Infinite Loot Box: A Platform for Simulating Video Game Loot Boxes

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***Abstract*—Loot boxes are garnering increased attention in both the industry and media. One focal point of the discussion is whether loot boxes should be considered a form of gambling [1]. While parallels can be drawn between loot boxes and random reward schedules, researchers have argued that the "glorification" aspect of loot boxes that have heightened player awareness (e.g., opening a box, a pack of cards, or spinning a wheel) of randomness is a relatively new trend in games [2]. However, there is currently a dearth of empirical research on loot boxes. We make two contributions in this paper: 1) *Infinite Loot Box*, an open-source Unity platform for experimenting with loot boxes created from scratch, and 2) a 2x2 experiment (high/low visual effects x high/low audial effects; N=1235). We find that high audial effects significantly increase the number of loot boxes opened. Neither audial nor visual effects were found to significantly impact other variables. These contributions push forward our understanding of loot boxes and their contextual factors.**

***Index Terms*—Loot box, loot box graphics, loot box embellishment, loot box juiciness, loot box visuals, loot box audio**

I. Introduction

LOOT boxes are receiving widespread interest in the games industry, in regulatory bodies, and in academic discourse. One implicit assumption underlying most discussions is that loot boxes are entirely novel. However, loot boxes can be classified under an overarching umbrella, which some researchers have termed "Random Reward Mechanisms" (RRMs) [2]. RRMs have existed long before video games have appeared—e.g., chance cards in *Monopoly*, or the randomness in opening baseball cards and *Magic: The Gathering* cards. Nevertheless, researchers argue that the "glorification" of these RRMs that have resulted in heightened player awareness of randomness is novel [2]. Moreover, researchers have long drawn comparisons between game design and slot machine design [3], [4]. For example, many of the loot boxes present in games such as *Hearthstone*, *Overwatch*, and *League of Legends* feature elaborate visual and audio effects (sometimes referred to as "juiciness" [5], [6]), similar to the audio-visual inundation featured in modern slot machine play. However, very few researchers have studied loot boxes, as they are a relatively new incarnation of RRMs. To fill this gap, we developed an open-source platform.

We present two core contributions: 1) *Infinite Loot Box*, an open-source Unity platform for experimenting with loot boxes, and 2) a 2x2 experiment (high/low visual effects x high/low audial effects; N=1235). Our experiment had three research questions:

RQ1: Do visual/audial effects translate into motivated behavior (i.e., do people exposed to higher levels of visual/audial effects open more loot boxes)?
RQ2: Do visual/audial effects positively impact player experience?
RQ3: Do visual/audial effects positively impact intrinsic motivation?

We created a platform, *Infinite Loot Box*, for experimenting with loot boxes. We then ran an experiment using *Infinite Loot Box*, varying the degree of visual and audial effects. Overall, we found that increased audial effects significantly increased the number of loot boxes opened. Neither audial nor visual effects were found to significantly impact other variables.

II. Related Work

A. Loot Boxes

A loot box is a digital container for a reward. These rewards are random in nature. Rewards can be purely cosmetic, but can also serve a functional purpose (e.g., affect the player's in-game performance). "Loot box" is a catch-all phrase for a variety of RRMs, such as crates, cases, and chests [7]. Loot boxes can be purchased using real-world currency, purchased using virtual in-game currency, offered as free rewards, or offered in some combination thereof. The following are some important characteristics encompassing loot boxes:

1) Rarity: Virtual rewards from loot boxes have an associated rarity. This rarity is understood to be a central aspect of virtual items [8].

2) Microtransactions: Loot boxes are a subset of microtransactions. Microtransactions are a business model in which players make purchases for virtual goods [9]. These goods can include extra game content (referred to as downloadable content, or "DLC"), virtual currency, and in-game items. Microtransactions are increasingly a crucial source of income for game companies. For example, microtransaction sales exceeded 50% of all annual income for *Activision Blizzard* in 2017 ($4 billion) [10].

3) Random Reward Mechanisms: Nielsen and Grabarczyk categorize loot boxes in the wider phenomenon known as RRMs [2]. The researchers note that loot boxes are a modernization of RRMs that have always existed. For example,

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defeating a monster in *Diablo* generates random loot. However, they argue that the *aesthetic form* of RRMs has evolved. For example, many modern RRMs include spinning wheels and excessive audio-visual effects. The sheer act of triggering a random procedure has been transformed into entertainment [2].

4) Exchangeability for Real-World Currency: In some instances, loot boxes are both purchased using real-world currency, and the subsequent rewards can be exchanged for real-world currency (i.e., 'cashed out'). This can be done either through the distribution platform of the game, or via a third-party website. This characteristic is viewed as important in determining whether a specific implementation of loot boxes can be deemed gambling [1], [2].

B. Gambling and Loot Boxes

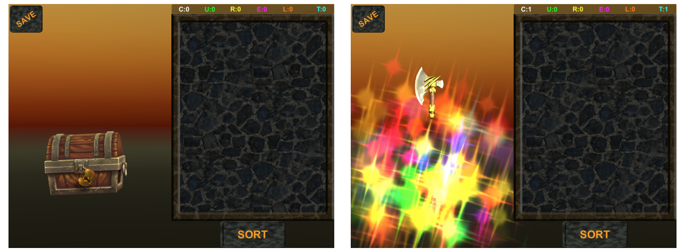
Researchers have argued that loot boxes can be considered gambling, e.g., [1], [11]. These researchers argue that there are sufficient similarities between loot boxes and gambling. For example, the random reward mechanisms from loot boxes are known as variable ratio reinforcement schedules, which are known to produce highly persistent behaviors [12]. Moreover, a recent study determined that a relationship exists between loot box spending and problem gambling [13], adding further support. However, there is currently no definitive consensus between the industry, regulators and researchers. For instance, the Entertainment Software Rating Board (ESRB) has argued [14]:

> ESRB does not consider [the buying of loot boxes] to be gambling because the player uses real money to pay for and obtain in-game content. The player is always guaranteed to receive something—even if the player doesn't want what is received. Think of it like opening a pack of collectible cards: sometimes you'll get a brand new, rare card, but other times you'll get a pack full of cards you already have.

Researchers, however, argue that if virtual items can be bought and sold using real currency, then loot boxes should be considered gambling [2], [11].

1) Consumer Backlash: The discourse on loot boxes arose in large part as a result of the loot box implementation in *Star Wars Battlefront 2*. Players felt that the developer, Electronic Arts, was charging excessively for virtual goods, such as the powerful in-game character Darth Vader [15]. This led some to complain that the game was "pay-to-win." The backlash prompted the removal of microtransactions from the game pre-launch. As a result of the fallout, Electronic Arts lost $3 billion in stock value [16]. The ensuing scrutiny by the media and gambling regulators is largely attributed to this single event [7].

2) Regulation: In some European countries, loot boxes have been ruled as gambling [7]. Certain types of loot boxes (called "complete gacha") have been banned in Japan [17]. Increasingly, it is becoming common for drop rates of loot boxes to be public knowledge.



(a) Starting screen. (b) Opening the first loot box.

Fig. 1: Screenshots from *Infinite Loot Box*.

3) Lack of Empirical Evidence: While there is increasing discourse on loot boxes, there is a lack of empirical evidence regarding contextual factors. We therefore: 1) create an open-source platform for experimentation with loot boxes, and 2) perform a study on the impacts of visual/audial effects in loot box opening.

III. The Testbed

We created a platform called *Infinite Loot Box* from scratch. See the following URL for a demonstration of the parameters: https://www.youtube.com/watch?v=iJHpb2MkVpk&feature=youtu.be.[1] See Figure 1.

Infinite Loot Box is created in Unity. *Infinite Loot Box* can be deployed on PC, Mac, or WebGL. Within *Infinite Loot Box*, the interface contains an animated 3D chest that opens when clicked. A random 3D item then emerges before being deposited into the inventory on the right-hand side. Counts of items received, broken down by rarity, appear at the top right. Hovering over each item in the inventory shows the name and rarity of the item.

The inventory in *Infinite Loot Box* scales automatically—the size of each item in the inventory shrinks when the screen space demarcating the inventory becomes full. Therefore, the possible number of items in the inventory is effectively infinite (an eventual limit may be reached depending on the CPU's maximum memory).

Infinite Loot Box currently features 102 different items. Each item can appear in five different rarities: 1) Common, 2) Uncommon, 3) Rare, 4) Epic, and 5) Legendary. Therefore, over 500 different possible item/rarity combinations exist. *Infinite Loot Box* was designed, developed, and documented from the start to be an open-source project. *Infinite Loot Box* is highly customizable using a set of parameters within a text file (i.e., does not require a rebuild of the Unity project). The following parameters are customizable from the *Settings.ini* file:

- Item Variety: # of Items Available (104)
- Rarity Drop Chances: Rarity Odds (70,21,5,3,1)
- Chest Opening Duration: Animation Duration (1s)
- Chest Opening Embellishment: # of Particles (160)
- Item Embellishment: Item # of Particles (0)
- Chest Spawn Delay: Seconds Before New Loot Box (2s)
- Chest Opening Audio Speed: Loot Box Audio Speed (1)

[1]Open-source repository: https://github.com/kalikao/InfiniteLootBox.

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- Audio Reverb Decay: Loot Box Reverb Decay (20s)
- Audio Reverb Volume: Loot Box Reverb Volume (90)
- Audio Flange Mix: Loot Box Audio Flange Mix (0)
- Rigged Item Opens: Guaranteed Rarity for Item #

Defaults are listed in parentheses. See Figures 2 and 3 for examples of "Chest Opening Embellishment" and "Item Embellishment." Audio sounds in *Infinite Loot Box* include: 1) Chest Opening, 2) Item Placed in Inventory, and 3) Music. *Infinite Loot Box* captures the following data:

- # of Loot Boxes Clicked
- # of Seconds Since Load
- # of Items Hovered Over
- # of Times Sort Button Clicked

These can be sent to a remote server (e.g., database), or copy/pasted as a tab-delimited string (e.g., to a survey).

IV. Methods

A. Creating Different Versions

We wanted to create four versions of *Infinite Loot Box* to be used in our experiment. The following lists each version and any deviations from the default values.

1) Low visual and low audial effects
   - Chest Opening Embellishment: 0
   - Audio Reverb Decay: 10
   - Audio Reverb Volume: 80
2) High visual and low audial effects
   - Chest Opening Embellishment: 200
   - Audio Reverb Decay: 10
   - Audio Reverb Volume: 80
3) Low visual and high audial effects
   - Chest Opening Embellishment: 0
   - Audio Reverb Decay: 100
4) High visual and high audial effects
   - Chest Opening Embellishment: 200
   - Audio Reverb Decay: 100

Any variables left unspecified are left at their default values.

B. Ensuring Consistent Frame Rate

To ensure the validity of the experiment, one of our initial goals was to normalize frames per second across our four conditions. A lower frames-per-second count in one or more of our conditions would present a possible experiment confound.

For testing, we used a 2018 PC (Windows 10) and a 2012 Macbook Pro (MacOS High Sierra). The PC had an Intel Core i7-7700k CPU (4.20 GHz), an NVIDIA GeForce GTX 1070, and 16 GB of RAM. The Mac had an Intel Core i5 (2.5 GHz), an Intel HD Graphics 4000 GPU, and 6 GB of RAM. Both systems used Firefox Quantum 63.0 to run the Unity WebGL game and for performance profiling.

We created an automatic-running test in the game, which opened six loot boxes in succession using a macro. Our macro opened the loot boxes as soon as they appeared. We then produced a performance profile for each machine and for each condition. We found that our conditions had consistent frame rates across both machines:

- Low visual / low audial (PC: 58.74 fps, Mac: 57.02 fps)
- High visual / low audial (PC: 58.58 fps, Mac: 56.52 fps)
- Low visual / high audial (PC: 58.95 fps, Mac: 57.56 fps)
- High visual / high audial (PC: 58.79 fps, Mac: 56.69 fps)

These average frame rates are $\sim$1 fps apart and are sufficiently identical for the purposes of this experiment.

C. Validating Fit

Before conducting the study, we wanted to ensure that the visual/audio effects in each condition "fit" the game as equally as possible. Otherwise, this could represent a potential confound to our experiment.

We recruited 131 participants on Amazon Mechanical Turk (AMT) (United States only). Participants were first asked to do a sound check to ensure their sound was turned on. They listened to a sound file containing English speech and were asked to type the words. Once they typed the dialogue correctly, they were then assigned, at random, to one of the four versions of *Infinite Loot Box*. They were asked to open at least three loot boxes before exiting. After exiting, participants were then asked the following questions on a seven-point Likert scale (1: *Strongly Disagree* to 7: *Strongly Agree*):

- The sounds fit the game.
- The visual effects fit the game.
- Overall, the sounds/visual effects fit the game.

Two participants were removed for not having opened at least three loot boxes. A one-way ANOVA found: 1) No significant effect of condition on fit of sounds, $F(3, 125) = 1.366$, $p>.05$; 2) no significant effect of condition on fit of visual effects, $F(3, 125) = 0.415$, $p>.05$; and 3) no significant effect of condition on fit of sounds/visual effects combined, $F(3, 125) = 0.887$, $p>.05$. These tests confirm that conditions were not perceived as having a significantly different "fit" in terms of visuals/audio in the game.

D. Conditions

The four conditions were:

1) Low visual and low audial effects
2) High visual and low audial effects
3) Low visual and high audial effects
4) High visual and high audial effects

All versions are *exactly identical* except:

- Audio during loot box opening
- Visual effects during loot box opening

E. Quantitative and Qualitative Measures

1) Loot Boxes Opened: We directly measure motivation as operationalized by the number of loot boxes opened.

2) Player Experience of Need Satisfaction: We use the 21-item Player Experience of Need Satisfaction (PENS) scale [18] that measures the following dimensions: Competence, Autonomy, Relatedness, Presence/Immersion, and Intuitive Controls. PENS is based on self-determination theory (SDT) [19]. PENS contends that the psychological "pull" of games is largely due to their ability to engender three needs—*competence* (seek to

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Fig. 2: Different settings of "Chest Opening Embellishment."

Fig. 3: Different settings of "Item Embellishment." (A loot box was opened, and the item has just been placed into the inventory.)

control outcomes and develop mastery [20]), *relatedness* (seek connections with others [21]), and *autonomy* (seek to be causal agents [22] while maintaining congruence with the self) [18]. PENS is considered a robust framework for assessing player experience [6], [23].

3) Intrinsic Motivation Inventory: The Intrinsic Motivation Inventory (IMI) assesses intrinsic motivation using four dimensions: 1) Interest/Enjoyment (e.g., I enjoyed doing this activity very much); 2) Effort/Importance (e.g., I put a lot of effort into this); 3) Pressure/Tension (e.g., I felt very tense while doing this activity); 4) Value/Usefulness (e.g., I believe this activity could be of some value to me) [24].

F. Participants

A total of 1,235 participants participants were recruited through Mechanical Turk. The data set consisted of 599 (48.5%) male and 636 (51.5%) female participants. Participants self-identified their races/ethnicities as white (978) (79.2%), black or African American (102) (8.3%), Chinese (32) (2.6%), Asian Indian (21) (1.7%), American Indian (10) (0.8%), Filipino (14) (1.1%), Korean (13) (1.1%), Vietnamese (7) (0.6%), Japanese (10) (0.8%), and other (48) (3.9%). Participants were between the ages of 18 and 74 (M = 35.8, SD = 11.0), and were all from the United States. Participants were reimbursed $1.00 to participate in this experiment.

G. Design

A 2 x 2 between-subjects factorial design was used. Participants were randomly assigned to one of the four versions of *Infinite Loot Box*.

H. Protocol

Participants were first asked to do a sound check to ensure their sound was turned on. They listened to a sound file containing English speech and were asked to type the words. Once they typed the dialogue correctly, they were able to proceed. Participants were then informed they could exit the game at any time without penalty. Participants then opened the link to the version of *Infinite Loot Box* that corresponded to their randomly assigned condition. When participants quit the game, they returned to the survey to complete the PENS and the IMI. The number of loot boxes opened was tracked automatically. Participants then filled out demographic information.

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I. Analysis

Data were extracted and imported into Statistical Package for Social Science (SPSS) version 23 for data analysis using analysis of variance (ANOVA), and multivariate analysis of variance (MANOVA). A two-way ANOVA was run for *Loot Boxes Opened*, with the independent variables *AudioHigh, VisualHigh*. Two-way MANOVAs were run for each separate set of items—*PENS, IMI*; with the independent variables—*AudioHigh* and *VisualHigh*. The independent variables *AudioHigh* (i.e., 0= low audio, 1= high audio) and *VisualHigh* (i.e., 0= low visual, 1= high visual) are both dichotomous variables. These results are reported as significant when $p<0.05$ (two-tailed). Prior to running our MANOVAs, we checked both assumption of homogeneity of variance and homogeneity of covariance by the test of Levene's Test of Equality of Error Variances and Box's Test of Equality of Covariance Matrices. Both assumptions were met by the data ($p>.05$ for Levene's, and $p>.001$ for Box's).

V. Results

RQ1: Do visual/audial effects translate into motivated behavior (e.g., do people exposed to higher levels of visual/audial effects open more loot boxes)?

A two-way ANOVA was conducted to compare the main effects of AudioHigh and VisualHigh and the interaction effect between AudioHigh and VisualHigh on the number of loot boxes opened. The main effect for AudioHigh yielded an F ratio of $F(1, 1231) = 3.96$, $p<.05$, indicating a significant difference between high audio participants ($M = 24.39$, $SD = 17.22$) and low audio participants ($M = 22.52$, $SD = 15.93$). The main effect for VisualHigh yielded an F ratio of $F(1, 1231) = 0.58$, $p>.05$, indicating that the effect for VisualHigh was not significant, high visual ($M = 23.80$ $SD = 16.97$) and low visual ($M = 23.11$, $SD = 16.23$). The interaction effect was not significant, $F(1, 1231) = 0.00$, $p>.05$. See Figures 4 and 5. The parallel lines in Figure 5 indicate that there is no interaction effect between the independent variables AudioHigh and VisualHigh.

RQ1 Summary: High audial effects significantly increased the number of loot boxes opened as compared to low audial effects.

RQ2: Do visual/audial effects improve player experience?

A two-way MANOVA was conducted to compare the main effects of AudioHigh and VisualHigh and the interaction effect between AudioHigh and VisualHigh on the PENS. The main effect for AudioHigh yielded nonsignificant effects for AudioHigh ($\lambda = 0.998$, $F(5, 1227) = 0.554$, $p>.05$) and VisualHigh ($\lambda = .997$, $F(5, 1227) = 0.820$, $p>.05$). Although there was a significant interaction effect between AudioHigh and VisualHigh ($\lambda = .987$, $F(5, 1227) = 3.143$, $p<.01$), there were no significant univariate effects, $p>.05$. See Figure 6.

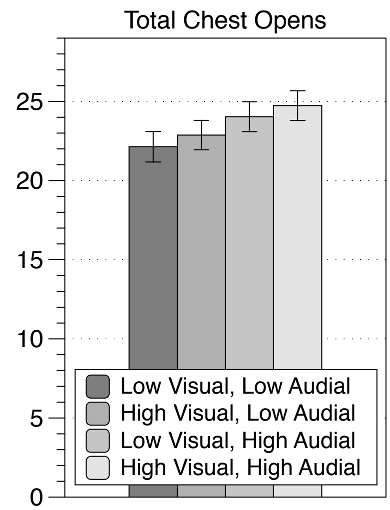

Fig. 4: Number of loot box openings is highest in the High Audial conditions. High Visual conditions also appear to increase loot box openings by a lesser amount. Error bars show standard error of the mean (SEM).

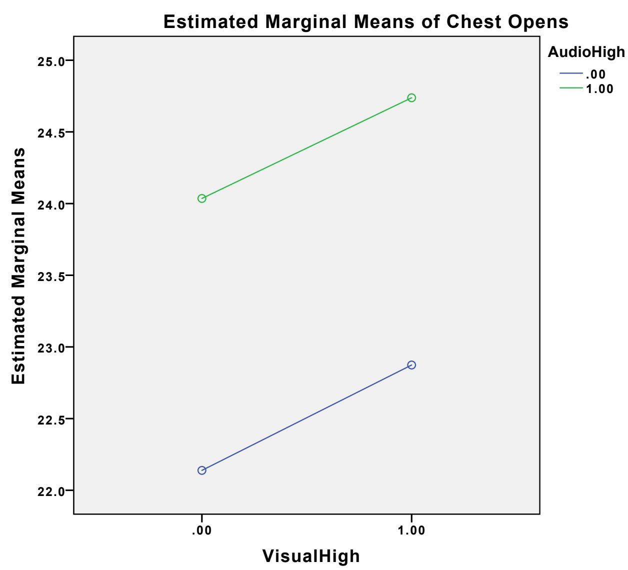

Fig. 5: Number of loot box openings.

RQ2 Summary: Visual and audial effects had no significant impact on player experience.

RQ3: Do visual/audial effects improve intrinsic motivation?

A two-way MANOVA was conducted to compare the main effects of AudioHigh and VisualHigh and the interaction effect between AudioHigh and VisualHigh on the IMI. The main effect for AudioHigh yielded nonsignificant effects for AudioHigh ($\lambda = 0.997$, $F(4, 1228) = 0.970$, $p>.05$), VisualHigh ($\lambda = 0.997$, $F(4, 1228) = 1.059$, $p>.05$), and the interaction between AudioHigh and VisualHigh ($\lambda = 0.998$, $F(4, 1228) = 0.707$, $p>.05$). See Figure 6.

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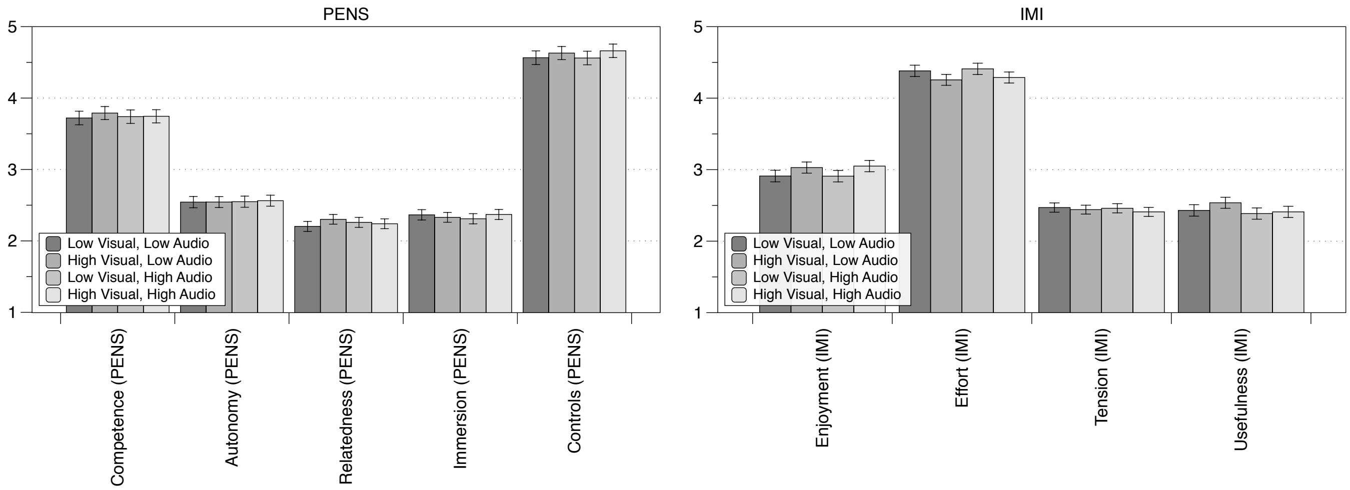

Fig. 6: Means of 7-point Likert scale ratings (+/- SEM) for Player Experience of Need Satisfaction (PENS) and the Intrinsic Motivation Inventory (IMI). Neither need satisfaction nor intrinsic motivation differed significantly between conditions.

RQ3 Summary: Visual and audial effects had no significant impact on intrinsic motivation.

VI. Discussion

In this paper, we: 1) presented *Infinite Loot Box*, an open-source Unity testbed for experimenting with loot boxes, and 2) ran a 2 x 2 experiment (high/low visual effects x high/low audial effects; N=1235). Our results show that audio effects–in particular, reverb effects–can have a significant impact on how many loot boxes participants opened.

Prior studies on audio in games have shown that audio is often linked to increased immersion/presence [25]–[27], influences physiological responses [28], and affects the "aura" of a computer game [29]. For example, Wolfson found that the combination of loud audio and the color red gave players the perception of excitement [29]. Here, the additional reverb effects included in the audio caused players to open significantly more loot boxes.

Interestingly, this impact of the additional audio effects only materialized in actual player behavior and not on the PENS or IMI measures. One possible cause is that the audio effects in some way encouraged players to continue clicking more loot boxes, but that the actual enjoyment, competence, etc. derived from doing so did not see a corresponding increase. More studies are needed to understand the conditions under which this occurs. For instance, it is possible that participants viewed opening loot boxes in this particular scenario as more of a task rather than a game.

Here, we have presented, to the best of our knowledge, the first empirical study on loot box special effects. We also presented an open-source platform for experimentation with loot boxes, *Infinite Loot Box*. Finally, our results suggest that audio can play a significant role when it comes to opening loot boxes. These contributions serve to advance our understanding of the contextual factors surrounding loot boxes, as well as to encourage future work in this domain. Our contributions are of use to designers, developers, practitioners, and researchers.

VII. Limitations

One limitation of our study is that loot boxes have been isolated from a specific game/economy context. For example, participants did not actually pay money for these loot boxes. This was an unavoidable ethical limitation of our study. Moreover, loot box items were not tied to a specific game. For this reason, the items would prove less valuable than if they subsequently appeared in-game. Secondly, our study was of short duration, and the significant audial effect we found might fade in long-term use. Finally, we are not able to fully control the conditions under which participants experience *Infinite Lootbox* (e.g., variations of computer monitors, graphics cards, processors, etc.) which may have affected frame rates.

Infinite Lootbox emulates the random reward mechanisms and the special audio-visual effects that are present in virtually all loot box games. We believe that *Infinite Loot Box* is a useful testbed for experimenting with loot boxes. However, future studies should integrate these loot box items into, for example, a role-playing game to further shed light on this work.

VIII. Conclusion

In this paper, we: 1) presented *Infinite Loot Box*, an open-source Unity testbed for experimenting with loot boxes, and 2) ran a 2 x 2 experiment (high/low visual effects x high/low audial effects; N=1235). We found that high audial effects significantly increased the number of loot boxes opened as compared to low audial effects. Neither audial nor visual effects were found to significantly impact any other variables. Our contribution is both a platform for studying loot boxes and a study demonstrating its feasibility, pushing our understanding of the contextual factors around loot boxes.

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Here, we have presented, to the best of our knowledge, the first open-source loot box platform and the first large-scale empirical study on loot box special effects. *Infinite Loot Box* is covered under the MIT License and is fully ready to use. A variety of parameters can be adjusted to modify loot box opening behavior. Moreover, the code is well documented and easily allows the addition of new items (3D models), new parameters, and new features. Our extensible platform and large-scale study makes a contribution to our understanding of this increasingly common random reward mechanic. Ultimately, our contributions will be valuable to designers, developers, practitioners, and researchers.

IX. Acknowledgments

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