://doi.org/10.1371/journal.pone.0230378>
- Drummond, A., Sauer, J. D., Hall, L. C., Zendle, D., & Loudon, M. R. (2020). Why loot boxes could be regulated as gambling. *Nature Human Behaviour*, *4*(10), 986–988.
<https://doi.org/10.1038/s41562-020-0900-3>
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. <https://doi.org/10.3758/BF03193146>
- Ferris, J., & Wynne, H. (2001). The Canadian Problem Gambling Index : Final report. *Canadian Centre on Substance Abuse*.
- Field, A. (2017). *Discovering Statistics Using IBM SPSS Statistics*. Sage Publications Ltd.
- Gambling Commission. (2018). Young People and Gambling 2018 Report, (October), 1–47.
Retrieved from <https://www.gamblingcommission.gov.uk/PDF/survey-data/Young-People-and-Gambling-2018-Report.pdf>

- Garea, S. S., Drummond, A., Sauer, J. D., Hall, L. C., & Williams, M. N. (2021). Meta-analysis of the relationship between problem gambling, excessive gaming and loot box spending. *International Gambling Studies*, 21(3), 460–479.
<https://doi.org/10.1080/14459795.2021.1914705>
- Goodman, J. K., Cryder, C. E., & Cheema, A. (2013). Data Collection in a Flat World: The Strengths and Weaknesses of Mechanical Turk Samples. *Journal of Behavioral Decision Making*, 26(3), 213–224. <https://doi.org/10.1002/bdm.1753>
- Kessler, R. C., Hwang, I., LaBrie, R., Petukhova, M., Sampson, N. A., Winters, K. C., & Shaffer, H. J. (2008). DSM-IV pathological gambling in the National Comorbidity Survey Replication. *Psychological Medicine*, 38(9), 1351–1360.
<https://doi.org/10.1017/S0033291708002900>
- Kim, H. S., Wohl, M. J. A., Salmon, M. M., Gupta, R., & Derevensky, J. (2015). Do social casino gamers migrate to online gambling? An assessment of migration rate and potential predictors. *Journal of Gambling Studies*, 31(4), 1819–1831. <https://doi.org/10.1007/s10899-014-9511-0>
- King, D. L., & Delfabbro, P. H. (2019). Video Game Monetization (e.g., ‘Loot Boxes’): a Blueprint for Practical Social Responsibility Measures. *International Journal of Mental Health and Addiction*, 17(1), 166–179. <https://doi.org/10.1007/s11469-018-0009-3>
- King, D. L., Delfabbro, P. H., Gainsbury, S. M., Dreier, M., Greer, N., & Billieux, J. (2019). Unfair play? Video games as exploitative monetized services: An examination of game patents from a consumer protection perspective. *Computers in Human Behavior*, 101(March), 131–143. <https://doi.org/10.1016/j.chb.2019.07.017>
- Kristiansen, S., & Severin, M. C. (2020). Loot box engagement and problem gambling among

- adolescent gamers: Findings from a national survey. *Addictive Behaviors*, 103(December 2019), 106254. <https://doi.org/10.1016/j.addbeh.2019.106254>
- Langham, E., Thorne, H., Browne, M., Donaldson, P., Rose, J., & Rockloff, M. (2016). Understanding gambling related harm: A proposed definition, conceptual framework, and taxonomy of harms. *BMC Public Health*, 16(1). <https://doi.org/10.1186/s12889-016-2747-0>
- Larche, C. J., Chini, K., Lee, C., Dixon, M. J., & Fernandes, M. (2021). Rare Loot Box Rewards Trigger Larger Arousal and Reward Responses, and Greater Urge to Open More Loot Boxes. *Journal of Gambling Studies*, 37(1), 141–163. <https://doi.org/10.1007/s10899-019-09913-5>
- Lee, G. P., Stuart, E. A., Ialongo, N. S., & Martins, S. S. (2014). Parental monitoring trajectories and gambling among a longitudinal cohort of urban youth. *Addiction*, 109(6), 977–985. <https://doi.org/10.1111/add.12399>
- Li, W., Mills, D., & Nower, L. (2019). The relationship of loot box purchases to problem video gaming and problem gambling. *Addictive Behaviors*, 97(May), 27–34. <https://doi.org/10.1016/j.addbeh.2019.05.016>
- Macey, J., & Hamari, J. (2022). Gambification: A definition. *New Media and Society*. <https://doi.org/10.1177/14614448221083903>
- Markham, F., Young, M., & Doran, B. (2016). The relationship between player losses and gambling-related harm: evidence from nationally representative cross-sectional surveys in four countries. *Addiction*, 111(2), 320–330. <https://doi.org/10.1111/add.13178>
- Montiel, I., Basterra-González, A., Machimbarrena, J. M., Ortega-Barón, J., & González-Cabrera, J. (2022). Loot box engagement: A scoping review of primary studies on prevalence and association with problematic gaming and gambling. *PLoS ONE*, 17(1

- January), 1–23. <https://doi.org/10.1371/journal.pone.0263177>
- Pickering, D., & Blaszczynski, A. (2021). Paid online convenience samples in gambling studies: questionable data quality. *International Gambling Studies*, 21(3), 516–536. <https://doi.org/10.1080/14459795.2021.1884735>
- Raylu, N., & Oei, T. P. S. (2004). The Gambling Related Cognitions Scale (GRCS): Development, confirmatory factor validation and psychometric properties. *Addiction*, 99(6), 757–769. <https://doi.org/10.1111/j.1360-0443.2004.00753.x>
- Russell, A. M. T., Browne, M., Hing, N., Rockloff, M., & Newall, P. (2022). Are any samples representative or unbiased? reply to Pickering and Blaszczynski. *International Gambling Studies*, 22(1), 102–113. <https://doi.org/10.1080/14459795.2021.1973535>
- Sidloski, B., Brooks, G. A., Zhang, K., & Clark, L. (2022). Exploring the association between loot boxes and problem gambling: Are video gamers referring to loot boxes when they complete gambling screening tools? *Addictive Behaviors*, 131(November 2021), 107318. <https://doi.org/10.1016/j.addbeh.2022.107318>
- Spicer, S. G., Fullwood, C., Close, J., Nicklin, L. L., Lloyd, J., & Lloyd, H. (2022). Loot boxes and problem gambling: Investigating the “gateway hypothesis.” *Addictive Behaviors*, 131(March), 107327. <https://doi.org/10.1016/j.addbeh.2022.107327>
- Watkins, R., & Molesworth, M. (2012). *Attachment to digital virtual possessions in videogames. Research in Consumer Behavior* (Vol. 14). Emerald Group Publishing Ltd. [https://doi.org/10.1108/S0885-2111\(2012\)0000014012](https://doi.org/10.1108/S0885-2111(2012)0000014012)
- Xiao, L. Y., & Henderson, L. L. (2021). Towards an Ethical Game Design Solution to Loot Boxes: a Commentary on King and Delfabbro. *International Journal of Mental Health and Addiction*, 19(1), 177–192. <https://doi.org/10.1007/s11469-019-00164-4>

- Xiao, L. Y., Henderson, L. L., & Newall, P. W. S. (2022). Loot boxes are more prevalent in United Kingdom video games than previously considered: updating Zendle et al. (2020). *Addiction*, (January), 21–23. <https://doi.org/10.1111/add.15829>
- Zack, M., St. George, R., & Clark, L. (2020). Dopaminergic signaling of uncertainty and the aetiology of gambling addiction. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 99(August 2019), 109853. <https://doi.org/10.1016/j.pnpbp.2019.109853>
- Zendle, D. (2019). Problem gamblers spend less money when loot boxes are removed from a game: A before and after study of Heroes of the Storm. *PeerJ*, 2019(10). <https://doi.org/10.7717/peerj.7700>
- Zendle, D., & Cairns, P. (2018). Video game loot boxes are linked to problem gambling: Results of a large-scale survey. *PLoS ONE*, 13(11), 1–13. <https://doi.org/10.1371/journal.pone.0206767>
- Zendle, D., & Cairns, P. (2019). Loot boxes are again linked to problem gambling: Results of a replication study. *PLoS ONE*, 14(3), 1–13. <https://doi.org/10.1371/journal.pone.0213194>
- Zendle, D., Meyer, R., & Ballou, N. (2020). The changing face of desktop video game monetisation: An exploration of exposure to loot boxes, pay to win, and cosmetic microtransactions in the most-played Steam games of 2010-2019. *PLoS ONE*, 15(5), 1–13. <https://doi.org/10.1371/journal.pone.0232780>
- Zendle, D., Meyer, R., Cairns, P., Waters, S., & Ballou, N. (2020). The prevalence of loot boxes in mobile and desktop games. *Addiction*, 115(9), 1768–1772. <https://doi.org/10.1111/add.14973>
- Zendle, D., Meyer, R., & Over, H. (2019). Adolescents and loot boxes: links with problem gambling and motivations for purchase. *Royal Society Open Science*, 6(6), 190049.

<https://doi.org/10.1098/rsos.190049>

Table 1*Participant Demographics*

Variable	Split by Baseline Gambling Status		Split by Baseline Loot Box Status	
	Non-gamblers (<i>n</i> = 415)	Gamblers (<i>n</i> = 221)	Loot Box Non-users (<i>n</i> = 251)	Loot Box Users (<i>n</i> = 385)
Mean Age (<i>SD</i>)	22.3 (1.91)	22.7 (1.89)	22.33 (1.89)	22.5 (1.92)
Gender:				
Woman	34.2%	20.4%	35.9%	25.2%
Man	62.4	76.9	61.0	71.7
Non-binary	3.37	2.71	3.19	3.12
Ethnicity:				
Caucasian/White	56.1%	68.3%	64.9%	57.4%
Asian	22.9	13.6	18.7	20.3
African/Black	5.78	5.43	3.59	7.01
Latin American	5.54	4.98	3.59	6.49
Multiracial	4.58	4.52	5.58	3.90
Other Ethnicity	5.06	3.17	3.59	4.94
Country of Residence:				
United States	47.2%	45.7%	44.6%	48.1%
United Kingdom	41.2	44.8	45.8	40.3
Canada	11.6	9.50	9.56	11.7
Median Education	2-Year College or Technical Degree	2-Year College or Technical Degree	Part college or university	2-Year College or Technical Degree
Ever Gambled	54.9%	100.0%	63.3%	75.3%
Mean Age of Gaming Onset (<i>SD</i>)	6.75 (2.80)	6.60 (2.53)	6.64 (2.54)	6.74 (2.81)
Median Weekly Gaming Hours	16-to-20 per week	16-to-20 per week	11-to-15 per week	16-to-20 per week

Note: The sample was sorted into gambling status, and then again into loot box use status. Gambling status was determined by response (Yes/No) to the question, “*do you currently gamble?*”. Loot box status was determined by indicating zero expenditure during the 12-months prior to baseline data collection.

Table 2*Loot Box and DPM Descriptives by Gambler Status at Baseline*

Variables	Non-Gamblers (<i>n</i> = 415)	Gamblers (<i>n</i> = 221)	Group Difference Testing
<i>Loot Boxes</i>			
Familiar with loot boxes:	99.8%	99.5%	$\chi^2 = .206, p = .650, \phi = -.018$
Played a game containing loot boxes:	96.9	98.2	$\chi^2 = .970, p = .325, \phi = .039$
Opened an awarded loot box without purchase:	94.0	95.5	$\chi^2 = .623, p = .430, \phi = .031$
Bought 'keys' to unlock or loot boxes directly:	61.0	71.5	$\chi^2 = 6.99, p = .008^*, \phi = .105$
Sold an item from a loot box for money:	35.2	45.7	$\chi^2 = 6.72, p = .010^*, \phi = .103$
Twelve-month expenditure on loot boxes (IQR): (<i>n</i> = 342 non-gamblers, 199 gamblers)	\$13.4 (0.00 – 50.0)	\$33.5 (6.70 – 120)	$U = 42,138, z = 4.68,$ $p < .001^*, r = .201$
<i>Direct Purchase Microtransactions</i>			
Familiar with DPMs:	98.1%	98.2%	$\chi^2 = .011, p = .917, \phi = .004$
Played a game that contains DPMs:	97.3	96.8	$\chi^2 = .140, p = .708, \phi = -.015$
Bought a DPM:	84.1	87.8	$\chi^2 = 1.57, p = .210, \phi = .050$
Sold an item that was bought as a DPM:	22.4	29.0	$\chi^2 = 3.33, p = .068, \phi = .072$
Twelve-month expenditure on DPMs (IQR): (<i>n</i> = 342 non-gamblers, 199 gamblers)	\$35.6 (14.6 – 93.8)	\$50.0 (20.0 – 134)	$U = 39,016, z = 2.85,$ $p = .004^*, r = .122$

Note: Expenditure data reflects the median and is calculated among participants that reported any microtransaction purchases in the past 12-months; Group differences ($*p \leq .05$, two-tailed) were assessed with chi-squared tests for the Yes/No questions, phi (ϕ) = effect size. Mann-Whitney U tests were used for expenditure (*n* = 541), and a derived *r* value is reported for effect size. Participants reported in currency of residence (USA, UK, Canada), and this was converted to USD using the conversion rate at the midpoint of data collection.

Table 3*Chi-square Tests of any Loot Box or DPM use at Baseline vs. Follow-up Gambling Status*

	Non-gambler	Gambler	
Baseline Non-gamblers:			
Any Loot Box Use: No	113	8	121
Any Loot Box Use: Yes	145	25	170
	258	33	$\chi^2 = 4.61, p = .032, \phi = .126$
Any DPM Use: No	46	4	50
Any DPM Use: Yes	212	29.0	241
	258	33	$\chi^2 = .670, p = .413, \phi = .048$
Reclassified Non-gambling Status:			
Any Loot Box Use: No	89	3	92
Any Loot Box Use: Yes	112	14	126
	201	17	$\chi^2 = 4.56, p = .033, \phi = .145$
Any DPM Use: No	33	2	35
Any DPM Use: Yes	168	15	183
	201	17	$\chi^2 = .252, p = .616, \phi = .034$

Note: $n = 291$, $df=1$ for baseline non-gamblers; $n = 218$, $df=1$ reclassified non-gambling status.

Reclassified non-gambling status determined by answering 'Never' to, "In the past 12 months, have you gambled at all?". Phi (ϕ) = effect size.

Table 4.*Logistic Regressions Predicting Migration to Current Gambler Status*

12-Month Microtransaction Expenditure							
Variables – Step 1	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-2.68	-4.00, -1.90	.422	48.9	<.001*		
DPM Expenditure	.143	-.044, .380	.077	4.14	.049	1.15	.957, 1.46
Test of Model Coefficient				$\chi^2 = 4.41$	$p > .036$		
Cox & Snell / Nagelkerke R^2				.015 / .030			
Step 2	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-3.00	-4.25, -2.22	.439	53.9	<.001*		
DPM Expenditure	.037	-.161, .275	.080	.236	.628	1.04	.851, 1.32
Loot Box Expenditure	.222	.017, .446	.078	8.79	.002*	1.25	1.02, 1.56
Test of Model Coefficient				$\chi^2 = 9.21$	$p = .002*$		
Cox & Snell / Nagelkerke R^2				.046 / .090			
Risky Loot Box Index							
Variables	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-2.06	-2.59, -1.68	.195	117	<.001*		
RLI Score	.480	.001, 1.00	.193	6.56	.008*	1.62	1.00, 2.72
Test of Model Coefficient				$\chi^2 = 6.70$	$p > .010*$		
Cox & Snell / Nagelkerke R^2				.023 / .045			

Note: $n = 291$, Step 1 $df = 1$, Step 2 $df = 2$, * $p \leq .0125$ (two-tailed). Bootstrapped (BCa, 5000 samples).

Significance level of $p \leq .0125$ and 98.75% CI are required for the Bonferroni correction applied. Expense variables were log base 2 +1 transformed to reduce positive skew; RLI scores were centred and standardized.

Table 5.*Linear Regressions Predicting Follow-up Gambling Spend*

12-Month Microtransaction Expenditure						
Variables – Step 1	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.889	.411, 1.42	.210		3.82	<.001*
DPM Expenditure	.093	-.029, .211	.048	.113	1.94	.059
R^2 / Adj. R^2				.013 / .009		
<i>F</i>				3.75, <i>p</i> = .054		
Step 2	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.703	.216, 1.26	.209		3.00	.001*
DPM Expenditure	.012	-.118, .138	.050	.015	.232	.804
Loot Box Expenditure	.182	.049, .318	.055	.222	3.46	.001*
R^2 / Adj. R^2				.052 / .046		
<i>F</i>				7.94, <i>p</i> <.001*		
Risky Loot Box Index						
Variables	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	1.34	.993, 1.71	.144		9.85	<.001*
RLI Score	.497	.130, .865	.147	.211	3.66	.001*
R^2 / Adj. R^2				.044 / .041		
<i>F</i>				13.4*, <i>p</i> <.001*		

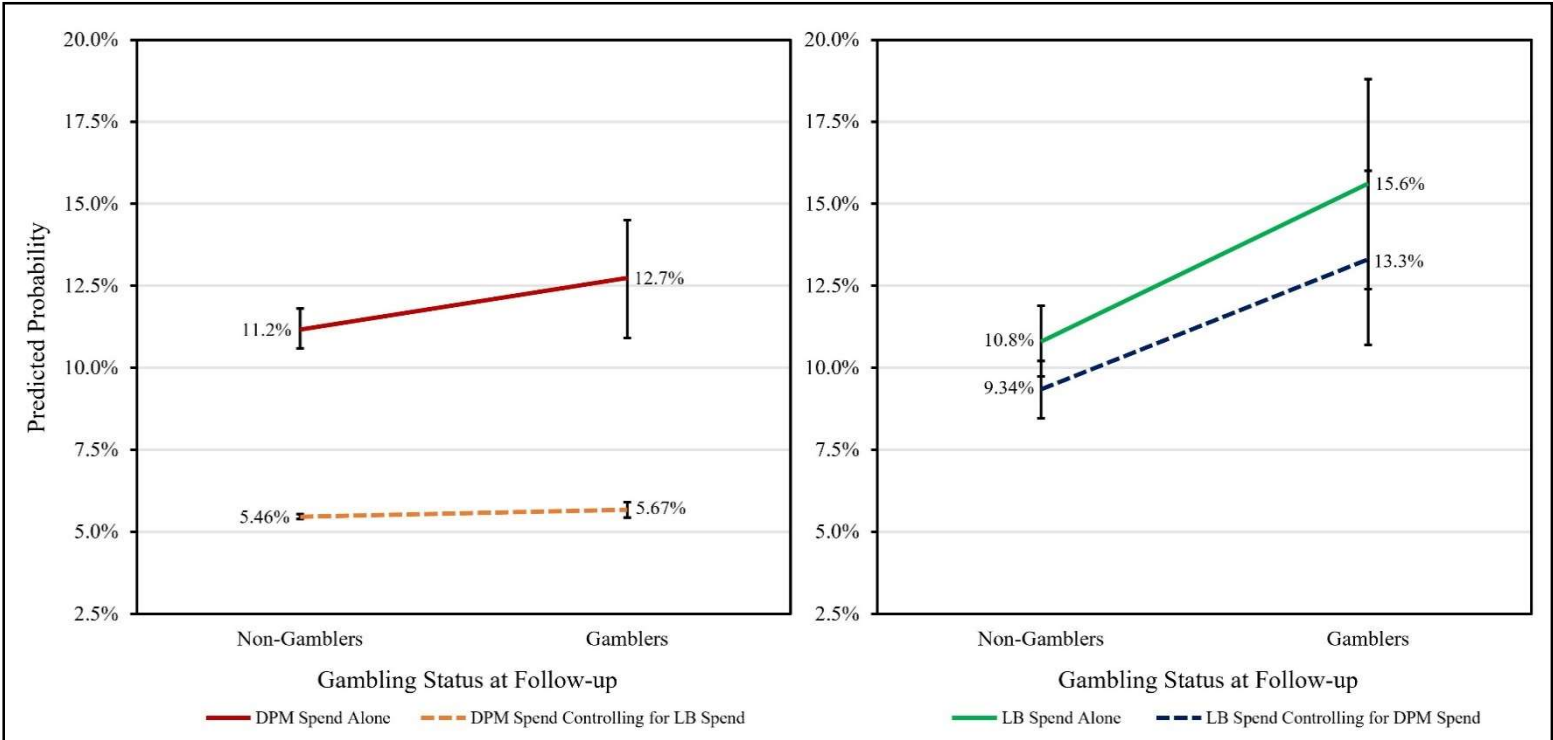
Note: *n* = 291, Step 1 *df* = 289, Step 2 *df* = 288, * *p* ≤ .0125 (two-tailed). β = standardized coefficient. B, 98.75% CI, SE, and predictor *p*-values are bootstrapped (BCa, 5000 samples). Significance level of *p* ≤ .0125 and 98.75% CI are required for the Bonferroni correction applied. Expense variables were log base 2 +1 transformed to reduce positive skew; RLI scores were centred and standardized.

Table 6.
Gambling Variables Predicting Follow-up Loot Box Expenditure

Problem Gambling Severity Index						
Variable	B	98.33% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.515	.288, .768	.104		4.66	<.001*
PGSI Score	.360	-.053, .860	.191	.198	2.69	.061
R^2 / Adj. R^2				.039 / .034		
<i>F</i>				7.24		
Gambling Related Cognitions Scale						
Variable	B	98.33% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	-2.72	-5.13, -.303	1.02		-2.75	.011*
GRCS Score	.632	.152, 1.12	.200	.248	3.41	.002*
R^2 / Adj. R^2				.062 / .056		
<i>F</i>				11.6*		
12-Month Gambling Expenditure						
Variable	B	98.33% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.438	.184, .724	.114		3.45	<.001*
Gambling Expenditure	.088	-.002, .191	.042	.187	2.54	.041
R^2 / Adj. R^2				.035 / .030		
<i>F</i>				6.44		
12-Month Direct Purchase Microtransaction Expenditure						
Variable	B	98.33% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.293	.044, .594	.119		1.98	.015*
DPM expenditure	.124	.022, .231	.043	.229	3.12	.005*
R^2 / Adj. R^2				.052 / .047		
<i>F</i>				9.76*		

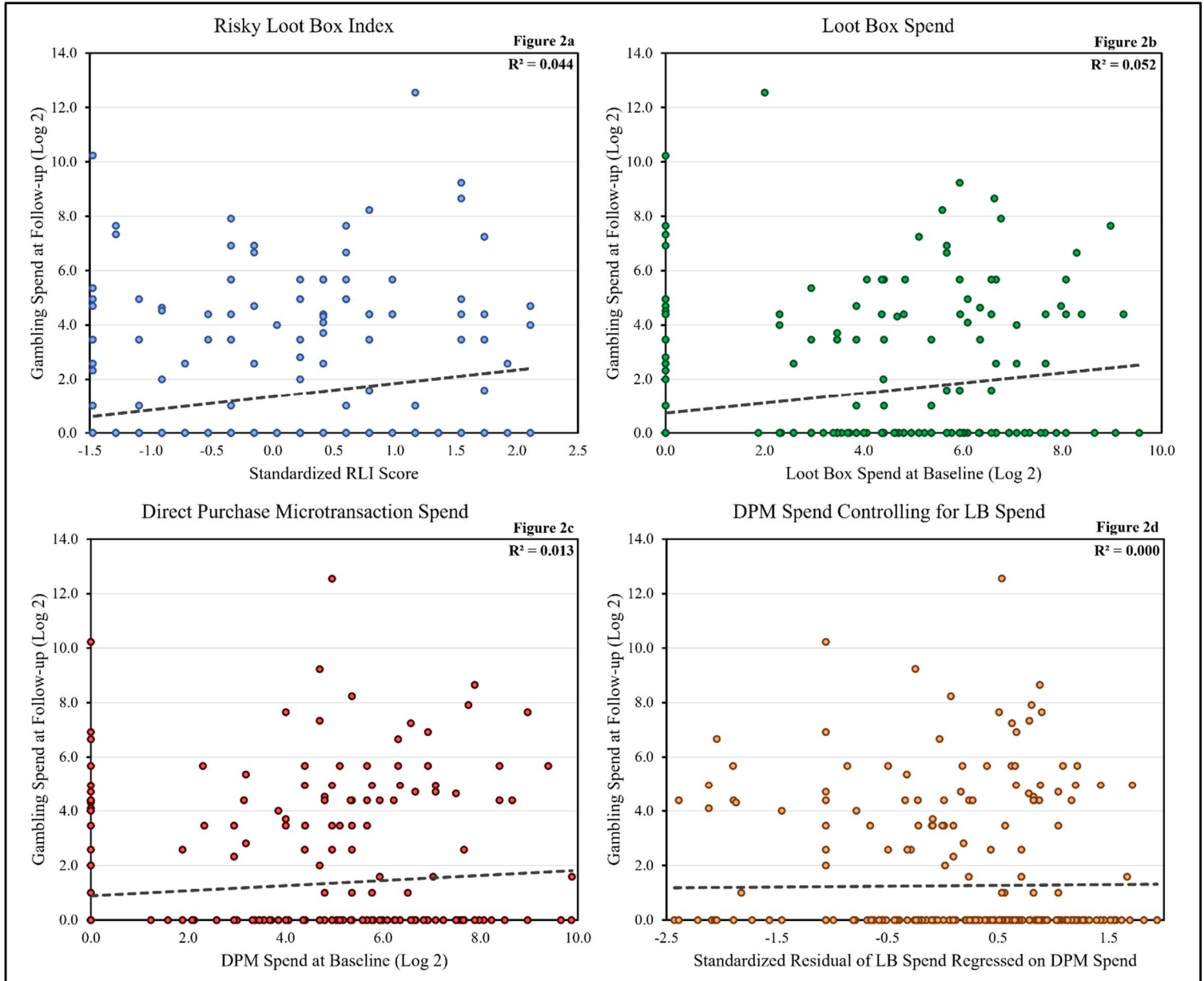
Note: $n = 179$, $df = 177$, $*p \leq .0167$ (two-tailed). β = standardized coefficient. B, 98.33% CI, SE, and *p*-value are bootstrapped (BCa, 5000 samples). Significance level of $p \leq .0167$ and 98.33% CI are required for the Bonferroni correction applied. The PGSI, GRCS, and expense variables were log base 2 +1 transformed to reduce positive skew. DPM expense included for comparison.

Figure 1.
Mean Predicted Probability of Migration for DPM and Loot Box Spend



Note: $n = 291$. 98.75% CIs. Percentages display the mean predicted probability of gambling migration based upon participants DPM or loot box expenditure, as calculated via logistic regressions.

Figure 2.
Scatterplots of Primary Variables Predicting Gambling Spend at Follow-up



Note: $n = 291$. 80 baseline non-gamblers reported gambling spend by follow-up. Expense variables were log base 2 +1 transformed to reduce positive skew; RLI scores were centered and standardized (Figure 2a). Figures 2b and 2c display the trendlines of loot box spend and DPM spend without controlling for DPM or loot box expenditure, respectively. Figure 2d plots the relationship between the standardized residual of loot box spend after regression upon DPM spend and follow-up gambling spend, to visualize the trendline for DPMs when loot box spend is controlled for.

Supplementary Materials

(Brooks & Clark ‘The gamblers of the future? Migration from loot boxes to gambling in a longitudinal study of young adults’)

1. Timeline of Data Collection

The pre-screen launched and completed in November 2020. In total, 663 individuals who completed the pre-screen met eligibility criteria for the non-gambler subgroup, and 397 were eligible for the gambler subgroup. Using custom Prolific filters, these individuals were provided access to the baseline survey. Data collection for the baseline survey (in both subgroups) launched on 16 December 2020. Data collection was terminated after reaching the target n for non-gamblers on 23 December 2020. In making this decision – i.e. to *also* terminate recruitment in the gambler subgroup before the target n was reached – we considered a number of factors: i) the eligible pool of gamblers ($n = 397$) on the Prolific platform was fairly small, due to the combination of eligibility criteria that required engagement in gambling and familiarity with video game loot boxes, and it was unlikely we would reach our original target of 392; ii) recruitment was expected to be slow through the seasonal holidays in December, and iii) we wanted to clearly delineate the 6-month follow-up interval across both subgroups, to avoid the possibility that external factors (e.g. pandemic-related events) might differentially affect the two subgroups. Data collection for the follow-up ran from 23 June 2021 to 20 July 2021 for both subgroups. From the exact timing across participants, all participants had at least six months between baseline and follow-up assessment, with this interval increasing towards seven months in a small minority (note that most data collection at both assessments occurred in the first week of survey launch).

2. Survey Structure

The baseline survey structure proceeded as follows: i) informed consent; ii) individual demographics, including video game and microtransaction descriptives; iii) questions about virtual item valuation; iv) Risky Loot Box Index (RLI); and v) beliefs and behaviours about microtransactions; vi) an online deployment within Qualtrics of the Balloon Analogue Risk Task that comprised 15 trials; vii) the standard Problem Gambling Severity Index (PGSI); viii) randomly presented trait scales (Schizotypal Personality Questionnaire – Brief, Depression Anxiety Stress Scale – 21 Items, TIPI 10 Question Big Five Measure, Internet Gaming Disorder Scale – Dichotomous Version, Gambling Related Cognitions Scale, Game Playing Preferences Scale, Beliefs Around Luck Scale, and Attitudes Toward Gambling Scale – 8 Item); ix) a modified version of the PGSI that instructed participants to not consider loot boxes in their responses and provided examples of conventional gambling (the inclusion of this scale was inspired by the argument presented in Sidloski et al 2022 and data will be reported elsewhere); and x) the gambling-related descriptives. Upon completion, participants read a debriefing message that included resources for participants who felt their gaming or gambling might be problematic, with different options for participants located in the USA, UK, and Canada.

The follow-up survey structure proceeded as follows: i) informed consent; ii) an abbreviated assessment of demographics and video game descriptives; iii) RLI; iv) questions about virtual item valuation; v) randomly presented select retained scales (Internet Gaming Disorder Scale – Dichotomous Version, Attitudes Toward Gambling Scale – 8 Item, the modified PGSI); vi) and gambling-related descriptives. The same debriefing resources from the baseline assessment were re-presented on completing the follow-up. The measures that are not reported in the current manuscript will be described elsewhere.

Supplementary Table 1*Correlations Between Predictors and Demographics*

Variable	Loot Box Expense	DPM Expense	Gambling Expense	RLI	PGSI	GRCS
Age	.077	.009	.088*	-.002	.052	.011
Gender:						
Man	.134*	.120*	.197*	-.030	.172*	.119*
Woman	-.140*	-.127*	-.187*	.020	-.169*	-.098*
Non-binary	.006	.010	-.040	.027	-.021	-.064
Ethnicity:						
Asian	.020	-.012	-.069	.049	-.005	.116*
Multiracial	-.039	-.004	-.023	.047	-.037	.002
African/Black	.034	.019	-.015	.017	.035	.039
Latin American	.063	.031	-.009	.016	-.009	.023
Caucasian/White	-.047	-.002	.094*	-.080*	.008	-.101*
Other Ethnicity	.006	-.024	-.041	.010	-.002	-.055
Education	.037	.010	.044	-.012	.012	.042
C19 Self-isolation	.063	.071	-.074	-.064	.033	-.028

Note: $n = 636$, $*p \leq .05$ (two-tailed). Gender and ethnicity variables were dummy coded (0 = No, 1 = Yes), and values reflect Pearson point-biserial correlations. All correlations conducted on baseline data. Expense variables are estimations of the past 12-month expenditure at baseline. Expense variables, PGSI, and GRCS were log base 2 +1 transformed. C19 Self-isolation = degree of self-isolation during the COVID-19 pandemic as reported by the participant, measured using a sliding scale from 0 – 100 (not at all – all the time).

Supplementary Table 2

Logistic Regressions Predicting Migration Among Reclassified Non-gamblers

12-Month Microtransaction Expenditure							
Variables – Step 1	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-3.20	-5.56, -2.15	.702	33.0	<.001*		
DPM Expenditure	.163	-.121, .609	.122	2.68	.128	1.18	.886, 1.84
Test of Model Coefficient				$\chi^2 = 2.92$	$p = .087$		
Cox & Snell / Nagelkerke R^2				.013 / .032			
Step 2	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-3.46	-5.79, -2.41	.745	35.2	<.001*		
DPM Expenditure	.042	-.242, .448	.122	.145	.690	1.04	.785, 1.57
Loot Box Expenditure	.237	-.002, .544	.093	5.12	.004*	1.27	.998, 1.72
Test of Model Coefficient				$\chi^2 = 5.27$	$p = .022$		
Cox & Snell / Nagelkerke R^2				.037 / .087			
Risky Loot Box Index							
Variables	B	98.75% CI	SE	Wald	p-value	OR	98.75% OR CI
Constant	-2.44	-3.23, -1.98	.288	89.3	<.001*		
RLI Score	.114	-.702, .812	.284	.190	.654	1.12	.496, 2.25
Test of Model Coefficient				$\chi^2 = .188$	$p = .665$		
Cox & Snell / Nagelkerke R^2				.001 / .002			

Note: $n = 218$, Step 1 $df = 1$, Step 2 $df = 2$, * $p \leq .0125$ (two-tailed). Baseline non-gamblers defined by answer of 'Never' to "In the past 12 months, have you gambled at all?". Bootstrapped (BCa, 5000 samples). Significance level of $p \leq .0125$ and 98.75% CI are required for the Bonferroni correction applied. Expense variables were log base 2 +1 transformed to reduce positive skew; RLI scores were centred and standardized.

Supplementary Table 3

Linear Regressions Predicting Follow-up Gambling Spend Among Reclassified Non-gamblers

12-Month Microtransaction Expenditure						
Variables – Step 1	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.684	.224, 1.28	.229		3.24	.003*
DPM Expenditure	-.001	-.131, .109	.044	-.001	-.019	.985
R^2 / Adj. R^2				.000 / -.005		
<i>F</i>				.000, <i>p</i> = .985		
Step 2	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.621	.173, 1.21	.224		2.92	.008*
DPM Expenditure	-.047	-.187, .077	.050	-.074	-.949	.348
Loot Box Expenditure	.096	-.030, .238	.054	.147	1.90	.077
R^2 / Adj. R^2				.016 / .007		
<i>F</i>				1.80, <i>p</i> = .168		
Risky Loot Box Index						
Variables	B	98.75% CI	SE	β	<i>t</i>	<i>p</i> -value
Constant	.681	.396, .995	.124		5.32	<.001*
RLI Score	-.001	-.326, .318	.126	.000	-.006	.996
R^2 / Adj. R^2				.000 / -.005		
<i>F</i>				.000, <i>p</i> = .996		

Note: *n* = 218, Step 1 *df* = 216, Step 2 *df* = 215, * *p* ≤ .0125 (two-tailed). Baseline non-gamblers defined by answer of ‘Never’ to “In the past 12 months, have you gambled at all?”. β = standardized coefficient. B, 98.75% CI, SE, and predictor *p*-values are bootstrapped (BCa, 5000 samples). Significance level of *p* ≤ .0125 and 98.75% CI are required for the Bonferroni correction applied. Expense variables were log base 2 +1 transformed to reduce positive skew; RLI scores were centred and standardized.

Supplementary Table 4*Correlations Between Predictor and Dependent Variables in Section 3.4.*

Baseline Non-gamblers				
Variable	2.	3.	4.	5.
1. DPM Expense (baseline)	.452**	.248**	.121*	.113
2. Loot Box Expense (baseline)	—	.537**	.217**	.228**
3. RLI Score (baseline)		—	.153**	.211**
4. Gambler Status (follow-up)			—	.639**
5. Gambling Expense (follow-up)				—
Reclassified Non-gambling Status				
Variable	2.	3.	4.	5.
1. DPM Expense (baseline)	.487**	.289**	.113	-.001
2. Loot Box Expense (baseline)	—	.542**	.197**	.111
3. RLI Score (baseline)		—	.030	.000
4. Gambler Status (follow-up)			—	.786**
5. Gambling Expense (follow-up)				—

Note: $n = 415$ at baseline & 291 at follow-up for baseline non-gamblers; $n = 302$ at baseline & 218 at follow-up for reclassified non-gamblers. * $p \leq .05$, ** $p \leq .01$ (two-tailed). Reclassified non-gamblers: Replied ‘Never’ to, “*In the past 12 months, have you gambled at all?*”. Baseline expense variables estimate past 12-months and follow-up gambling expense estimates past 6-months. Gambler status was dummy coded (0 = No, 1 = Yes). Expense variables are log base 2 +1 transformed. Pairwise exclusions.

Supplementary Table 5*Correlations Between Predictor and Dependent Variables in Section 3.5.*

Loot Box Non-users				
Variable	2.	3.	4.	5.
1. DPM Expense (baseline)	.071	.116	.148*	.229**
2. Gambling Expense (baseline)	—	.602**	.376**	.187*
3. PGSI Score (baseline)		—	.437**	.198**
4. GRCS Total Score (baseline)			—	.248**
5. Loot Box Expense (follow-up)				—

Note: $n = 251$ at baseline & 179 at follow-up; * $p \leq .05$, ** $p \leq .01$ (two-tailed). Loot box non-user status is based upon no expense reported during the 12-months prior to baseline. baseline expense variables estimate past 12-months and follow-up loot box expense estimates past 6-months. Variables are log base 2 +1 transformed to reduce positive skew. Pairwise exclusions.