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Increased volatility in video poker results in more winning players but shorter winning streaks – Evidence from simulations

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FULL-LENGTH REPORT

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ABSTRACT

Objective and Method: Electronic gambling machines are a prominent cause of significant gambling harms globally. We use simulations of a simplified video poker game to show how changes in game volatility, defined primarily by the size of the main prize, affect patterns of wins and losses as well as winning streaks. *Results:* We found that in low- and medium volatility games the proportion of winning players quickly drops to zero after about 30 h of play, while in the high volatility game 5% of players are still winning after playing for 100 h. However, the proportion of winning streaks was significantly higher in the low- and medium volatility games compared with high volatility: the simulated players were on a winning streak about 26.3, 25.6 and 18% of the time in the low-, medium- and high volatility games, respectively. *Conclusions:* Fast-paced video poker with varying volatility levels but identical return-to-player rates and win frequencies can yield highly different result patterns across individuals. These patterns may be counter-intuitive for players and difficult to realize without simulations and visualizations. We argue that the findings have relevance for responsible gambling communication and for building a better understanding of how cognitive biases influence gambling behaviour.

KEYWORDS

EGMs, video poker, simulations, winning streaks, volatility

Fast-paced electronic gambling machines (EGMs) such as slot machines or video poker games are a significant reason for gambling harms globally (Browne et al., 2023; Järvinen-Tassopoulos, Marionneau, & Nikkinen, 2021). They are played by tens of millions of people, both online and offline, and constitute about 60–70% of the global market value of gambling in total (CPRG, 2018). The popularity of EGMs can partly be attributed to their various reinforcement design elements, such as the pleasantly rewarding sounds, losses disguised as wins, and near-misses, which reel the players in and keep them immersed. Over time, most EGM players experience a steady monetary decline into debt (Barton et al., 2017).

There is a wide range of EGMs offered that suit most everyone's preference, and, consequently, the differences between EGMs are so large it is difficult to define what a typical EGM is. Rather there are several general game types including spinning reel games with progressive prizes that increase over time, flat top spinning reels (without progressive prizes),

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video poker and less common games such as keno, and blackjack (Turner & Horbay, 2003). Recent years have seen the introduction of numerous table games that have been modified into single- or multiplayer EGM games (Turner, 2011b, 2019). Generally, however, EGMs can be described by their reinforcement or reward schedules in terms of volatility and return-to-player (RTP) rates (Yücel, Carter, Harrigan, van Holst, & Livingstone, 2018). RTP refers to what the player is mathematically expected to lose by playing the game, and volatility refers to the variability or fluctuation of wins and losses across multiple bets. According to Turner (2011a), volatility is a measure of the variation in potential outcome from bet to bet. It is computed using the 90% confidence interval ($z = 1.65$) of the theoretical standard deviation of the outcome of a bet after 10,000 spins (see Harrigan & Dixon, 2009; Kilby, Fox, & Lucas, 2005; Turner, 2011a). Both concepts, especially volatility, are difficult for players to understand and for the game providers to effectively communicate to the players (Newall, Russell, & Hing, 2021; Newall, Russell, Sharman, & Walasek, 2021).

Turner (2011a) shows that commercial games are characterized by different combinations of volatility and RTP rates with three main types: (1) lotteries, which have significant volatility including a number of small prizes, a very rare enormous prize and a low RTP rate, (2) multiple level prize games such as slot machines and video poker, which have both small and large prizes, and (3) even money games that have a very low volatility and relatively high RTP rates. There are also variations in between these game types including volatility-increasing side bets in blackjack, or a game of daily keno that allows players to choose any combination of bets from low volatility with frequent wins, to high volatility for the grand prize.

Existing research is inconclusive on what type of reinforcement schedules players generally prefer, though the topic has been extensively discussed (e.g., Delfabbro, King, & Parke, 2023; Newall, Byrne, Russell, & Rockloff, 2022; Newall, Walasek, & Ludvig, 2022; Newall, Walasek, Ludvig, & Jenkins, 2022). Turner (2011a) suggests that different players prefer different configurations of rewards: some prefer the wild ride of a moderate volatility game (EGM), others like to dream of the very rare grand prize (lottery), and still others prefer the high frequency wins of low volatility games (blackjack, baccarat). Some games such as roulette and craps provide options for moderate and low volatility games. This is also the case with many EGMs where players can choose between a more volatile experience by betting heavily on only one line and a less volatile experience by covering all possible lines (Turner & Shi, 2015). The gaming industry offers games that meet the preferred reward schedule for many different individuals.

While the players' game experience is influenced by RTP rates and volatility, the players are often unable to tell merely by playing what the game's reward schedule is (Turner, 2011a). It is possible for a player to reverse engineer the actual pay structure, but it would take careful observation of all outcomes over numerous bets (for an example, see wizardofodds.com). In other words, it is often not clear to the players what kind of results they might expect should they continue playing the game for an extended period. Statistical simulations are an efficient way to gain insights into the volatility profiles of long-term play across hundreds of players in slow-, medium-, and fast-paced gambling. For example, Turner (2011a) used simulations to illustrate and demystify gambling games to reduce common misunderstandings, and to explore variability in betting results over the short and long-term depending on the prize structure of the game.

In this paper, we build on earlier simulation work, but instead of focusing on multiple different EGMs to capture their diversity (as in Turner, 2011a), we use a simplified simulated game to illustrate how changes in the prize structure, primarily the main prize, affect patterns of profit and loss all else being equal. Specifically, we illustrate patterns of short- and long-term volatility, including the proportion of winning players and the likelihood of winning streaks, in simulated games with (near) identical RTP rates, identical *win frequencies* but different *win size distributions*. That is, the probabilities of each win are the same, as are the overall RTP rates, but the individual win sizes differ across three levels of low, medium, and high volatility, defined primarily by the size of the main prize.

As we will show, these differences in game configurations have significant effects on patterns of profit and loss. Moreover, we argue these patterns are relevant with respect to various cognitive biases in gambling behaviour. Early wins and winning streaks for example are more commonly reported in people with gambling problems (Turner, Littman-Sharp, & Zangeneh, 2006, 2008c). Problem gamblers commonly hold erroneous beliefs about random chance (Ejova, Delfabbro, & Navarro, 2015; Goodie & Fortune, 2013; Leonard, Williams, & Vokey, 2015; Toneatto, Blitz-Miller, Calderwood, Dragonetti, & Tsanos, 1997), and people in general hold biases to frequent or recent information (Tversky & Kahneman, 1990). Other erroneous beliefs include the gambler's fallacy, the belief in luck, the illusion of control, insensitivity to sample sizes, the hot hand fallacy, and base rate neglect (Ejova et al., 2015; Gilovich, Vallone, & Tversky, 1985; Goodie & Fortune, 2013; Leonard et al., 2015; Leonard & Williams, 2016; Turner et al., 2022). These errors are not limited to problem gamblers, but there is ample evidence that problem gamblers hold more erroneous beliefs (Turner et al., 2022).

The results from the simulations will help us understand how fast-paced gambling games with the same RTP rates and even the same win frequencies can yield different patterns of results across individuals. We discuss the potential impact of these differences for risk of gambling harm via various known cognitive biases, and their implications for responsible gambling communication.

METHOD

Sample and game details

Our samples are fully based on simulations of a hypothetical *video poker* game. The simulated game is a simplified form of video poker where the "players" are assumed to play 5 rounds per minute for N rounds with a constant 1 euro bet size. The return to player (RTP) on optimal strategy is set at ~90%, which has been shown to be roughly the international average RTP for EGMs (Schwartz, 2013; Woolley, Livingstone, Harrigan, & Rintoul, 2013). In other words, for every 1 euro bet made, the players are expected to lose 10 cents on average when playing with optimal strategy.

We will treat the simulated game as if there was no skill involved. In recent versions of video poker, the game suggests the best cards to hold for the player, essentially removing the skill element from the game; if people follow the suggested cards, they are playing an optimal strategy. There are three types of games simulated based on volatility level: low, medium, and high.[1] The volatility level -based payouts, their probabilities, and the (near-identical) RTPs are presented in Table 1. Commercial video poker pay tables vary from game to game with larger prizes offered for less common outcomes. The three pay tables given in Table 1 are not identical to any specific commercial game, but similar (as a reference, we used video poker odds reported by the online gaming website pinnacle.com).

Based on the above payouts and probabilities, we simulated the winnings across N rounds of play and P simulated players. Here were report the results for iterated simulations for $P = 100$ and Ns = 150, 300, 3,000, 9,000, 15,000, 22,500 or 30,000, which equal 0.5, 1, 10, 30, 50, 75, and 100 h of play, respectively. We provide visualizations of example simulations. All simulations were run using R (version 4.2.1, R Core Team, 2022), and the code is freely available at https://doi.org/10.6084/m9.figshare.24131466.

Table 1. Volatility level-based payouts, their probabilities and RTPs

Hand	Probability (%)	Payout (euros)		
		Low volatility	Medium volatility	High volatility
Royal flush	0.002	100	500	2,000
Straight flush	0.011	50	65	50
Four of a kind	0.236	30	45	33
Full house	1.151	15	13	14
Flush	1.101	8	7	7
Straight	1.123	7	6	5
Three of a kind	7.445	3	3	3
Two pair	12.928	2	2	2
Nothing	76.003	0	0	0
RTP		89.955%	89.934%	89.965%

Note. RTP = Return to player.

[1]Here the low volatility game is still much higher in volatility compared to an even money game such as Baccarat, and the high volatility game is lower in volatility compared to a lottery or progressive gambling EGMs. The terms "low", "medium" and "high" volatility are merely defined here with respect to one another.

We also calculate the mean- and standard deviation values for *proportion of winning players* after N rounds played for all three levels of volatility. This is done by rerunning the simulations 500, 100, 75 or 50 times depending on the number of rounds being simulated and computing time requirements.

Finally, we use a custom sliding-window regression analysis to evaluate the proportion of *winning streaks* for each simulated player. For each player, betting rounds were regressed on euros won/lost for width-300 (one hour of play) sliding windows: regression models were fit for betting rounds 1 through 301, then for rounds 2 through 302, and so on, until rounds N–300 through N. This yielded N–299 separate slope coefficients for each simulated player, which represent the linear trends (winning trend vs. losing trend) of a series of overlapping but progressing one-hour game periods. The proportion of positive slope coefficients was calculated for each player, and these were averaged across all players, resulting in an overall estimate of *the average proportion of time players were having a winning streak* (and the standard deviation of this proportion). For proof-of-concept, see Fig. 2. Winning streaks may include both wins and losses, but the overall trend of wins and losses will be positive (i.e., more wins than losses on average over a specific period).

RESULTS

The mean number of players (among 100 simulated players, thus also representing the mean proportion of players) who are winning after 0.5, 1, 10, 30, 50, 75 or 100 h of play depends heavily on the game's volatility level. Table 2 and Fig. 1 present the proportion of profiting players across three volatility levels (low, medium, and high) and length of play in hours. As can be seen in Fig. 1, the proportion of players in profit ("lucky winners") significantly depends on volatility. For the high volatility version of the game, on average, 5.16% of the players were winning even after 100 h of continued play. Importantly, these differences are not explained by RTP rates or win frequencies, which are near-identical across volatility levels.

In terms of winning streak proportions, in the low, medium, and high volatility simulations, the average proportions of one-hour upswings experienced were 26.3, 25.65 and 18.07% (SDs 10.7, 12.2 and 9%), respectively. The difference between low and medium is a small effect size (Cohen's $d = 0.056$); the effect size of medium and high and low and high are large effect sizes (Cohen's ds = 0.83 and 0.70 respectively). Winning streak proportions were calculated only for 10-h (3,000 round) periods across 100 simulated players (which, for the winning streak calculations, is the same as simulating 6,000 rounds across 50 players, or 12,000 rounds for 25 players, and so on). This process was repeated three times, and the results were pooled. Thus, upswings were 7–8% more frequent in the low and medium volatility games, compared with the high volatility game, despite the high volatility games having, on average, a higher proportion of winning players. Figure 2 visualizes the

Table 2. Mean proportion (%) of players (standard deviation in brackets) in profit separately for varying length of play and volatility of the simulated video poker game

Volatility	Hours of play						
	0.5	1	10	30	50	75	100
Low	28.72 (4.56)	23.52 (4.14)	2.03 (1.39)	0.02 (0.14)	0 (0)	0 (0)	0 (0)
Medium	27.8 (4.55)	23.74 (4.15)	7.11 (2.56)	1.46 (1.25)	0.31 (0.54)	0.06 (0.24)	0 (0)
High	22.67 (4.06)	16.76 (3.71)	6.33 (2.45)	16.37 (4.06)	11.68 (3.41)	7.38 (2.31)	5.16 (2.06)

Note. The return to player rate is near-identical (about 90%) across volatility levels.

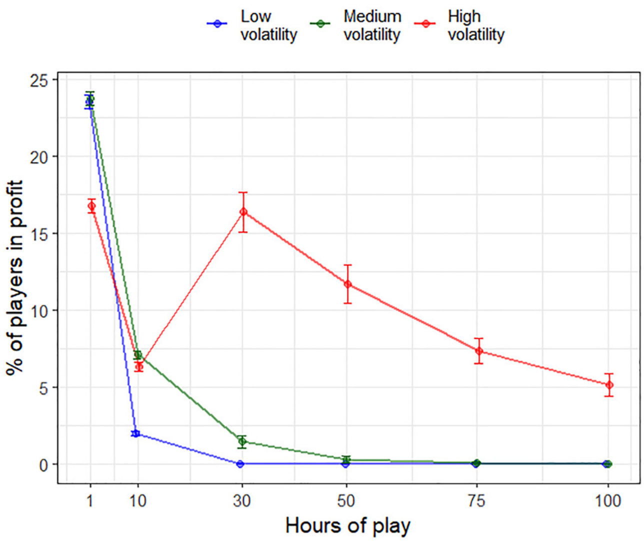

Fig. 1. Mean proportion (%) of players in profit across three levels of game volatility (low, medium, high)
Note. Error bars represent 95% confidence intervals. The return to player rate is near-identical (about 90%), and the win frequencies are identical across volatility levels.

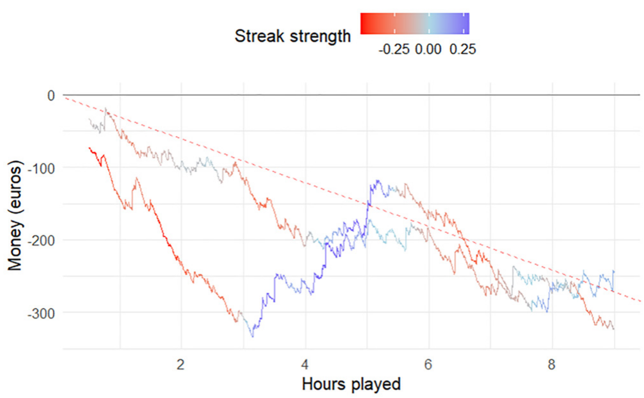

Fig. 2. Proof of concept for the sliding-window regression for upswing detection
Note. The curves represent two individual simulated players (playing the low-volatility version of the simulated game), with upswings and downswings colored based on the sliding-window regression modelling output. Shades of blue and red denote model-predicted upswing and downswing periods, respectively. Shades of light blue denote periods of no clear up- or downswings. The streak strength values (ranging from −0.25 to 0.25 in this example) refer to the unstandardized sliding-window regression model coefficients and can be interpreted as the linear slope steepness at a given time point.

winning streak modelling for two example simulations as a proof-of-concept. As can be seen in Fig. 2, upwards trending periods are colored in shades of blue, and downwards trending periods in shades of red, while periods without clear up- or downwards trends are colored in shades of light blue.

As can be seen in Fig. 3A–C, playing the low volatility version of the game (top left panel), most players are losing after having played the game for 10 h. For medium and high volatility (top right and bottom left panels), while most players are losing after having played game for 10 h, there are quite a few who are still winning. Rerunning these simulations 500 times (i.e., calculating 500 figures as seen in Fig. 3A–C), the mean numbers of players (SD in brackets) who are still winning after 10 h are 2.032 (1.395) for low-, 7.11 (2.561) for medium-, and 6.332 (2.45) for high volatility.

For simulations of 30 h of play we do not visualize the low volatility version of the game since it is very unlikely to have made a profit after 9,000 rounds with low volatility. For low volatility, the mean number of players winning after 30 h of play is 0.02 with a SD of 0.14. Simulations for medium and high volatility are visualized below. Figure 4A and B shows that as hours of play increase, the number of players still winning approaches zero; though after 30 h of play, there are quite a few more "winners" in the high volatility game compared with medium volatility. Rerunning these simulations 100 times (i.e., calculating 100 figures as seen in Fig. 4A and B), the mean numbers of players (SD in brackets) who are still winning after 30 h are 1.46 (1.25) for medium-, and 16.37 (4.06) for high volatility.

Figure 5A and B shows that after 100 h of play, it is extremely unlikely to still be in profit when playing the medium volatility version of the game. In the high volatility simulations about 5% of players are still likely to be winning. Rerunning these simulations 50 times (i.e., calculating 50 figures as seen in Fig. 5A and B), the mean numbers of players (SD in brackets) who are still winning after 100 h is 5.16 (2.06) for high volatility, and 0 for medium validity.

DISCUSSION

We investigated the role of prize volatility on patterns of profit and loss, when controlling for RTP rates and win frequency, using simulations of a simplified video poker game. Results indicate that both lower and medium volatility

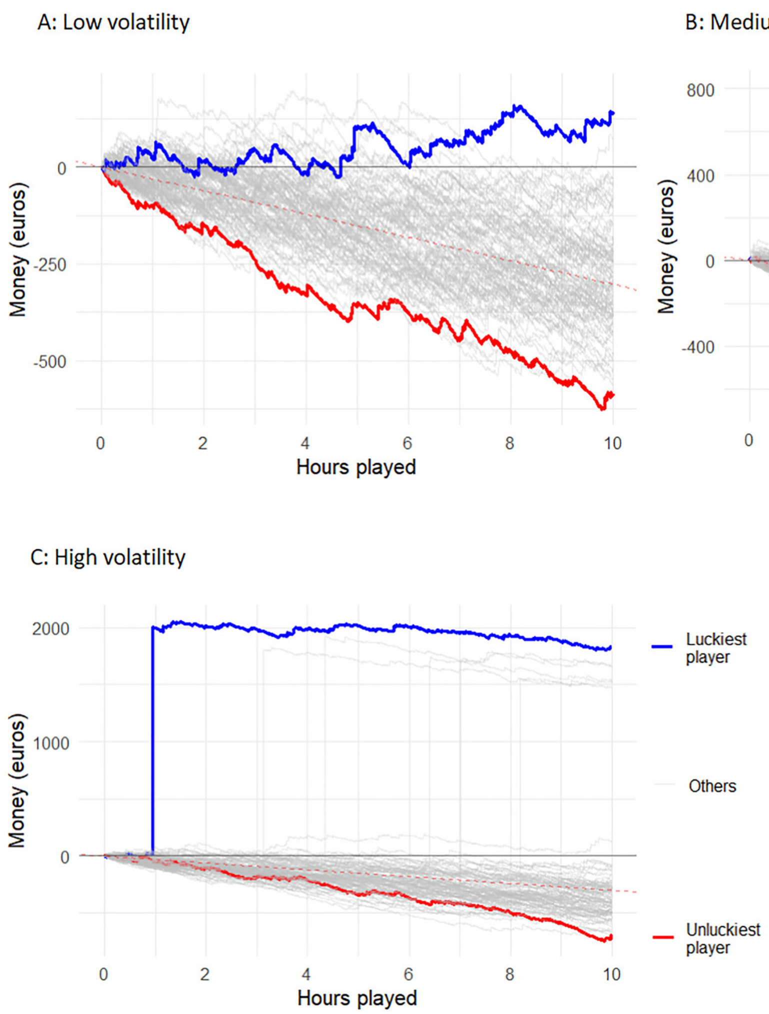

Fig. 3. A–C. Simulations for 10 h of play (3,000 rounds of betting)
Note. Example simulations for a) low, b) medium, and c) high volatility and 3,000 rounds (10 h of play) for 100 players, with the "luckiest" and "unluckiest" players highlighted in blue and red color, respectively. The red dashed line is the expected value for all players and represents a return to player rate of 89.955% (low volatility), 89.934% (medium volatility) and 89.965% (high volatility).

games have a higher percentage of wins in the (very) short term and a relatively high number of winning streaks (26.3 and 25.7%, respectively), whereas high volatility games are characterised by fewer winning streaks (18.1%), but a larger proportion of individuals in profit after 30 h of play.

The influence of cognitive biases on the development of problematic gambling behaviour is well established (Blaszczynski & Nower, 2002; Devos et al., 2020), yet such biases do not exist in a vacuum. Rather, they stem from a range of flawed or maladaptive cognition, including misinterpretation and misattribution among others (e.g., Donati et al., 2018; Ejova & Ohtsuka, 2020; Ledgerwood et al., 2020). It is likely that the game experiences can contribute to the development of cognitive biases, either at the point of origin or by reinforcing pre-existing biases. The erroneous belief with the most relevance for this paper is the gambler's fallacy. Though often difficult for players to realize, random chance does not correct itself and short-term outcome variation such as losing streaks do not predict future wins. Rather over the long term the house edge emerges, as clearly shown by the simulations. Moreover, short periods of play may lead to a distorted sense of players' long-term chances of winning (as detailed in Turner, 2011a). Winning over the short term is relatively frequent (in our simulations, almost 30% of the players are winning after playing for 30 min) but cumulative sessions significantly reduce the likelihood of coming out ahead.

The longer winning streaks evident in low and medium volatility games may reinforce overconfidence and illusion of control, inflated perception of skill, and consequently, superstitious behaviour. The illusion of control is the belief that one's actions can influence random events (Leonard & Williams, 2016). The gambling industry encourages this belief with stop buttons, bonus rounds with choices, or by allowing players to choose their own numbers or the number of lines they play. Selecting more lines does change the game experience by decreasing the volatility or their outcome (Turner & Shi, 2015). Covering more buttons decreases volatility and increases the hit rate of the game by introducing losses disguised as wins (Dixon, Harrigan,

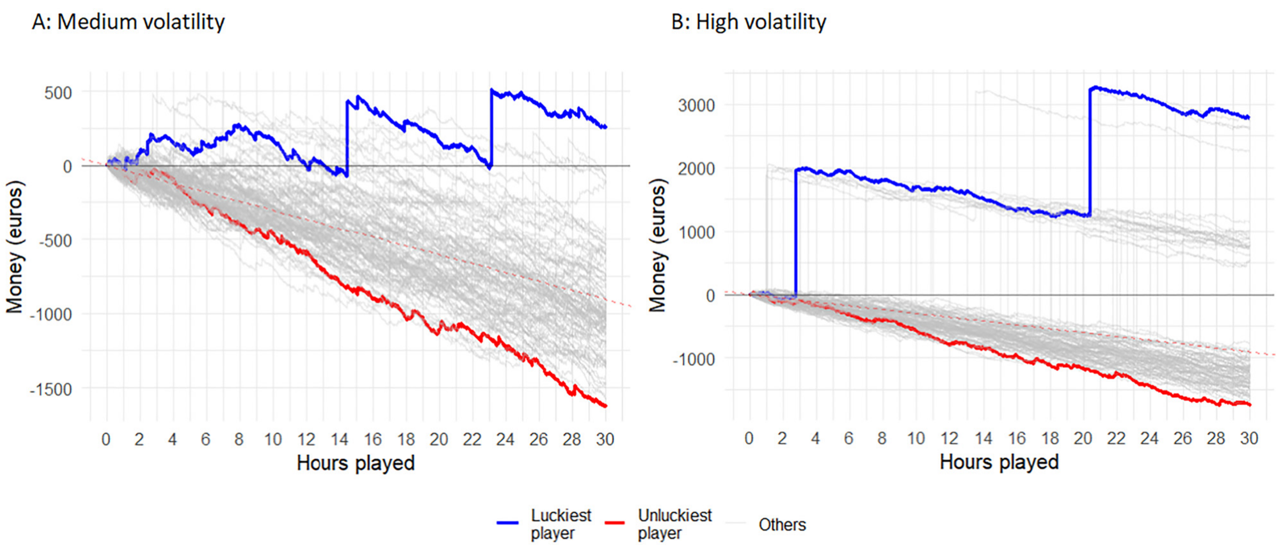

Fig. 4. A and B. Simulations for 30 h of play (9,000 rounds of betting)
Note. Example simulations for a) medium, and b) high volatility and 9,000 rounds (30 h of play) for 100 players, with the "luckiest" and "unluckiest" players highlighted in blue and red color, respectively. The red dashed line is the expected value for all players and represents a return to player rate of 89.934% (medium volatility) and 89.965% (high volatility).

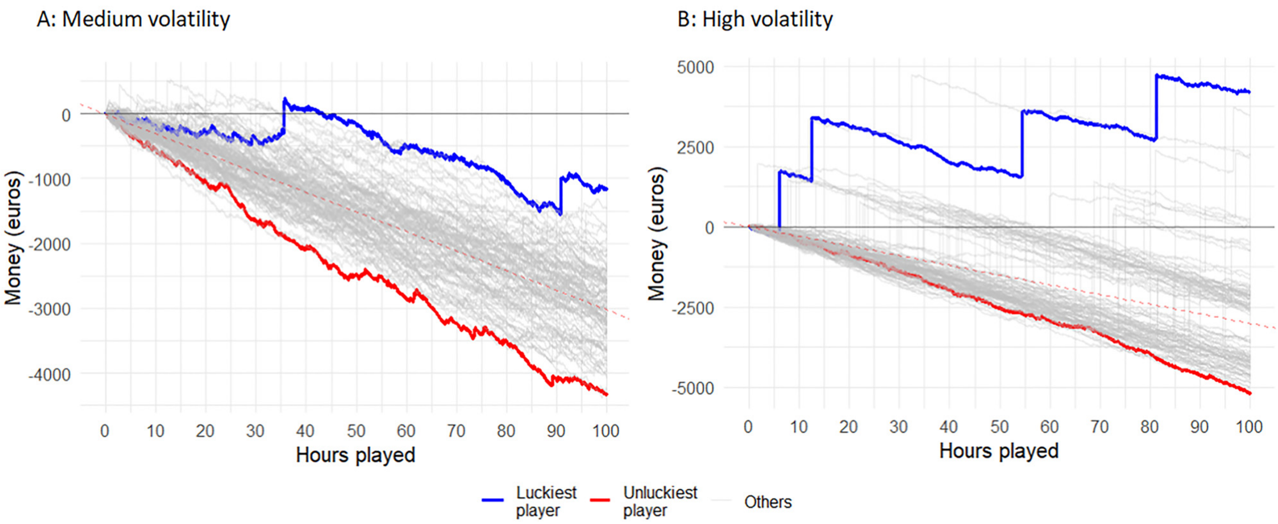

Fig. 5. A and B. Simulations for 100 h of play (30,000 rounds of betting)
Note. Example simulations for a) medium, and b) high volatility and 30,000 rounds (100 h of play) for 100 players, with the "luckiest" and "unluckiest" players highlighted in blue and red color, respectively. The red dashed line is the expected value for all players and represents a return to player rate of 89.934% (medium volatility) and 89.965% (high volatility).

Sandhu, Collins, & Fugelsang, 2010); it also mitigates the fear of missing out on combinations on other lines that were not bet on. Furthermore, the upswings in fortune may help convince players in low volatility games that the game can be beaten, with the upswing being misattributed to either skilled play or an unconnected "lucky" action, as imagined by the individual player, or that they are "learning" the machine (e.g., Ohtsuka, 2013; Zhou et al., 2012).

It is noteworthy that in addition to EGMs this potential consequence of low volatility structure can be extended to other commercially available low volatility games (e.g., baccarat, blackjack) which often have a lower house edge (higher RTP), and which also require higher minimum bets (Turner, 2011a). The higher RTP in even money games (baccarat) compensates for absence of a big win. As a result, there is often a trade-off between the potential big win (high volatility) and winning streaks. Given the lower house edge and larger bets involved in low volatility games, the result can be wild swings of fortune during the long winning streaks despite low volatility.

In respect to higher volatility games, the bigger individual wins and higher proportion of winning players may reinforce an illusion about "others' wins" and bias players' memory; others' big wins are promoted, both by individuals and the operators, thereby increasing visibility and giving rise to unrealistic expectations (Binde, 2014). Furthermore, individuals' big wins are remembered while constant small losses are not (or they are disguised as somewhat inconsequential wins; Thaler & Johnson, 1990), and therefore, those who do not win the big prize continue to lose even more than the RTP rate suggests, while the winners may have inflated sense of profitability and an inaccurate perception of odds of winning. This, in turn, may result in chasing after losses or wins (Chen, Doekemeijer, Noël, & Verbruggen, 2022; Thaler & Johnson, 1990).

When assessing the potential association between volatility and gambling harm, the question is one of which configuration is more dangerous, games characterised by more winning streaks with smaller wins, or infrequent bigger wins? Endorsing a greater number of cognitive biases related to gambling has been found to be positively associated with the likelihood of developing problematic gambling behaviours (Ejova et al., 2015; Goodie & Fortune, 2013; Leonard et al., 2015; Turner et al., 2022). However, no specific cognitive biases have been found to be especially influential in the development of problematic behaviours, with different individuals endorsing different combinations of biases. It is likely that the two profiles identified above have a similar relationship in that they are more likely to contribute to problematic gambling behaviours for different types of players; it is a reasonable assumption that the more volatile EGM games appeal to people who dream about the big win in the same way as lotteries do, while low volatility games appeal more to those motivated by more prolonged play and, potentially, perception of skilled play. Part of the appeal of different game configurations, therefore, is a trade-off between a focus on the grand prize (higher volatility) or a focus on the short-term win and winning streaks (lower volatility). As a result, the relationship between volatility and problem gambling is not a simple one, but dependent on player preferences.

Volatility is just one aspect of game design and experience, indeed, other structural characteristics, such as ability to reinvest winnings, or contextual factors like presence of alcohol and escapism may subsume or reduce the overall impact of volatility (see also Percy, Tsarvenkov, Dragicevic, Delfabbro, & Parke, 2021). For example, lotteries are extremely volatile but commonly recognised as being among the least problematic forms of gambling (Castrén, Perhoniemi, Kontto, Alho, & Salonen, 2018; Salonen, Kontto, Perhoniemi, Alho, & Castrén, 2018), with their impact mitigated by such structural characteristics as event frequency and ease of reinvesting winnings (Ariyabuddhiphongs, 2011). EGMs are perhaps the perfect balance of volatility and speed to maximize addictiveness; the combination of reinforced cognitive biases, the fast pace, and automatic reinvestment of wins being potential explanations of EGMs' association with increased experience of gambling-related harms. Volatility, therefore, is likely to be more indirectly connected to problem gambling than being a direct predictor of gambling harm experienced by individuals, for example through the etiology of maladaptive cognitions, with the effects being enhanced or degraded through combining volatility with different levels of payback and bet size. Moreover, different combinations of bet size, volatility and RTP rates may appeal to, and be addictive to, different people.

The relationship between volatility and problem gambling is further confused by the lack of readily available, intuitively understandable information on RTP rates. Indeed Turner (2011a) argues that in all cases commercial games are set up to make it hard for the players to realize the house edge (even if it is textually described as a percentage). Lotteries have a substantial house edge and are characterised by a combination of extreme volatility and well advertised winners (availability heuristic). Alternatively, table games have a small house edge, large bets, a strong illusion of skill and low volatility which support the illusion of control. EGMs, however, have enough volatility to hide a moderate house edge (e.g., 10%), but still are low enough in volatility to produce winning streaks, potentially influencing a range of cognitive biases (misattribution of skill vs. luck, superstitious behaviours). Our current results add to the existing body of literature informing of the ways in which game design can obscure the long-term outcomes for players, specifically how a series of small wins experienced as streaks mask long term losses (Turner & Shi, 2015).

Limitations and future directions

Given the simplicity of our simulated game, it is unclear how well the results generalize across the different varieties of actual gambling games. The finding that winning streaks are more common for low volatility games is interesting and novel. There are games that are relatively low in volatility (such as multi line games covering all the lines), and their appeal may be partly linked with longer winning streaks. Still, the parameters of actual games should be tested to assess whether our current results do generalize. In this paper we have visualized simulations with 10 or more hours of play. Most people play for short periods of time, but go back after short sessions, which results in more cumulative hours played. Our simulations are applicable not only for "non-stop" playing but also for accumulated hours of play over longer time periods (in terms of multiple sessions over many days, months, or years). Thus, the outcome of 30 h of play would be essentially the same if done in 10 sets of three hours, in two sets of 15 h, or in one set of 30 h.

To further flesh out the nature of EGM winning streaks, future studies should program actual EGM games and measure their streak frequency, length, and intensity across different game decisions (e.g., covering a single line, or all lines). Gamblers could also be interviewed on their gambling habits and experiences of winning streaks, and whether winning streaks are experienced more frequently when playing low volatility games.

Simulations also have significance for games with an element of skill (e.g., sports betting, poker), but the topic is severely under-studied. Recent developments in online sports betting, including in-play betting and combination bets (Parke & Parke, 2019) have resulted in increased experience of gambling harm. It may be that these products are becoming more akin to EGMs than traditional forms of sports betting (see also Newall, Russell, & Hing, 2021; Newall, Russell, Sharman et al., 2021). However, few studies have explored the volatility of sports betting, likely because there is no standardized gambling experience (other than maybe parlay bets) to study. That is, people can make a variety of different within game bets so each player's experience (and the volatility) would be different. Sports betting also theoretically has an element of skill, though this is mitigated by the way the industry sets the odds or the line. Studies of sports gamblers suggest they typically overestimate the role of skill in the game (see Cantinolli, Ladouceur, Jacques, 2014; Mercier et al., 2018). To our knowledge there are very few existing works that apply simulations to understand skill in sports betting, which would be an intriguing venue for future work.

Based on simulations, Palomäki, Laakasuo, Cowley, and Lappi (2020) argued that in poker, equally skilled players (based on pre-defined theoretical long-term win rates and their standard deviations) will likely have widely different results over tens or even hundreds of thousands of hands played. The ability to accurately recognize one's "true skill" is profoundly masked by outcome variability, and simulations are an excellent way to highlight this. In addition, skill in a poker game as well as other skilled games is always relative to the skill of the other players. That is, someone with mediocre skill will likely win against novice players but be easily beaten by highly skilled players (Turner & Fritz, 2001).

Finally, the graphical output presented herein offer a comprehensible and easy to access method by which such information can be communicated to EGM players, thereby illustrating the overall futility of the game. Exposing individuals to the experience of random chance was shown to effectively improve their understanding of it (Donati, Primi, & Chiesi, 2014; Primi & Donati, 2022; Turner, Macdonald, & Somerset, 2008, Turner, Macdonald, Bartoshuk, & Zangeneh, 2008). Indeed, such methods have been found to be effective in altering players' perceptions and improving overall understanding of how slot machine games operate (Newall, Russell, & Hing, 2021; Newall, Russell, Sharman et al., 2021; Newall, Byrne et al., 2022; Newall, Walasek, & Ludvig, 2022; Newall, Walasek, Ludvig et al., 2022; Turner, Robinson, Harrigan, Ferentzy, & Jindani, 2018). Utilising the graphical output of this work (see also Turner et al., 2018) would build upon recent work examining effectiveness of gambling messages which include information about volatility and RTP, offering an alternative strategy to traditional textual messaging (Newall, Byrne et al., 2022; Newall, Walasek, & Ludvig, 2022; Newall, Walasek, Ludvig et al., 2022). In addition to public, or untargeted messaging, they may also be a useful aid in more targeted treatment interventions, for example those which address maladaptive cognitions.

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Conflicts of interest: Authors JP and NT have no conflicts of interest. Author SC works a part time private practitioner clinical psychologist at Addiktum Clinic Helsinki, Finland, treating mainly individuals with addiction problems, and at Mehiläinen Medical Center, Forum Helsinki, where she offers treatments to various psychological issues. She is a clinical advisor to the Canadian company Alavida, Vancouver (remote/internet treatment for alcohol disorder). She also trains professionals to treat gambling disorder with evidence-based methods as a part of her duty at the Finnish Institute for Health and Welfare, and addictions in general privately. She has received fees from Helsinki University, Tampere City, Vocational school Stadi, Lundbeck, the Finnish Association of Addiction Medicine, the Finnish Association on Intellectual and Developmental Disabilities (FAIDD), and Mehiläinen for her lectures on behavioural addictions and for training professionals, and writer's fees from the Finnish Medical Society Duodecim, Finnish Medical Journal and Myllyhoitoyhdistys ry. She received fees from Svenska Spel (Sweden) for evaluating grant proposals, and Tampere University for preliminary examination of PhD work. She declares no conflict of interest in relation to this manuscript. JM has received fees from the Finnish NGO EHYT and the Euro Lotteries association for speaking on the convergence between video games and gambling.

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