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The Effects of Immersion on Harm-inducing Factors in Virtual Slot Machines

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Figure 1: The core element of the slot machine game is the grid displaying the drawn symbols. Payouts are emphasized with audiovisual effects, here, big win. Particularly large wins trigger a rain of gold coins.

Abstract

Slot machines are one of the most played games by pathological gamblers. New technologies, e.g. immersive Virtual Reality (VR), offer more possibilities to exploit erroneous beliefs in the context of gambling. However, the risk potential of VR-based gambling has not been researched, yet. A higher immersion might increase harmful aspects, thus making VR realizations more dangerous. Measuring harm-inducing factors reveals the risk potential of virtual gambling. In a user study, we analyze a slot machine realized as a desktop 3D and as an immersive VR version. Both versions are compared in respect to effects on dissociation, urge to gamble, dark flow, and illusion of control. Our study shows significantly higher values of dissociation, dark flow, and urge to gamble in the VR version. Presence significantly correlates with all measured harm-inducing factors. We demonstrate that VR-based gambling has a higher risk potential. This creates the importance of regulating VR-based gambling.

Index Terms: Human-centered computing—Human computer interaction (HCI)—HCI design and evaluation methods; Human-centered computing—Human computer interaction (HCI)—Empirical studies in HCI; Human-centered computing—Interaction paradigms—Virtual Reality;

1 Introduction

Gambling disorder or pathological gambling dominates a patient's lifestyle and leads to a deterioration of social, professional, material as well as family values and commitments [72]. While millions of people suffer from this disorder [15], the gambling industry continues to use new and more attractive gambling methods, e.g., online-gambling and gambling in immersive Virtual Reality (VR) [29]. Using new technologies has the potential to increase the risk potential of gambling [3], e.g., the potential to evoke an addiction. By now, several immersive VR gambling games have been released. Targeting Head-Mounted Display VR, Gonzo's Quest VR [47] provides a virtual slot machine and PokerStars VR [39] allows multiple players to play poker in a social and visually exaggerated virtual environment (VE). However, the effects of VR-based gambling on the risk potential are *unclear* [26].

It was shown that immersive VR increases several harm-inducing factors, such as dissociation [1] and urge to gamble [50]. Higher harm-inducing factors potentially increase the risk potential of gambling. This suggests a higher dangerousness of gambling games when transferred from a desktop environment, i.e., online gambling, to an immersive VR version. However, current methods for assessing the risk potential are based on the analysis of game mechanics [14,53]. This neglects the effects caused by the visualization technology used.

Hence, based on the upcoming stream of new VR-based gambling products, it is critical to analyze their risk potential. Measuring harm-inducing factors allows for a direct comparison of gambling games in respect to this quality. This approach is in line with assessing the effectiveness of harm-minimization strategies intended to lower a game's risk potential [8,18]. Working with this approach, the risk potential of gambling games providing the same game mechanics but being visualized with different technologies can be compared.

1.1 Contribution

We evaluate the *risk potential* of VR-based gambling by measuring the effects of immersive VR on harm-inducing factors, i.e., dissociation, dark flow, urge to gamble, and illusion of control. In a novel user study, two versions of a virtual slot machine (see Fig. 1), i.e., a desktop version and an immersive VR version, are compared in respect to these factors. The study's results show significantly higher values in dissociation, dark flow, and urge to gamble when playing the VR slot machine. Also, presence significantly correlates with all measured harm-inducing factors. Thus, our contribution is twofold:

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1) We show that immersive VR increases the risk potential of virtual slot machines. 2) We demonstrate that measuring harm-inducing factors allows for a comparison of gambling games in respect to their risk potential.

1.2 Structure

This paper begins with a review of the related work. Then, we present the system design of our slot machine. This is followed by the description of our user study including the experimental design, the measurements, and the procedure used. After that, we present and interpret the results and conclude the paper with indications for future work.

2 Related work

Both the *International Statistical Classification of Diseases and Related Health Problems* and the *Diagnostic and Statistical Manual of Mental Disorders* classified pathological gambling in their current editions as disorders due to substance use or addictive behavior [73] [4]. Thus, gambling addiction is on the *same* level as alcohol and cannabis addiction. Gambling addiction typically is measured using the Problem Gambling Severity Index [16]. This 9-item questionnaire measures the severity of a gambling addiction by considering a person's gambling behavior over the past year [22]. The problem gambling rates across different countries in the world are 0.12%-5.8% [15].

One can distinguish gambling in soft and hard gambling games [42]. Soft gambling games have a rather low risk potential. In most countries, one of the most played soft gambling games are lotteries [15]. Hard gambling games have a comparatively high risk potential. Slot machines are one of the most played games by pathological gamblers [15]. They demonstrate the highest risk potential [6, 15]. Also, they generate the highest revenue with only a fraction of the player base of lotteries [6]. Thus, we target *slot machines* to evaluate the effects of immersive VR on the risk potential of gambling.

2.1 Slot Machines

Slot machines exist for several technologies, such as video-based casino slot machines, desktop-based online slot machines [46] and VR-based slot machines [47]. They are classified as *Electronic Gambling Machines (EGMs)* which also include video poker and video lottery machines [66]. EGMs can provide many different game mechanics [2] that affect a game's risk potential. Game mechanics encode a game's underlying principles, thus structuring the overall gameplay [49]. For instance, *losses disguised as wins* audiovisually presents payouts that are smaller than the initial bet like a win. This increases the trial-by-trial enjoyment of non-win outcomes [59] and leads to the illusion of winning more frequently [27]. Overall, gambling related game mechanics target one particular goal: the evocation and/or exploitation of erroneous beliefs in respect to gambling [66].

There are, however, strategies to reduce the risk potential of gambling by adding constraints to the gameplay. Typically used *harm-minimization strategies* are breaks in play, warning messages, limit setting and behavioral tracking [31]. Harm-minimization strategies mostly target specific factors. For instance, breaks in play aim at preventing players from getting into a dissociative state and from building up urge to gamble [8]. To evaluate the effectiveness, the individually targeted harm-inducing factors are measured. These factors include the urge to gamble and the dissociation [8], the risk taken, the number of plays and the number of spins [24], the arousal, the excitement and the enjoyment [27] or whether participants adhere to their pre-set monetary limits [71]. Harm-minimization studies demonstrated the feasibility of comparing two versions of the same gambling game by evaluating specific harm-inducing factors. As a result, by analyzing a game in respect to multiple harm-inducing factors, an analysis as well as a comparison of the risk potential is possible.

2.2 Harm-inducing Factors

One of the current assessment methods of a game's risk potential is the *AsTERiG* tool [53]. It determines the risk potential by analyzing the realization of specific game mechanics, e.g., the event frequency as well as the size of the jackpot, and the availability of the game. However, studies indicate an influence of a higher immersion on a player's gambling experience [1, 23, 41]. Hence, AsTERiG might be useful to determine the risk potential of traditional gambling games, but does not allow for a comparison between different technologies.

In contrast, the *VICES* framework compares gambling games in respect to their general characteristics, e.g., visual and auditory enhancements, illusions of control, and cognitive complexity [3]. Thus, VICES determines the effects and the changes in gambling behavior caused by a transfer process between technologies. While this allows for a comparison of traditional gambling games to their digital counterparts, it provides no insights about the risk potential of an EGM. This is especially critical as the development of VR gambling games can result in new forms of gambling that have not existed before.

Thus, it is necessary to find a different method for analyzing the risk potential of gambling games. We present a collection of different measurable factors capable of causing harm in the context of EGMs. These factors are not dependent on specific game mechanics and can therefore be applied to any EGM. Measuring these factors provides insights into the harm-inducing properties. This approach is in line with the effectiveness measurements of harm-minimization strategies [8, 18]. We identified the following harm-inducing factors as relevant as they are not a game mechanic and they demonstrated to increase the risk potential:

Dissociation describes a state of changed identity [33], colloquially called the *zone* [58]. Pathological players often report various types of dissociative states either during or shortly after their participation in a gambling activity [34]. Characteristics of dissociation include losing track of time, feeling like being someone else, blacking out, not recalling own actions or being in a trance-like state [30]. The player hides problems and loses track of the lost money while gambling. This makes dissociation the most harmful factor [34].

Urge to gamble is the desire, craving and motivation to gamble again. It is a key factor involved in the development, maintenance and relapse of gambling disorder [74]. Urge to gamble is often a symptom of gambling addiction [51]. A desire to gamble also occurs when being interrupted while gambling [65]. For instance, Candy Crush implements a forced break after a defeat. This causes a craving resulting in some players spending money to skip the forced break [8]. An increased urge to gamble value in non-pathological gamblers could indicate a high chance to gamble again.

Dark flow has its origins in sports describing a possible cause for exercise addiction [52]. Flow is the complete absorption of a person into the performance of an activity [19]. Dark flow describes the dependency on the experience of flow by repeating a specific activity, e.g., running or surfing [52]. This phenomenon also is observable in gambling. Gamblers with a higher Problem Gambling Severity Index showed more dark flow on a slot machine [21].

Illusion of control is one of the main fallacies involved in the maintenance of gambling behavior [3]. There are multiple factors creating an illusion of control, like active or passive involvement, choice, familiarity and competition [37]. It leads to the experience of a **sense of personal competence** and **perception of skill**. This experience results in higher bets when being allowed to throw the ball in roulette [35] or the dice in dice games [37]. Despite having no influence on the final outcome, slot machine game mechanics, such as stop buttons, can evoke illusion of control [20].

2.3 Immersive VR

Immersion is achieved with objective system properties reducing sensory inputs from the real world and replacing them with digital information [63], e.g., by wearing a head mounted display. *Presence*, telepresence, or place illusion is the subjective sensation of being in a real place, i.e., the VE, despite physically being located in a different environment [60]. The experience of this quality depends on the degree of the immersion [61,69]. For presence to occur, it is important to support sensorimotor contingencies, e.g., allowing users to move their heads or to walk [60]. For maintaining presence, a continuous stream of stimuli and experience is required [70]. Presence distinguishes from *plausibility illusion* describing the subjective illusion of perceiving events taking place in a VE as real events [60]. Achieving a high degree of presence can be a central goal, e.g., for VR storytelling [57]. Presence increases, amongst other things, a user's intrinsic motivation for knowledge learning [40] and overall performance in a training scenario [64]. It was shown that presence positively correlates with dissociation in a non-gambling context [44]. This makes it necessary to also investigate the relationship between presence and the identified harm-inducing factors in a gambling context. Aiming at other VR specific factors can positively increase presence. For instance, a VR application can provide an avatar as a proxy for a user's body [32] leading to the illusion of virtual body ownership [62]. This illusion increases presence [69]. Hence, by only changing the degree of the immersion without adding other VR specific factors to it, measuring presence can confirm the desired difference.

Immersive VR is successfully being used in therapy of gambling disorder [9,51]. It provides emotionally charged contexts to patients in the safety of the therapist's office [10]. During therapy sessions, VR induced a strong urge to gamble which is comparable to physical EGM terminals commonly found in casinos [10]. This contributes to the overall indication that immersive VR potentially increases the overall attractiveness as well as the risk potential of gambling.

The analysis of previous work revealed that immersive VR increases harm-inducing factors. Measuring specific harm-inducing factors allows for a comparison of two games in the case of harm-minimization strategy effectiveness measurements. This also suggests that measuring the identified factors in Sect. 2.2 provides a means to compare gambling games. Hence, this approach should provide insights into the risk potential of VR-based games.

3 Slot Machine System

To validate our assumptions, we compare two versions of a slot machine: desktop 3D (see Fig. 2 top) and immersive VR (see Fig. 2 bottom). Slot machines only require two core interaction possibilities. These interactions are to determine the size of the bet and to start a game round. These two interactions can easily be realized in both versions of the game without confounding the results, e.g., by mapping them to the same buttons on a controller used for both versions.

Both applications utilize (1) the same user interface (UI) elements, both in size and position, (2) the same input methods, (3) the same sound effects and (4) the same game mechanics.

3.1 Core Gameplay

A slot machine game round typically involves (1) selection of a bet level, i.e., the amount of coins, (2) start of the round, (3) draw of a random selection of available symbols, and (4) payout of a potential win. The bet level is limited to a certain maximum thus prohibiting all-in bets.

A slot machine provides multiple symbols displayed in a grid. Each symbol has a different value and chance of appearance in a game round. After starting a game round, the slot machine draws a random selection of symbols. A win depends on the order of the symbols in specific lines. A line corresponds to a pre-defined sequence of specific fields on the grid (see Fig. 3). In our slot machine, we use 8 different symbols and 10 lines. At least one line must contain three identical symbols (starting from the left) for a win to occur. The symbol's value in combination with the number of matching symbols in a line determines the size of the win per line. The overall win is the sum of the wins across all lines multiplied by the player's bet level and a multiplier. If a win occurred, the involved symbols are replaced by randomly drawn symbols and the multiplier is increased. Then, the game checks again the lines for potential wins. When no (further) wins are detected, a game round ends, and all intermediate wins are summed up to the final payout (see Fig. 4 and Fig. 5).

Figure 2: Our slot machine user interface realized for desktop (top) and VR (bottom). Both use the same UI elements.

In particular, the combination of the symbol's value and chance of appearance results in the *return to player* value. This value indicates the percentage to which the overall bets are returned as wins. While video-based casino slot machines typically have a return to player of 70 - 90% [28], online slot machines provide a return to player up to 99% [7]. Another important feature is the *hit frequency*. Hit frequency is the rate of how often a game round results in a win independent of the win size. In contrast, the *real hit frequency* indicates how often the player receives a payout larger than the bet

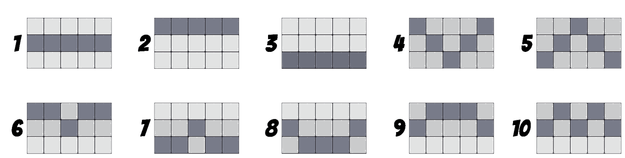

Figure 3: Our slot machine provides 10 different lines. A line is a specific sequence of fields on the grid. For a win to occur a line must contain at least three identical symbols.

Figure 4: A player can select the size of the bet and start a game round (left). Then, the slot machine draws symbols and displays wins (middle). Finally, the slot machine displays the final win (right).

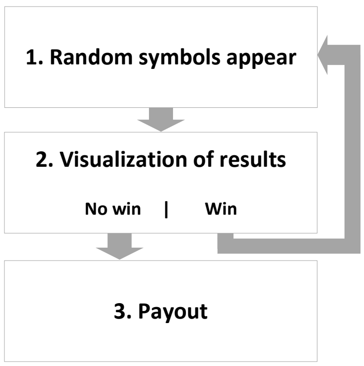

Figure 5: Random symbols are drawn at the start of a round (1). Then, the game checks all lines for wins. In case of a win, they are visualized (2) and new symbols are drawn. If no (further) wins are detected, the final payout is displayed (3).

made. To align with state-of-the-art online slot machines, our slot machine has a return to player value of 97%, a hit frequency of 66%, and a real hit frequency of 33%.

For visualizing the gameplay, we chose an underwater scenario. For symbols, we use aquatic animals that are displayed on stone cubes. Symbols removed after detecting a win dissolve into bubbles. New symbols fall down from above.

3.2 Game Mechanics and Properties

To achieve a better comparability to commercial virtual slot machines, we implemented further game mechanics. Since the primary goal of our research is to identify risks of a higher immersion on gambling, we limited our selection of game mechanics to the ones that already exist. Naturally, more entertaining and possibly more harm-inducing game mechanics would be possible in VR. However, we do not want to provide any considerations or recommendations for effective gambling design. Thus, we selected the following commonly found game mechanics:

Losses disguised as wins: Losses, i.e. payouts that are smaller than the bet, are presented the same way as a win, i.e. payouts that are bigger than the bet.

Near wins: If there is a chance of a full line, the game slows down to create excitement independent of the final outcome.

Level system: With each game round, the player receives experience points depending on the size of the bet. A higher bet results in a greater amount of experience points. When the player reaches a new level, they receive a reward in form of coins.

Money rain: If the player receives a very large payout, i.e., three times the size of the bet, coins start to rain for 3 seconds (see Fig. 1).

Music: Background music is a relaxing underwater ambient music during the regular gameplay. When the multiplier rises, a fast and exciting music begins to play. Each event triggers a different sound effect.

3.3 Technology

The two slot machine versions were developed with Unity 2018.1.1f [67] using the SteamVR plugin in the version 1.2.2 [68]. For the VE, we used the 3D asset *Aquarium* [55]. For symbols, we used the 2D icon pack *Sealife* [25].

Both versions implement the HTC Vive controller as input device. Pressing the touchpad on the left or the right side adjusts the bet. Pulling the trigger button starts a game round. The controller is only displayed inside the VE in the VR version using its 3D asset. This decision was made to provide players of the VR version with the position of the input device. This is not necessary for desktop 3D.

The static interface elements used to display relevant information, i.e., coins, win and experience, have a slightly bigger text size in the VR version to ensure readability (see Fig. 2). All other UI elements, e.g., bet, bet-level and payout animations, do not differ between the two versions.

Aside from the technology itself, the other main difference is the output device used. The desktop 3D version is played on a regular computer screen. The VR version is played using the HTC Vive Pro.

4 Study

Due to the indications discussed in Sect. 2, we assume the following hypotheses (H):

H1: The immersive VR version of our slot machine causes more dissociation than its desktop 3D counterpart.

H2: The immersive VR version of our slot machine causes more urge to gamble than its desktop 3D counterpart.

H3: The immersive VR version of our slot machine causes more dark flow than its desktop 3D counterpart.

H4: The immersive VR version of our slot machine causes more illusion of control than its desktop 3D counterpart.

To answer our hypotheses and to compare the two slot machine versions in respect to the identified harm-inducing factors, we conducted a within-subjects experiment. All participants played both versions, i.e., the *VR* condition and the *desktop* condition, in counterbalanced order.

Players begin each condition with a total amount of 2500 coins. The lowest possible bet is 20 coins and highest possible bet is 1000 coins. A player can modify the bet size in steps of 100 coins and reaches a new level after betting 1500 coins. The reward for a new level is 300 coins.

To achieve comparability between the two game versions, we implemented a seed for each playing session (see Table 1). The first session is played with the first seed and the second session with the second seed. Both seeds have the same hit frequency (HF), real hit frequency (RHF), a nearly similar return to player (RTP) value and include one money rain. This ensures a similar game experience for every participant.

Table 1: Overview of the seeds used.

Round	RTP Session 1	RTP Session 2
1	0.15	2.65
2	0	0
3	1	2.9
4	6.6	1
5	0	3.95
6	0.15	0.7
7	0	0
8	0.15	0
9	0	0.15
10	2.65	0
11	0	0.2
12	1.25	0
13	0	1.55
14	1.25	0
15	1.5	1.3
RTP	0.98	0.96
HF	0.66	0.66
RHF	0.33	0.33

4.1 Task

To create an initial incentive for the participants to play the game, we gave them the task to maximize their virtual money. They were not told the number of game rounds per playing session. Each session ended after 15 game rounds.

4.2 Apparatus

The experimental setup (see Fig. 6) consisted of a desk, a computer (CPU: Intel Xeon E31230v5@3.40GHz, RAM: 16GB, GPU: NVIDIA GeForce GTX 980 Ti), two screens (resolution: 1920x1080), a mouse and a keyboard. Both versions of the slot machine were played on the same computer using the same HTC Vive controller. Participants sat on a chair during the two playing sessions. The gameplay of the VR version was rendered to an HTC Vive Pro (2160x1200 resolution per eye). Inside the VE, symbols had a size of 1m x 1m and the player was positioned 7m away from the grid. The gameplay of the desktop version was displayed on a 24" screen. In this way, the apparent size of the symbols and the UI was similar for both versions.

4.3 Measures

Participants filled in questionnaires before the experiment and after each experimental condition. We used the questionnaires in their original language along with a translated version matching the common language of the study's location. The demography questionnaire and the orally communicated single-item questions were only presented in the common language of the study's location. Questionnaires were selected in alignment with our theoretical considerations of harm-inducing factors as risk indicators in Sect. 2.2. Here, we target all identified harm-inducing factors.

4.3.1 Demographics

We asked for demographic information, i.e., age, gender, gaming experience, VR experience, attitude towards gambling and slot machine knowledge. As a control variable, the study included the Immersive Tendency Questionnaire (ITQ) [70].

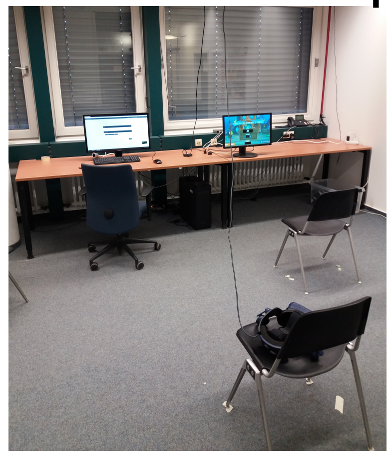

Figure 6: Study room setup: the left screen presents the questionnaires, the right screen displays the gameplay of the desktop version. While playing the desktop version, the participant sits on the rightmost chair. For playing the VR version, the player sits on the foremost chair.

4.3.2 Presence

The Mid Immersion Presence Questionnaire (MIPQ) is a single-item questionnaire assessing a person's current presence [11, 12]. The MIPQ consists of the orally presented question "How far do you feel present in the virtual environment at this moment?". Rating is done on a scale from 0 to 10. Higher scores indicate higher presence. The MIPQ was assessed after the eighth game round in session 1 and after the ninth game round in session 2 (see Table 1). This decision was made as we thus assessed the presence in the fourth game round after a big win, i.e., a money rain event.

4.3.3 Dissociation

The Clinician Administered Dissociative States Scale (CADSS) is a 23-item questionnaire measuring the current dissociation [13]. The items are answered on a 5-point Likert scale ranging from 0 to 4 (4 = highest degree of dissociation). The questions refer to the current state of the participant as assessed after the stimulus.

4.3.4 Urge to gamble

The Gambling Urge Scale (GUS) is a 6-item questionnaire measuring the current urge to gamble [54]. Participants rate statements about their current urge to gamble on a 7-point Likert scale ranging from 1 to 7 (7 = strong urge to gamble).

Also, we assessed a participant's motivation to play our type of gambling game again using a single-item questionnaire [36]: "To what extent would you be motivated to go elsewhere to play the same game, either today or another day?" The questionnaire uses a 10-point Likert scale ranging from 0 to 9 (9 = high motivation).

4.3.5 Game Experience

The Game Experience Questionnaire (GEQ) is a 42-item questionnaire with the subscales immersion, flow, competence, tension, challenge, positive affect and negative affect [45]. We used the GEQ to measure *dark flow* using the subscales of flow and positive affect [21]. The competence subscale provided insights into the illusion of control. The GEQ uses a 5-point Likert scale ranging from 1 to 5, higher scores indicate a higher experience.

4.4 Procedure

Each experimental session lasted about 45 minutes and consisted of the following stages:
(1.) Welcome: Each participant receives a short introduction to the experiment as well as to the health and safety rules and signs a consent form.
(2.) Pre-Questionnaire: The participant fills in the demographics questionnaire and the ITQ.
(3.) Introduction: The participant receives an explanation of the game and the respective game controls.
(4.) Playing Session 1: The participant plays the slot machine for 15 game rounds. After the 8th game round, we assessed the MIPQ.
(5.) Post-Questionnaire: The participant completes the CADSS, the GEQ, the current motivation to play again, and the GUS.
(6.) Playing Session 2: The participant plays the slot machine for 15 game rounds. After the 9th game round, we assessed the MIPQ.
(7.) Post-Questionnaire: The participant completes the CADSS, the GEQ, the current motivation to play again, and the GUS.
(8.) End: The participant receives information about the dangers of real gambling games and watches a short information video about gambling addiction.

Studies demonstrated that players gamble less risky when they are observed by others [43, 56]. The presence of the experimenter could cause a confounding effect. For safety reasons, the experimenter could not leave the room entirely. Thus, to limit this influence, we told each participant that the experimenter would work during the playing sessions. The experimenter then sat at a table which was positioned at the opposite side of the room (about 4 meters behind the participant) facing towards a wall.

4.5 Ethics

An ethics proposal was submitted for this study and was approved by the institutional review board of Human-Computer-Media at the University of Würzburg. To limit the risk of playing a gambling game during this study, we implemented the following measures: (1) The participants had to be of age 18 and older. (2) They showed a score of 0 on the Problem Gambling Severity Index before the study. (3) No real money was used in this study. (4) We informed the participants about the risks of gambling after the study. The participants had to watch a short information video about gambling addiction. We also provided further educational material.

4.6 Participants

In total, 48 participants (34 females, 14 males) were recruited from the undergraduate students who were enrolled at the University of Würzburg using an online participant recruitment system that rewards students with credits mandatory for obtaining their bachelor's degrees. The participants had a mean age of 20.92 years ($SD = 2.23$) and reported a score of 0 on the Problem Gambling Severity Index. None of them had severe visual impairments. 26 participants used an HTC Vive or Oculus Rift ($M = 5.14$ hours, $SD = 7.40$) before and 26 participants reported a previous computer game experience with a mean weekly playtime of 6.27 hours ($SD = 7.41$). The participants' mean slot machine knowledge was 1.22 (1 = no knowledge, 5 = expert knowledge, $SD = 0.47$) and mean attitude towards gambling was -0.23 (-2 = very negative, 2 = very positive, $SD = 0.67$) based on self-report. Their mean ITQ score was 4.29 ($SD = 0.62$).

5 Results

To compare the two conditions, we calculated paired-samples t-tests [48]. For determining the effect size, we calculated Cohen's d. We used rmcorr to check for a correlation between factors at the intra-individual level [5]. Fig. 7 provides a graphical comparison of our measurements.

5.1 Presence

Presence was significantly higher ($t(47) = 14.79$, $p < 0.01$) in the VR condition ($M = 5.90$, $SD = 2.07$) compared to the desktop condition ($M = 3.04$, $SD = 1.85$) with a very large effect size ($d = 1.46$). All harm-inducing factors and presence were positively correlated (see Table 2).

Table 2: Overview of correlations between presence and the measured harm-inducing factors.

Harm-inducing Factor	$r_m(47)$	p	95% CI
Dissociation	0.57	< 0.01	$[0.34, 0.74]$
Urge to gamble	0.35	0.01	$[0.07, 0.58]$
Motivation	0.56	< 0.01	$[0.33, 0.73]$
Dark Flow	0.77	< 0.01	$[0.61, 0.86]$
Competence	0.30	0.03	$[0.02, 0.54]$

5.2 Dissociation

Dissociation was significantly higher ($t(47) = 6.27$, $p < 0.01$) in the VR condition ($M = 0.48$, $SD = 0.39$) compared to the desktop condition ($M = 0.17$, $SD = 0.17$) with a large effect size ($d = 1.10$).

5.3 Urge to gamble

The urge to gamble was significantly higher ($t(47) = 1.89$, $p = 0.03$) in the VR condition ($M = 1.37$, $SD = 0.72$) compared to the desktop condition ($M = 1.20$, $SD = 0.45$) with a small effect size ($d = 0.29$).

The motivation to play the game again was significantly higher ($t(47) = 4.97$, $p < 0.01$) in the VR condition ($M = 4.54$, $SD = 2.83$) compared to the desktop condition ($M = 3.06$, $SD = 2.35$) with a medium effect size ($d = 0.57$).

5.4 Dark Flow

The dark flow was significantly higher ($t(47) = 7.23$, $p < 0.01$) in the VR condition ($M = 2.96$, $SD = 0.82$) compared to the desktop condition ($M = 2.35$, $SD = 0.63$) with a large effect size ($d = 0.85$).

5.5 Illusion of Control

The competence subscale of the GEQ was not significantly different ($t(47) = 1.34$, $p = 0.09$) in the VR condition ($M = 2.46$, $SD = 0.81$) compared to the desktop condition ($M = 2.32$, $SD = 0.74$).

6 Discussion

The study was designed to compare two versions of a virtual slot machine in respect to identified harm-inducing factors. Both versions differed in the technology used, i.e., desktop 3D and immersive VR, but implemented the same game mechanics and provided the same information. In this way, we investigated the influence of immersive VR on identified harm-inducing factors and thus the risk potential of VR-based gambling.

Compared to other current approaches, e.g., AsTERiG [53], our approach is independent of the game mechanics used. AsTERiG would have determined the same risk potential for both tested versions. In contrast, our approach of measuring the identified harm-inducing factors revealed differences between the two versions. This provides a first indication that measuring the identified harm-inducing factors allows for a comparison of EGMs in respect to their risk potentials. However, future research is needed to validate this approach.

6.1 Effects of Immersive VR on Harm-Inducing Factors

As intended, the full visual immersion of the VR slot machine resulted in a significantly higher presence in comparison to the desktop version. The results of our study show a significant correlation between presence and all tested harm-inducing factors. The factors

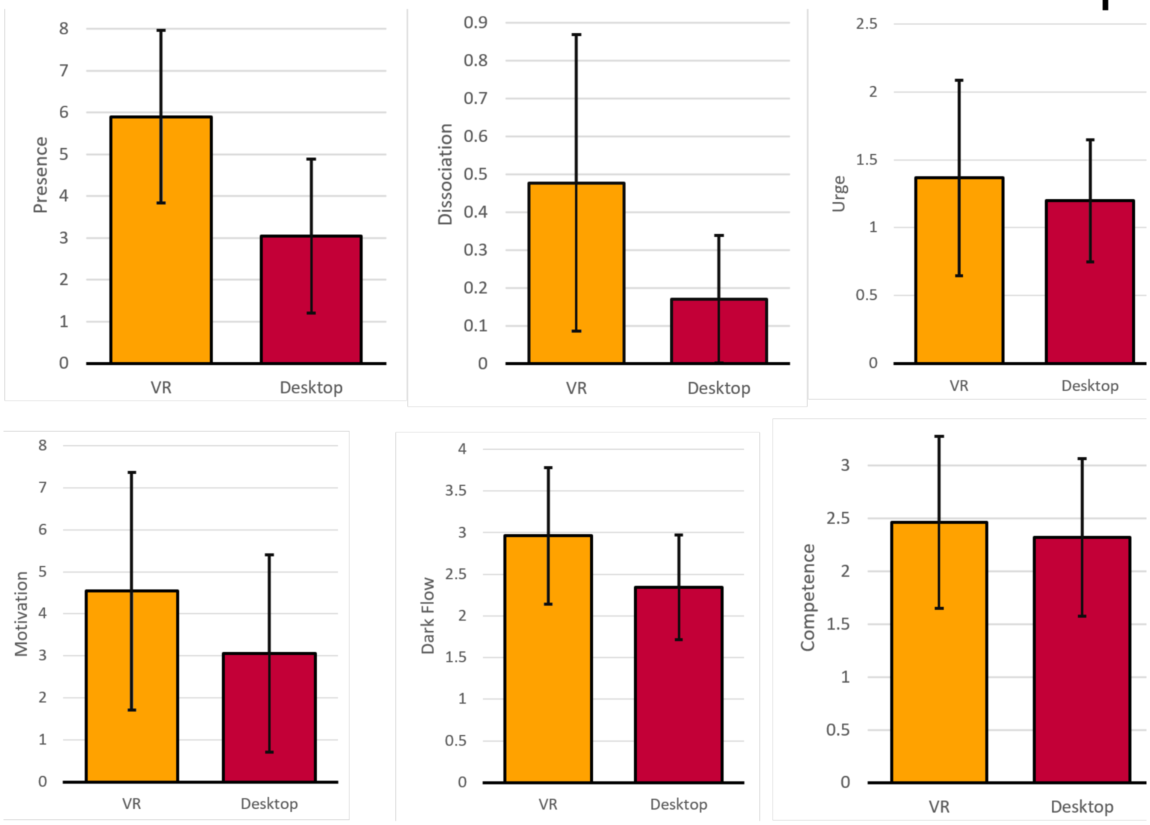

Figure 7: Comparison of the harm-inducing factor measurements between the two versions of our slot machine. Error bars indicate standard deviations.

dissociation, urge to gamble, motivation and illusion of control show a weak to moderate linear correlation. Dark flow has a clear linear relationship.

We found significantly higher values in dissociation, urge to gamble, dark flow and motivation. The competence subscale of the GEQ and hence the illusion of control did not differ significantly between the two conditions. This is explainable by the lack of a game mechanic potentially evoking an illusion of control. For instance, the implementation of a stop button has demonstrated to cause this effect in the context of gambling [20].

H1 More Dissociation: The results of our user study show a significant difference between the two conditions in respect to dissociation. We found a significant correlation between presence and dissociation. Thus, H1 is *supported*.

H2 More Urge to Gamble: Our study shows a significantly higher urge to gamble and motivation to gamble again in the VR condition. We found significant correlations between presence and the two factors. Thus, H2 is *supported*.

H3 More Dark Flow: The results show a significant difference in dark flow between the two conditions. We found a significant correlation between presence and dark flow. Thus, H3 is *supported*.

H4 More Illusion of Control: The results revealed no significant difference between the two conditions in respect to the competence subscale. However, we found a significant correlation between presence and the competence subscale. Thus, we cannot confirm H4 and need to *reject* it.

Our ethical considerations might have resulted in a confounding effect. Winning money is the main motivation when playing gambling games [6]. By not winning or losing real money, a player's engagement could have been compromised. However, gambling games often try to achieve a *suspension of judgement* by using virtual currencies [28]. This breaks the connection between real money and virtual money and makes the players place higher bets despite still playing with real money [38]. Thus, although no real money was used, the present study's results are of high relevance, especially for online gambling.

As dissociation is the most dangerous factor [34], our results are critical for assessing the general risk potential of VR-based gambling. High values in harm-inducing factors indicate a high risk potential. Here, we found higher harm-inducing factor values when playing the VR slot machine. Thus, we provide first insights of immersive VR *increasing* the *risk potential* of slot machines. We only used healthy individuals. Considering this, the present study indicates the dangerousness of VR-based gambling, especially for new players. As our participants represent the target group of immersive VR gambling games [29], our results are of *high relevance*.

6.2 Recommendations

Therefore, we recommend to regulate and to control the development of VR-based EGMs. One potential approach would be to require the implementation of harm-minimization strategies aiming at the tested harm-inducing factors [8, 31]. In respect to VR-based gambling, even new harm-minimization strategies might be possible [26]. However, harm-minimization strategies have not yet been tested in immersive VR. This raises the need to analyze the effectiveness of these strategies in an immersive VR gambling scenario.

However, we merely analyzed two versions of a slot machine.

Other types of EGMs or an aspect of social gambling might result in different effects on harm-inducing factors. Thus, it is critical to conduct further research to analyze a wider range of EGMs. Also, an analysis of other factors, e.g., the provision of an illusion of virtual body ownership or social presence, is of high importance. It would not only provide further insights into the risk potential of VR-based gambling, but also reveal potential dangers of games like PokerStars VR [39] that already provide embodied social virtual gambling.

While gambling in VR indicates to have a higher risk potential, the outcomes of the present study are of high importance for gambling addiction therapy [9]. Evoking higher harm-inducing factors could be beneficial for treatment methods of cue exposure therapy [17]. Cue exposure therapy aims at a desensitization of patients by an over-saturation. By providing an immersive VR gambling treatment, the therapy could create stronger stimuli and hence be more effective.

7 Conclusion

This paper analyzes the effects of immersive VR on the risk potential of gambling. In this paper, we present two different versions of a virtual slot machine: a desktop 3D version and an immersive VR version. Both versions are identical in their game design. For evaluating the games' risk potential, we identify relevant harm-inducing factors as an assessment tool. In particular, we compare the two versions in respect to dissociation, urge to gamble, dark flow, and illusion of control. Overall, higher values in these factors indicate a higher risk potential.

In a novel user study, we measured significantly higher values of dissociation, dark flow, and urge to gamble when playing the VR slot machine. The illusion of control, however, did not differ between the two versions. The study revealed a significant correlation between presence and all assessed harm-inducing factors. Thus, our contribution is twofold: 1) We show that immersive VR increases the risk potential of virtual slot machines. 2) We demonstrate that measuring harm-inducing factors allows for a comparison of EGMs in respect to their risk potential.

Future research is needed to analyze further VR-based EGMs as well as to compare them to their physical counterparts in respect to the risk potential. Also, evaluating effects of other factors, such as the illusion of virtual body ownership and social gambling, presents an important research goal. Another research direction is the analysis of harm-minimization strategies for VR-based gambling. Finally, it is necessary to validate our approach of measuring the risk potential by analyzing harm-inducing factors.

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