Meta-Analysis of the Relationship between Problem Gambling, Excessive Gaming and Loot Box Purchasing

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Abstract

Loot boxes are purchasable randomised rewards contained in some video games. Concerns have been raised that these share psychological and structural features with traditional forms of gambling, and that they may exacerbate excessive video gameplay. Here, we quantitatively summarise two specific research areas regarding loot box spending using meta-analyses. We examined the relationships between loot box spending and (1) problem gambling (15 studies), and (2) excessive gaming (7 studies). We found significant small-to-moderate positive correlations between loot box spending and gambling symptomology, r = 0.26 (r = 0.37 using Trim and Fill), and excessive gaming, r = 0.25. Our results suggest a small, but replicable and potentially clinically relevant, relationship between gambling symptomology and loot box spending that is at least as large as the relationship between excessive gaming symptoms and loot box spending. Further research should examine the potential for statistical interactions between these constructs.

Keywords: Loot Box, Video games, Excessive Gaming, Problem Gambling, Meta-analysis

Psychologists, policy makers, and the public have expressed concerns about gambling-like reward mechanisms within some video games (Drummond & Sauer, 2018; Prati, 2019). Some of these mechanisms meet psychological and legal criteria for gambling (Drummond & Sauer, 2018), and researchers have highlighted the need to determine the potential for harm to gamers, especially vulnerable gamers; underage gamers, and those with symptoms of excessive gaming or problem gambling, as these gamers may be overspend (King & Delfabbro, 2018; Zendle et al., 2019).

Loot boxes are one reward mechanism which has received particular attention. Loot boxes are digital containers, often purchasable with real money, that provide randomised digital rewards to players (Brooks & Clark, 2019; Macey & Hamari, 2019; McCaffrey, 2019). Rewards may provide in-game competitive advantage (e.g., powerful weapons) and/or cosmetic changes (e.g., new costumes). Some rewards can also be cashed out to real world currency via digital marketplaces (Brooks & Clark, 2019; Drummond & Sauer, 2018; Drummond, Sauer, Hall, et al., 2020; Griffiths, 2018). These marketplaces are popular – over 6 billion items were listed as of 2018 on the Steam Marketplace – allowing a virtual economy to flourish. Additionally, marketplaces take a small portion of the proceeds (e.g., Steam fee = 5%) from each transaction, and some game developers take an additional small portion (e.g., Dota 2 fee = 10%) from each transaction (Steam, 2017). Thus, marketplaces/developers are financially incentivised by sales (Juniper Research, 2018). Loot box revenue reached 30 billion USD in 2018 (Li et al., 2019) – exceeding online casino revenue of 3.2 billion USD (Derevensky & Griffiths, 2019) – and is projected to reach 50 billion USD by 2022 (Juniper Research, 2018). Loot boxes are found in bought games for consoles and PCs, and in many free-to-play online and smartphone games which also often present players with obstacles, such as time restrictions or difficulty increases, to encourage loot box purchases (King et al., 2019). Additionally, some games include limited edition items exclusively available in loot boxes over a specific time period (e.g., around Halloween), or increased chance of success in-game from powerful items gained in loot boxes. These purchase incentives are often employed in combination with the aforementioned obstacles to encourage loot box spending.

A key feature of loot boxes is the randomisation of rewards delivered (Drummond, Sauer, Hall, et al., 2020; King & Delfabbro, 2018; Zendle et al., Under Review). Prizes ranging in scarcity and value are often delivered on a variable-ratio reward schedule – a reinforcement schedule known to promote the rapid uptake and frequent repetition of behaviour, and present in most forms of conventional gambling (Derevensky & Griffiths, 2019; Drummond & Sauer, 2018; Ferster & Skinner, 1957; Griffiths, 2018). Loot boxes often also employ arousing auditory and visual cues; drawing further comparisons to slot machines (Larche et al., 2019; Li et al., 2019). Although loot boxes are a relatively new mechanic in video games, research has already identified associations between loot

box engagement and gambling cognitions (Brooks & Clark, 2019) and shown that loot boxes in many games meet the psychological criteria for gambling (Drummond & Sauer, 2018; Griffiths, 1995, 2018). Moreover, some loot boxes meet common legal criteria of gambling: requiring an entry cost (consideration), having an outcome based on chance (chance), and providing a reward (prize) of value (Drummond & Sauer, 2018; Drummond, Sauer, Hall, et al., 2020).

Loot boxes may appear similar to lucky-dips or 'blind-box' toys/card games (e.g., where consumers purchase a pack of cards hoping to get rare cards). However, there are important differences. First, loot box prizes, unlike those in traditional lucky dips, can be extremely valuable. Second, more than 90% of people who sell loot box items on digital marketplaces recoup less than the loot box purchase price, suffering a net loss and falsifying the claim that 'everyone' wins as they might in a lucky dip (Drummond, Sauer, Hall, et al., 2020). Finally, loot box spending is associated with problem gambling symptoms, whereas similar activities such as collectable card games (e.g., blind boxes) are not (Zendle, Walasek, et al., 2020). This suggests that in addition to meeting the psychological criteria for gambling it is important to establish whether an activity is engaged with disproportionately by gamblers to determine whether regulation is appropriate. As such, a primary goal of the present meta-analysis is to establish whether problem gambling symptoms bear a reliable relationship to loot box spending.

The Diagnostic and Statistical Manual (DSM-5) lists gambling disorder as a behavioural addiction characterised by '*persistent and recurrent problematic gambling behaviour leading to clinically significant impairment or distress*' (American Psychiatric Association, 2013). However, such gambling issues (where behaviours result in significant impairment or distress) have been known more generally as compulsive gambling, pathological gambling, disordered gambling, and problem gambling (Ferentzy & Turner, 2013). Problem gambling is a general term used to define gambling that adversely affects social, financial, and occupational wellbeing (Dowling et al., 2019; Ferentzy & Turner, 2013). Considerable overlap has been found between these varying concepts of problem gambling constructs (Holtgraves, 2009). Thus, for non-clinical populations, tools such as the problem gambling severity index (PGSI) have been developed to measure the severity and prevalence of this combined symptomology (Wynne, 2003).

The literature suggests a reliable positive relationship between problem gambling symptomology and loot box spending (Brooks & Clark, 2019; Drummond, Sauer, Ferguson, et al., 2020; Kristiansen & Severin, 2020; Li et al., 2019; Zendle, 2019, 2020). However, reported effect sizes vary from small (Li et al., 2019) to large (Kristiansen & Severin, 2020). Although these effects are correlational, meaningful relationships would be problematic irrespective of causal direction. Whether loot box spending causes problem gambling, problem gambling causes loot box spending,

or both are caused by third variables (e.g., preference for high-risk activities), all possibilities represent problematic relationships. A robust relationship between problem gambling and loot box spending would imply that either loot boxes are increasing problem gambling symptoms, or that they draw a disproportionate amount of revenue from vulnerable users. In either case, a vulnerable group appears to be at increased risk of overspending or experiencing other adverse effects due to engaging with loot boxes (Drummond et al., 2019; Griffiths, 2018, 2019; King & Delfabbro, 2018).

The identified similarities between gambling and loot boxes have led to some countries restricting access to loot boxes based on players' age, banning loot boxes entirely, or requiring additional consumer information be presented to players (Drummond et al., 2019; King & Delfabbro, 2018). However, many jurisdictions continue to debate the appropriateness of various regulatory responses, based on perceptions of the extent to which loot boxes approximate gambling (Derevensky & Griffiths, 2019; Drummond et al., 2019; Drummond, Sauer, Hall, et al., 2020; Prati, 2019; Zendle & Cairns, 2018). A reliable, quantitative summary of the relationship between problem gambling symptomology and loot box spending may help frame considerations of appropriate policy response, especially as related to vulnerable players (Derevensky & Griffiths, 2019; Drummond et al., 2019; King et al., 2019; Macey & Hamari, 2018).

Debate also exists as to whether loot box overuse is best conceptualised under a problem gambling or problem/excessive gaming theoretical framework (King & Delfabbro, 2019). We use the term excessive gaming here for two reasons. First, most studies measuring excessive gaming behaviour have employed continuous symptomology measures, resulting in a non-dichotomous continuum of user symptom scores wherein users may not meet the 'problem gaming' criteria, yet have symptoms of excessive gaming. Second, pragmatically, we use the term excessive gaming to avoid confusion with problem gambling. Despite significant scholarly disagreement (van Rooij et al., 2018), Gaming Disorder has been added to the World Health Organization's (WHO) International Classification of Disorders (ICD). The DSM seems likely to include Internet Gaming Disorder in the near future (Derevensky & Griffiths, 2019; Li et al., 2019). Gaming Disorder and Internet Gaming Disorder will likely share diagnostic criteria related to negative effects of excessive gaming on wellbeing (social and financial effects of excess will likely contribute to quality-of-life considerations). To the extent that excessive gaming may lead to maladaptive social and financial outcomes for some players, loot boxes that meet the psychological criteria for gambling and leverage variable ratio reinforcement to increase gamer engagement and spending, should be of interest to researchers and policy makers. However, the relatively few studies that have investigated the relationship between excessive gaming and loot box spending have yielded mixed results (Brooks & Clark, 2019; Li et al., 2019; Orben & Przybylski, 2019; Wilkins, Unpublished Thesis; Zendle, 2020). Accordingly, in

the present meta-analysis, we address three important research questions relating to loot boxes. First, does participants' loot box spending correlate with gambling symptomology? Second, does participants' loot box use correlate with excessive gaming? Third, what does the current research tell us about the relative strengths of these associations? Specifically, do they exceed guidelines for the smallest effect size of practical and clinical importance (Ferguson, 2009), and does one variable have a stronger relationship with loot box spending than the other? If one relationship is stronger than the other, this may assist more precise decision making around which potential harm reduction measures are likely to be most effective.

Loot box research has seen significant growth over the past 3 years, with ongoing interest from policy makers and classifications bodies about the most appropriate public policy response. It is therefore timely and important to collate and quantitatively summarise the existing literature relating loot boxes to problem gambling and excessive gaming symptomology. Thus, we present results from two meta-analyses of existing research looking at each of these relationships with a view to compare their effect sizes. Additionally, as the existing research is relatively nascent, Trim and Fill and Rosenthal's *Fail-safe N* analyses were conducted to determine whether publication bias appears to have affected the field, and to provide better point estimates for the effect sizes.

Methods

This meta-analysis presents an exploratory summary of the literature and as such was not pre-registered. As the research field grows in size, pre-registration will increase in importance for further meta-analyses.

Study Retrieval and Selection.

To be included in these meta-analyses, datasets were required to be independent (i.e., no included dataset was a reanalysis or subgroup of another included study). Eligibility criteria for meta-analysis 1 was that problem gambling and loot box spending were measured. Eligibility criteria for meta-analysis 2 was that excessive gaming and loot box spending were measured. Studies did not need to focus exclusively on these topics, but the data for the associations between variables needed to be reported within the publication, or the dataset made available for reanalysis. Measures deemed eligible to be included in this study needed to have a valid index of problem gambling (e.g., Problem Gambling Severity Index; PGSI) OR excessive gaming (e.g., Internet Gaming Disorder [IGD] symptomology scale) and loot box engagement. Thus the PGSI, Risky Loot Box Index (RLI), and IGD were common tools utilised in research studies that were incorporated in these meta-analyses.

We searched PsychINFO and Medline (Ovid) for combinations of phrases associated with loot boxes, gambling, and excessive gaming. We employed the following specific phrases: problem gambling AND loot box OR gambling AND loot box OR gambler AND loot box OR Excessive Gaming AND loot box OR Problem Gaming AND loot box OR Gaming Disorder AND loot box OR video game AND loot box or spend* AND loot box OR loot box OR microtransactions. The search included articles published up until 28/02/2020. Studies from all regions were eligible.

Twenty articles were identified through database searches, these were supplemented with 6 additional studies taken from the reference list of searched articles and from examining the research pages of the authors who were found to have published in this area based on the PsychINFO search (with one of these supplemental sources being an unpublished thesis supervised by the second author). Of the 26 identified articles, one was removed due to having no relevance to loot boxes. Thus 25 full text articles were accessed. Thirteen were excluded for either not reporting data, or in one case because the data was a reanalysis of another study.

The risks of bias within studies appeared relatively low. We identified that 5/15 (33%) of the included studies in meta-analysis of problem gambling were preregistered and 3/7 (42%) of studies included in the meta-analysis of excessive gaming were preregistered. However, all studies were cross-sectional correlational studies implying that one source of potential bias was the potential for spurious correlations. All of the studies were conducted in Western Educated Industrialized Rich and Democratic (WEIRD) samples (Henrich et al., 2010), limiting our ability to generalise to non-WEIRD populations. We also note that many of the included studies were conducted through Prolific Academic or Mechanical Turk. Research shows that Mechanical Turk samples are generally similar to more traditional samples in terms of their demographic and political makeup (Levay et al., 2016) and they make analogous decisions to traditional samples (Goodman et al., 2013). However, both data sources are potentially subject to self-selection biases in a similar manner to other advertised samples. Nonetheless, that the majority of studies did not focus upon undergraduate university samples as is common in psychology literature is a particular strength of this research area.

Regarding loot box spending and problem gambling, our search resulted in the inclusion of 15 studies across 12 articles. Regarding loot box spending and excessive gaming, our search resulted in the inclusion of 7 studies across 5 articles (all 5 articles were also included in the problem gambling meta-analysis due to these papers including these variables in separate analyses). See Figure 1. Participant numbers, and effect sizes for relationships between problem gambling/excessive gaming and loot box spending were extracted by the first author (SG) and converted to effect sizes in r. The second and fourth authors (AD and LCH) verified these effect sizes.

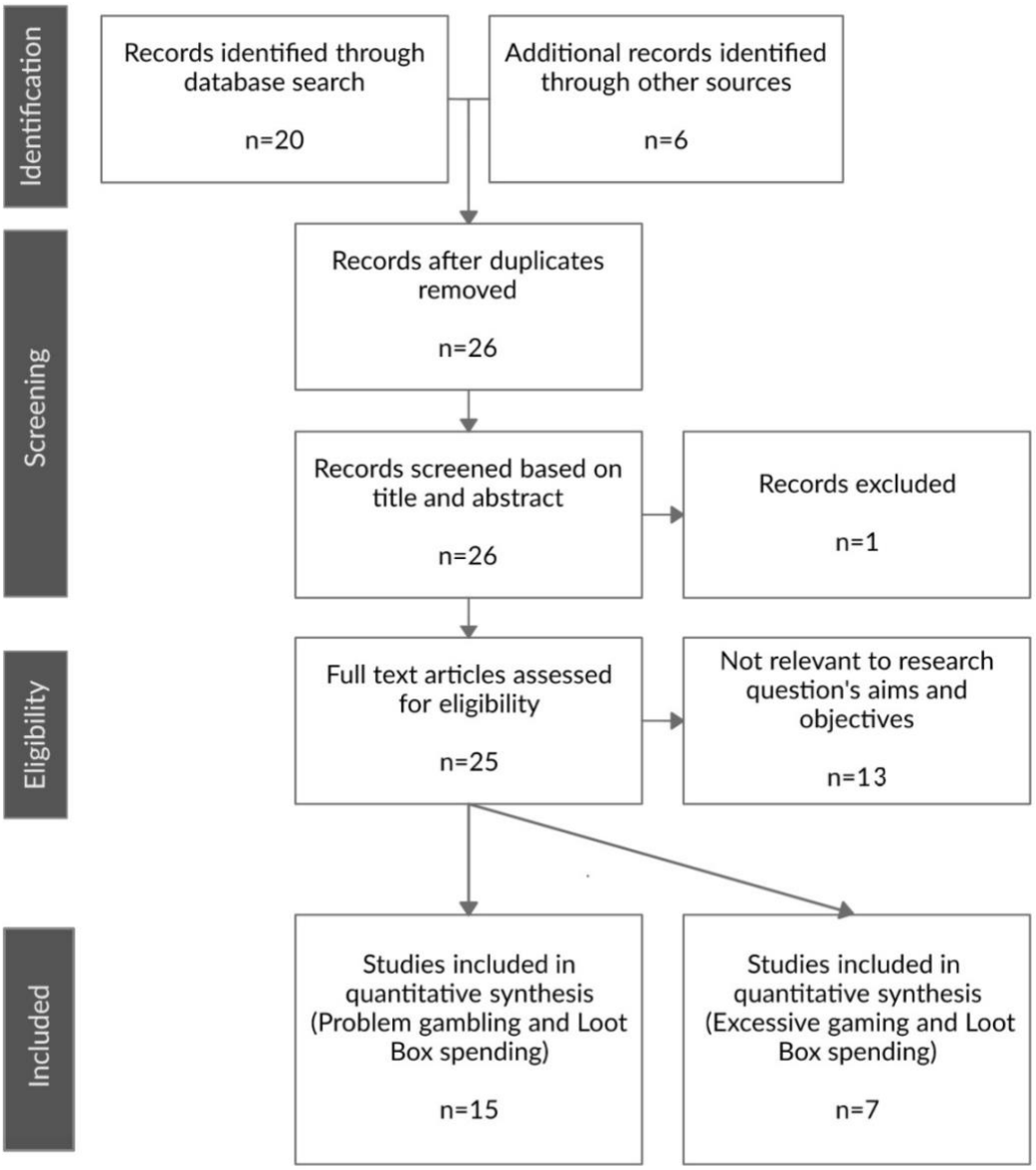

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart detailing article and study identification and inclusion/exclusion for both analyses. One article was excluded at screening for not mentioning video games or loot boxes. Twelve articles were excluded at the eligibility stage for not reporting correlations between loot box spending and excessive gaming/problem gambling. One article was excluded due to not reporting data which could be converted into an effect size in r. This left 12 articles (containing 15 studies due to several articles reporting more than one study) for meta-analysis 1, and 5 articles (containing 7 studies) for meta-analysis 2.

The total number of participants across all studies for the association between problem gambling and loot box spending was 16,229. The total number of participants across all studies for the association between excessive gaming and loot box spending was much smaller, totalling 3,436. Variable measurement of loot box spending (which varied across studies between continuous, categorical, and dichotomous) was also identified. Full lists of studies used in each analysis are detailed in Tables 1 and 2 below. For more details about the specific items analysed see supplementary tables 1 and 2 available in the supplementary materials available online.

Table 1.
Alphabetical list of articles used in Meta-analysis 1 (Problem gambling and loot box spending) with participant numbers and type of variable-measurement used for determining loot box use.

Authors	*n*	Studies Added to Meta-Analysis 1	Year Published	Loot Box Use Measurement
Brooks and Clark (Brooks & Clark, 2019)	257	2	2019	Continuous
Drummond et al. (Drummond, Sauer, Ferguson, et al., 2020)	1049	1	2020	Continuous
Kristiansen and Severin (Kristiansen & Severin, 2020)	1137	2	2020	Categorical
Li, Mills, and Nower (Li et al., 2019)	618	1	2019	Dichotomous
Macey and Hamari (Macey & Hamari, 2018)	582	1	2019	Categorical
Wilkins et al. (Wilkins, Unpublished Thesis)	431	2	2020	Continuous
Zendle (Zendle, 2019)	125	1	2019	Continuous
Zendle and Cairns (Zendle & Cairns, 2018)	7422	1	2018	Categorical
Zendle and Cairns (Zendle & Cairns, 2019)	1172	1	2019	Continuous
Zendle et al. (Zendle, Cairns, et al., 2020)	1200	1	2020	Continuous
Zendle, Meyer, and Over (Zendle et al., 2019)	1155	1	2019	Continuous
Zendle (Zendle, 2020)	1081	1	2020	Categorical
Total	16229	15		

Table 2.
Alphabetical list of articles used in Meta-analysis 2 (Excessive gaming and loot box spending) with participant numbers and type of variable-measurement used for determining loot box use.

Authors	*n*	Studies Added to Meta-Analysis 2	Year Published	Loot Box Use Measurement
Brooks and Clark (Brooks & Clark, 2019)	257	2	2019	Continuous
Drummond et al. (Drummond, Sauer, Ferguson, et al., 2020)	1049	1	2020	Continuous
Li, Mills, and Nower (Li et al., 2019)	618	1	2019	Dichotomous
Wilkins et al. (Wilkins, Unpublished Thesis)	431	2	2020	Continuous
Zendle (Zendle, 2020)	1081	1	2020	Categorical
Total	3436	7		

Statistical Analysis

Meta-Analyses were conducted on both sets of study results. Additional Trim and Fill analyses were conducted also alongside publication bias measures (*Fail-Safe N)*. JASP 0.11.1.0. was used to conduct these analyses. Effect size estimates from each study, if not presented as a Pearsons *r* or Spearmans rho, were converted to an effect size in Pearsons *r* through the formulas found in Cohen (Cohen, 1988) converting between eta-squared, *f*, and *d*, and Rosenthal (Rosenthal, 1994) regarding converting between *d* and *r*. Additionally, restricting analyses to peer-reviewed publications (i.e., excluding the unpublished Masters thesis) did not materially alter the results of the analyses.

As a distribution of effects sizes across the published studies was expected, the analyses aimed to find their average so a random-effects model was used (Borenstein et al., 2010; Higgins et al., 2019). The presence of heterogeneity made it suitable also for the use of the random-effects model (Hedges & Vevea, 1998). However, additional meta-analyses were conducted removing studies not using continuous measurement of loot box use (as an attempt to eliminate/identify the source of the heterogeneity detected). Excluding these studies did not materially alter the results of the main reanalyses but for meta-reanalysis 1; no studies were imputed in the Trim and Fill.

Results

Note: All data are open and available for reanalysis and further analysis here: https://osf.io/h9k4m/?view_only=50c90c523c0b45188a510dd41c0aad24

Analyses

Meta-Analysis 1: Loot Box Spending and Problem Gambling

A meta-analysis produced an average correlation coefficient of $r = 0.26$, 95% CI [0.15, 0.38], z = 4.66, $p < .001$. The analysis yielded an I^2 of 98.25 [96.60, 99.32] indicating very strong heterogeneity in the data. This heterogeneity may have been partially due to the relatively small number of studies in the analysis. To counteract the effect of this heterogeneity we employed a Random Effects, rather than Fixed Effects Model which does not assume an identical effect/relationship across the data and distribution, and performs better at identifying the average effect size when heterogeneity is high (Hedges & Vevea, 1998; Higgins et al., 2019; von Hippel, 2015). We also report bias-corrected, Trim and Fill Models and *Fail-Safe N* to assess the robustness of the estimates. See the Forest plot below for results (Figure 2).

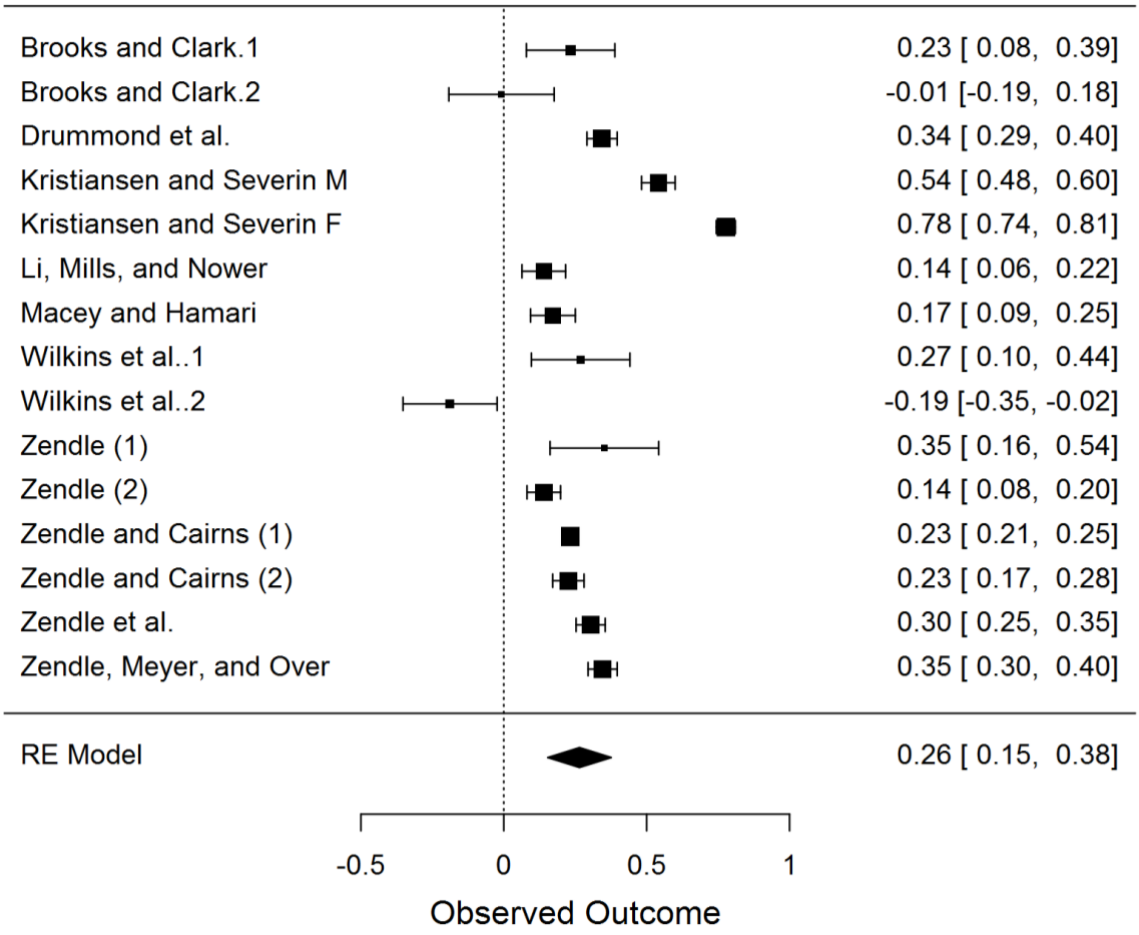

Figure 2. Forest plot of the correlation coefficients (*r*) associating loot box use with problem gambling. Bars reflect 95% confidence intervals. For multiple studies within one paper entries are given an unbracketed number, e.g., 1, 2. For studies where data was split by gender (and data was unavailable to calculate separately) studies identify male as M and female as F. For multiple papers published by the same author/authors bracketed numbers have been added eg: (1), (2). RE=Random-effects model. Observed outcome = Average effect size/correlation.

Additionally, a funnel plot of the results highlights some slight asymmetry, which could imply a potentially biased estimate. Moreover, while a general effect size is identified, the spread of results - especially the high number of studies falling outside of the funnel- may further indicate the heterogeneity of the effect size estimate. One possibility is that unidentified differences between studies may be resulting in a bimodal distribution of effect sizes (see Figure 3). We discuss this possibility further in the additional analyses section below.

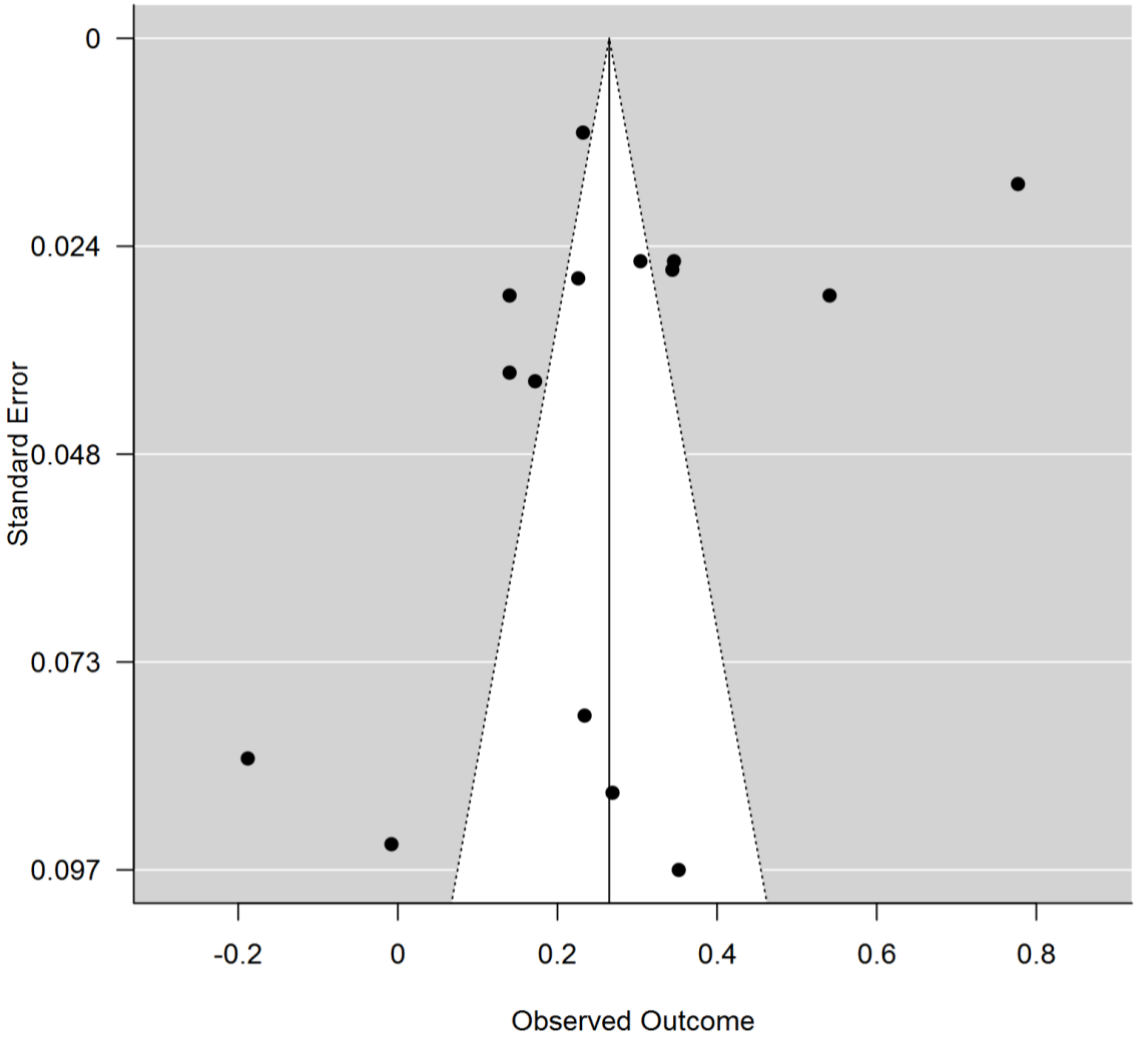

Figure 3. Funnel plot of the association between loot box use and problem gambling showing a bimodal distribution with minor asymmetry downward-biasing the effect size slightly toward zero. Observed outcome = Average effect size/correlation.

Robustness Checks

Due to potential biases in publication, differences between the way that different studies measure the constructs of interest, or bimodal distributions caused by unidentified third variables, meta-analysis effect sizes may sometimes present biased estimates of the true effect sizes (Shi & Lin, 2019). Trim and Fill analyses were therefore attempted to identify and adjust potential biases (such as omission) in meta-analysis results by removing outliers and/or imputing newly generated entries in order to normalise or re-centre a distribution of effect sizes (Higgins et al., 2019). Due to the slight asymmetry in the data which appeared to slightly overrepresent smaller effect estimates compared to larger effect size estimates, a Trim and Fill analysis on the gambling/loot box data yielded a

slightly increased effect size, *r* = 0.37 [0.25, 0.48]. The analysis imputed 5 additional studies in the original meta-analysis results thereby correcting for potential asymmetry (see Figure 4).

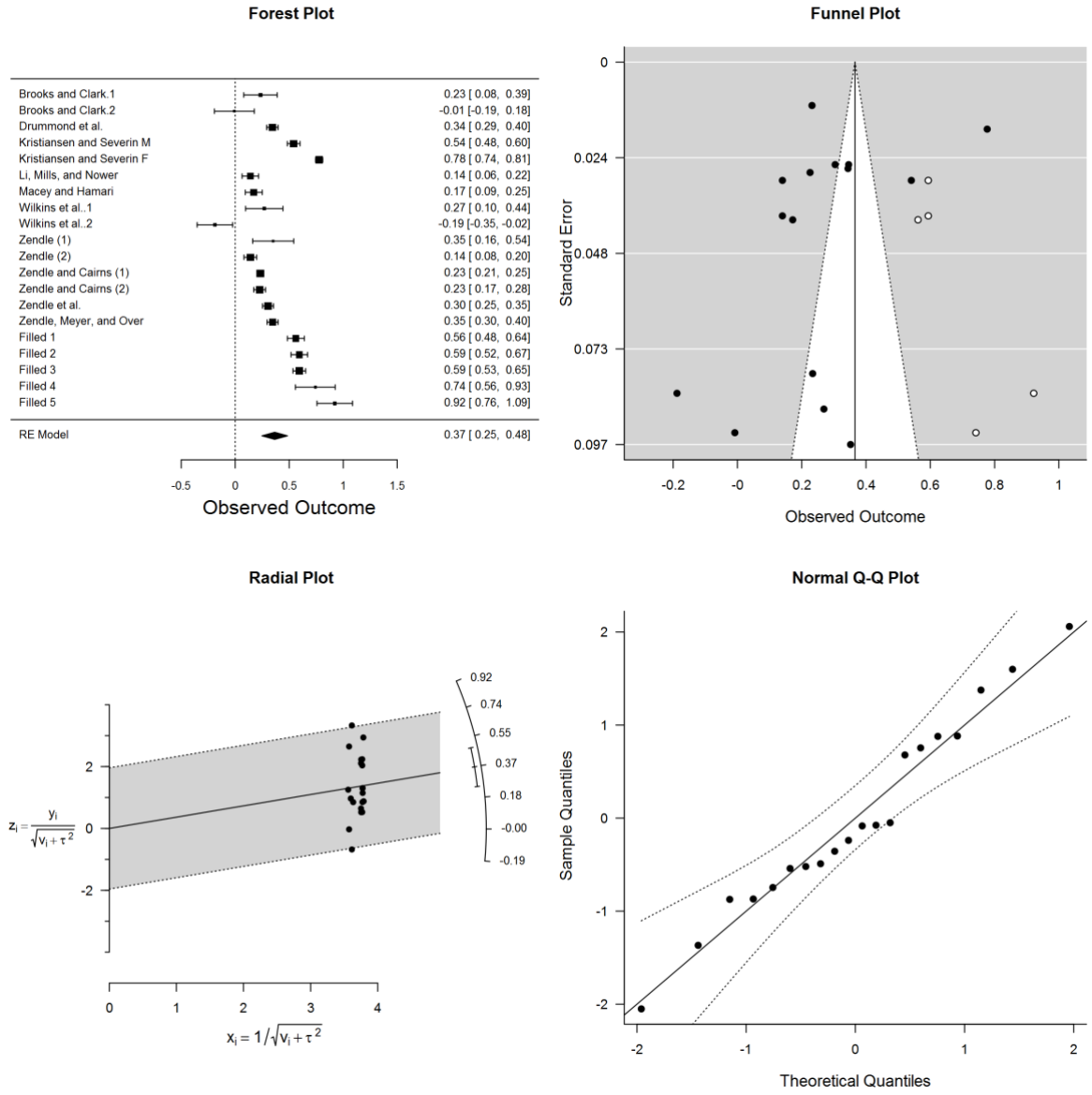

Figure 4. Trim and fill analyses (Forest, Funnel, Radial, and Q-Q) for association between loot box use and problem gambling identifying a larger potential effect. Trim and Fill analyses imputed an additional 5 studies to normalise effect size distributions. The radial plot highlights that most effect sizes are within 2 standard errors of one another.

Additionally, there was strong evidence for the robustness of the observed effect. Calculations showed a Rosenthal's *Fail-safe N* score of 8,360 for analysis 1, indicating a very strong

robustness of the current results to potential publication bias (this *Fail-safe N* suggests that over 8,000 studies with a mean effect size of zero would be needed for the current meta-analysis effect size to become non-significant).

Meta-Analysis 2: Loot Box Spending and Excessive Gaming

A meta-analysis produced an average correlation coefficient of $r = 0.25$, 95% CI = (0.15, 0.36), z = 4.822, $p < .001$. The analysis yielded an I^2 of 88.71 [67.65, 97.91], again indicating strong heterogeneity in the data possibly linked to the relatively small number of studies in the analysis. Again, we used a Random Effects Model to counter this heterogeneity (Higgins et al., 2019; von Hippel, 2015). As per analysis 1, we also report bias-corrected Trim and Fill Models and the *Fail-safe N* to assess the robustness of our estimates. For Forest and Funnel plots of results, see Figures 5 and 6 below.

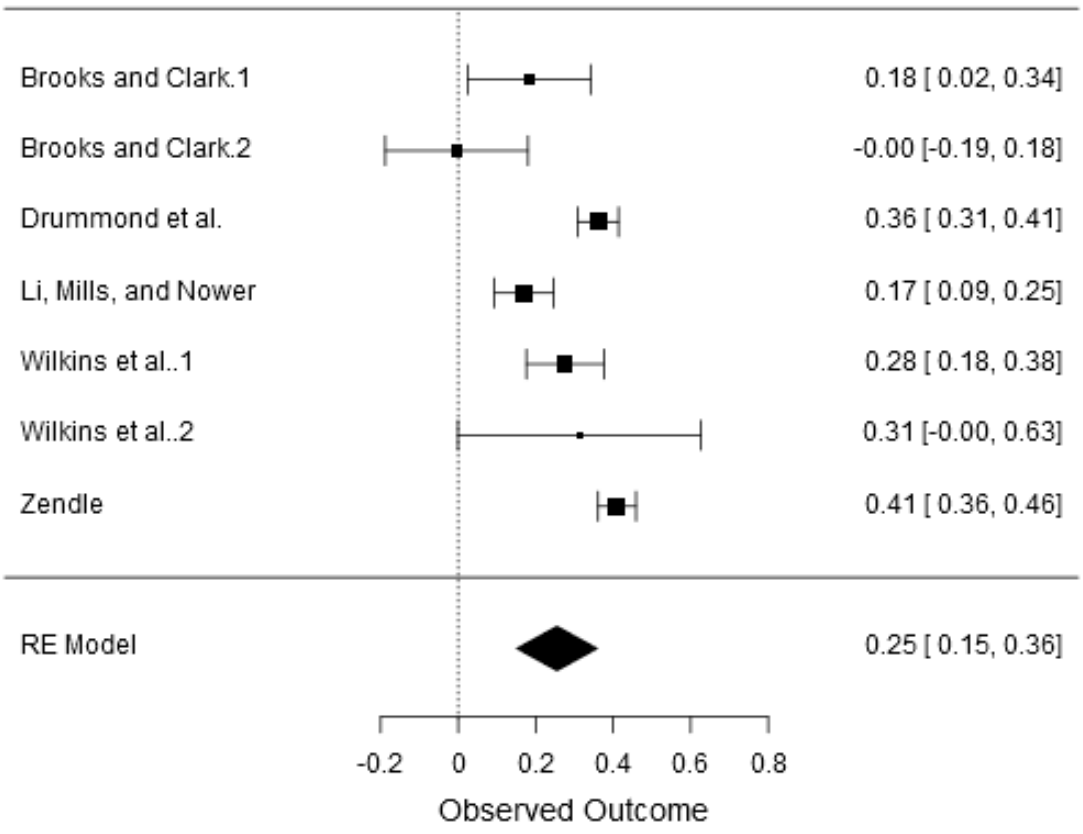

Figure 5. Standardised regression coefficients associating loot box use with excessive gaming. Bars reflect 95% confidence intervals. For multiple studies within one paper entries are given an unbracketed number, e.g., 1, 2. RE=Random-effects model. Observed outcome = Average effect size/correlation.

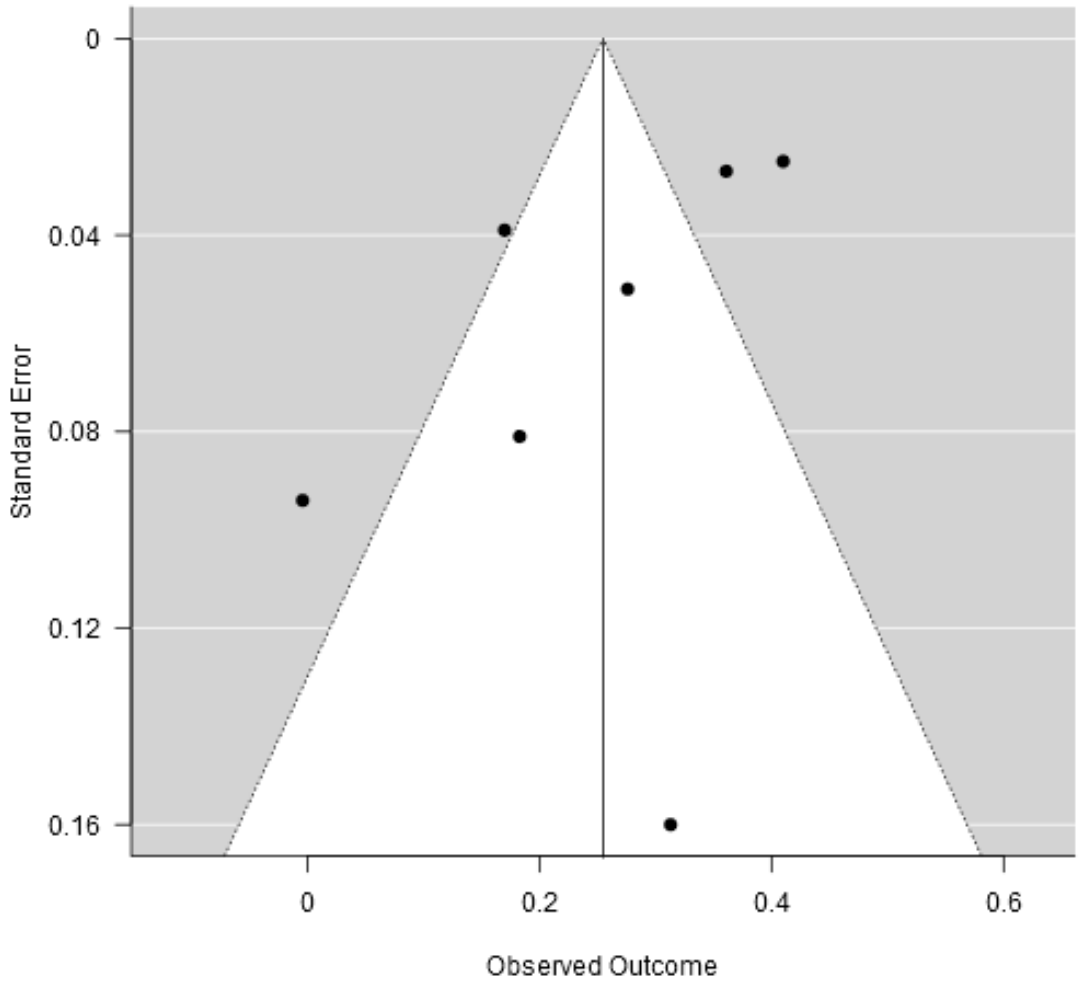

Figure 6. Funnel Plot of the association between loot box use and excessive gaming showing a relatively symmetrical distribution (less potential bias detected) compared to that seen in the problem gambling estimates (as in Figure 3). Observed outcome = Average effect size/correlation.

Robustness Checks

A Trim and Fill analysis imputed no additional studies and therefore produced no change in the estimated average effect size (results duplicated those of the meta-analysis; r = 0.25, [0.15, 0.36]). Calculations showed a Rosenthal's *Fail-safe N* score of 700 indicating strong robustness for the current results to potential publication bias.

Additional analyses

Raw effect sizes across both meta-analyses were relatively stable when removing studies that measured loot box spending as dichotomous or categorical variables (Loot box spending and problem gambling; r = 0.22 [0.10, 0.33], *p* = <.001; Loot box spending and excessive gaming r = 0.27 [0.15, 0.39], *p* = <.001). However, for the problem gambling analysis the Trim and Fill now imputed no additional data points and as such no longer increased the predicted effect size.

Additionally, potential moderator effects were perfectly confounded with timeframe measurement differences across studies (i.e., no study which examined loot box spending over a period longer than monthly used a continuous measure of spending, see Table 1). Thus, although a moderator analysis incorporating timeframe differences showed longer timeframes were associated with slightly larger effects (*r* = 0.02, *p* = .029), it is unclear whether it is the variable measurement type of loot box spending or timeframe that is resulting in the inflated effects as seen the Trim and Fill results in Figure 4. However, when eliminating timeframe differences and/or variable measurement differences there was still large heterogeneity in the data. Further examination of the data revealed that two studies which reported a negative association appeared to be part of the cause of the high heterogeneity scores (Brooks & Clark, 2019; Study 2; Wilkins, Unpublished Thesis; Study 2) and removal of these in addition to all non-continuous measures of loot box Spending resulted in heterogeneity declining to moderate levels (I^2 = 58.28), while the effect size increased to *r* = 0.31, *p* < *.001*. Examination of these two studies might provide some clue as to why they appear to report results opposite the predicted direction. Unlike other studies, both studies were run almost exclusively on undergraduate university student samples. Further research should examine whether the effects differ between University and non-University samples.

Discussion

We examined the evidence for relationships between loot box spending and problem gambling and loot box spending and excessive gaming. Problem gambling and excessive gaming were both positively related to loot box spending, with unadjusted effect sizes of .26 and .25 for problem gambling and excessive gaming, respectively. As correlation effect sizes of .20 or more have been proposed to be clinically or practically relevant (Ferguson, 2009), our unadjusted effects are likely to bear practical import. These findings also add to the literature by identifying that the relationships are most likely to be small-to-moderate in size (narrowing ranges found in previous research which have included effect sizes varying from small to very large). Accordingly, the

evidence suggests that players with problem gambling or excessive gameplay symptoms appear to spend more on loot boxes compared to peers without such symptoms.

Furthermore, the relationship between loot box spending and problem gambling symptomology strengthened when using a Trim and Fill approach, potentially suggesting some publication bias in the literature. However, the *Fail-Safe N*'s for both meta-analyses suggest our estimates are robust. Our analyses did not suggest that publication bias may be artificially inflating our effect sizes. Although one Trim and Fill analyses suggested the opposite – that some publication bias was slightly suppressing the problem gambling effect size – it appears that this may have reflected differences in the way that loot box spending was measured. When studies were restricted to continuous measures, the Trim and Fill no-longer suggested a larger relationship. Future work would benefit from the standardized use of continuous measures of loot box spending to avoid inflating effect sizes. We acknowledge that *Fail-Safe N's* are not the only bias detection technique. Thus, our data are openly available for validation and analysis using alternate publication bias detection techniques (Ferguson & Heene, 2012).

Obviously, we cannot determine the causal direction of the observed relationships. Loot box spending may produce problem gambling symptomology or excessive gaming time through a pattern of learned behaviour. Equally people with existing problem gambling symptoms or excessive gaming time may purchase loot boxes disproportionately compared to peers without such symptoms, or third variables such as personality traits and genetic factors may produce both problem gambling and loot box spending. The explanation that people with existing problem gambling/excessive gaming symptomology might purchase loot boxes disproportionately seems more plausible as it does not require engagement with loot boxes to produce psychopathology. Nonetheless, further research should attempt to disentangle these explanations. However, any of these explanations is concerning. If loot boxes are disproportionately bought by those with problem gambling symptoms or who play excessively, this would require careful consideration of the implementation of appropriate harm minimisation techniques (e.g., limit setting) to mitigate the potential for harm to these vulnerable users (Drummond et al., 2019). Alternatively, if loot box engagement leads to the development of problem gambling or excessive gaming this would be even more concerning, implying that loot box engagement can drive psychopathology with the potential to increase the prevalence of these disorders and increase the burden on mental health systems. Although understanding whether loot box engagement is producing problem gambling/excessive gaming or whether loot boxes are instead exploiting vulnerable populations is an important research objective (Drummond et al., 2019; King & Delfabbro, 2018), the data presented here cannot determine which explanation is correct. Further, understanding the causal mechanisms at play will

allow a greater understanding of the potential risks associated with loot box engagement, and a more nuanced understanding of which public policy responses are more likely to effectively reduce harm. Nonetheless, our results provide policymakers with evidence of a robust association between behavioural addictions and loot box spending, suggesting, at a minimum, that vulnerable population/s may be at risk of overspending on these processes. Furthermore, from a clinical perspective this implies a need for clinicians to understand loot boxes and their potential to act as a pathway for overspending for clients with problem gambling symptomology. Future research looking at disposable income and buyer regret may also assist in determining when overspending becomes harmful in relation to loot box spending.

We did observe significant heterogeneity in effect size estimates, with what appears to be a clustering of results showing substantially higher than the average effect size, and another clustering of results revealing lower than the average effect size. There are many potential reasons for this. Though loot box research has focused primarily upon English-speaking Industrialised Nations, the sampled populations have varied, with samples drawn from the UK, US, Australia and New Zealand. Cultural differences may therefore account for some of the variability in effect sizes. There may also be differences in the estimates due to differences between studies in how problem gambling, excessive gaming and loot box spending is measured.

As unidentified moderating factors may also result in estimates differing between studies, additional analyses removed non-continuous measurement of loot box use and accounted for differential timeframe measurements. Those raw results were relatively similar to the main results and heterogeneity remained high. Heterogeneity may be due in part to two studies (Brooks & Clark, 2019; Study 2; Wilkins, Unpublished Thesis; Study 2) which employed University samples and feature negative correlations. Investigating whether these effects differ in University and non-University populations, or as a function of education, is a potentially fruitful avenue for further research. However, it is important to note that exaggerated heterogeneity errors (I^2) have been identified previously in small meta-analyses (von Hippel, 2015). The inclusion of more studies in future meta-analyses may reduce bias in the correlation coefficient and imprecision of the I^2 statistic.

Additionally, when there is only a small number of studies available, particularly in the analysis of excessive gaming scores here, care should be taken when interpreting meta-analytic results (Hedges & Vevea, 1998). The scarcity of IGD studies in relation to loot box spending may render the effect size estimate presented here unreliable. Although the meta-analyses in the present study used a random-effects model, it is important to reduce between-study variance/increase precision in future meta-analyses by adding more studies to future analyses as the body of research

grows (Borenstein et al., 2010). However, the narrow confidence intervals observed suggest our sample of studies and participants were sufficient to estimate mean effect sizes with moderate precision. Moreover, the analyses for problem gambling scores are more robust as they include more studies, and many more participants than the analyses of excessive gaming. Accordingly, the results suggest that, compared to excessive gaming, the relationship between loot box spending and problem gambling appears to be at least as strong, if not stronger.

Despite assertions from industry representatives that loot boxes are simply surprise mechanics (Hopkins, 2019), these mechanics share psychological mechanisms with conventional forms of gambling (Derevensky & Griffiths, 2019; Drummond & Sauer, 2018; Griffiths, 2018). Further, identification of the value attributed to virtual items has also been made highlighting the propinquity between loot boxes and the legal definitions of gambling practices (Drummond, Sauer, Hall, et al., 2020). However, disorders such as problem gambling share common features with excessive gaming especially concerning behavioural addictions, feelings of 'loss of control', and withdrawal symptoms which can combine to result in significant impairment of physical, social, and financial functioning (Bargeron & Hormes, 2017). This is also seen in classification overlaps between pathological gambling and pathological gaming (Lemmens et al., 2015). Although the present analyses examine these relationships separately, there is clearly potential for combined or additive risk that has not been identified. Therefore, future research should consider whether these relationships independently contribute to loot box spending or whether there is some shared variance between the two. Overlapping features may also result in interaction effects between problem gambling and excessive gaming behaviours going un-noticed.

Accordingly, recent work showed that when problem gambling was included as an additional factor in an analysis looking at excessive gaming and loot box spending, the subsequent effect of excessive gaming was reduced relative to problem gambling (Drummond, Sauer, Ferguson, et al., 2020). Moreover, high problem gambling and excessive gaming symptoms might interact to be collectively associated with higher spending than peers with lower symptoms of both these constructs. To date, few studies have examined the relationship between excessive gaming and loot box spending at all, let alone the interaction/s between problem gambling and excessive gaming with loot box spending. Thus, more research, both in separating the concepts and definitions, and in investigating possible moderation effects, is required.

Given the associations of a clinically relevant magnitude observed in both analyses, research looking into the potential impact loot box spending has on vulnerable populations such as children and adolescents seems prudent. Few studies have examined adolescent or child engagement with

loot boxes, and the few studies specifically investigating this issue showed larger effects for adolescents than adults (Zendle et al., 2019). Additionally, experimental and longitudinal research attempting to determine the causal direction of these relationships would be beneficial, especially regarding continuing legislative and societal discussions around the access/availability of these mechanisms.

We present evidence of a robust link between problem gambling and loot box spending. This relationship appears to be as strong as, or stronger than, the association between excessive gaming and loot box spending. Future work needs to focus on experimental and longitudinal studies to elucidate the causal direction of these relationships. Further, identifying what effects loot box mechanisms present to potentially vulnerable populations will hopefully assist to produce a more accurate and nuanced picture of loot box effects across varying populations and thus allow for more educated discussions around their use/access. Irrespective of causal direction, our findings suggest that both problem gambling and excessive gaming symptoms are risk factors for increased loot box spending and are robust associations with increased loot box spending.

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