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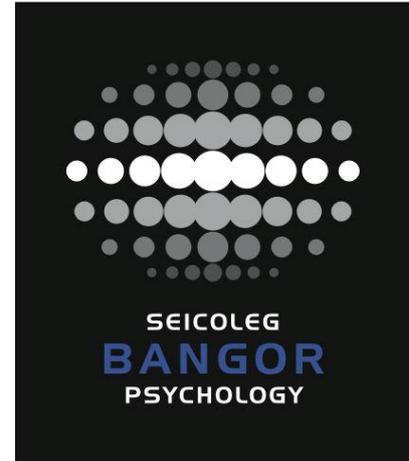
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A scoping investigation of eye-tracking in Electronic Gambling Machine (EGM) play

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Disclosure Statement

All authors declare no financial relationships with any other organisations that might have an interest in this work; and no other relationships or activities that could appear to have influenced the work.

Executive Summary/Abstract

The nature of the association between Electronic Gambling Machines (EGMs) and gambling problems remains uncertain. Eye-tracking offers a potentially powerful method to understand how individuals attend to the visual displays and features of machine games as a function of machine experience, use of other commercial gambling products, the degree to which some game features capture players' attention and, critically, vulnerability to problematic patterns of machine play. Characterizing machine players' attention to machine games may aid the design of harm-minimization measures such as, but not limited to, pop-up messages and visible clocks; and provide an important ancillary measure for testing their efficacy.

Here, we conducted the first study to use eye-tracking to improve our understanding of how machine players attend to EGM displays in local bookmaker offices (LBOs) situated across North West England, as well as North East and North Wales. Through liaison with 4 bookmaker operators, we recruited a sample of 118 LBO customers who, first, completed a small number of questionnaires about their gambling history and other gambling activities and, then, completed a typical machine gambling session with their own money while wearing eye-tracking glasses to capture eye-movement pattern. The protocol captured regions of gaze fixation while playing (B2) roulette or (B3) slots on B category machines (Gambling Commission, 2012). The final dataset consisted of 91 eye-tracking recordings: 59 games of roulette and 57 slots games.

Our principle dependent measure was the percentage of fixations of visual features and machine display locations (as areas of interest; AOIs) as an objective indicator of overt visual attention and their importance to machine players. Our data analysis included statistical correction for differences in the relative size (display area) and display duration across AOIs. To summarise, our main findings are as follows:

- In roulette, 56.3% of LBO machine players' fixations were distributed over the chip-placement area while placing bets (in the stationary states of the game), rising to 75.1% while the roulette wheel

spun in the moving states of the games). Machine players looked at their credit balance 7.2% of the time while placing bets, only slightly more frequently than the previous winning number at 6.8%.

- In slots games, the slot-reels dominated machine players' visual attention: accounting for 53.6% of fixations while placing bets, rising to 91.7% while spinning. Players' fixations of their credit-balances amounted to 14% of the total while placing bets but only 5.1% while the slot-reels spun.
- Fixations away from the machine were more frequent while placing bets in both roulette and slots games: 13.5% and 13.4% respectively, dropping to 2.4% and 1.1% while the wheel/slot-reels spun.
- Players' age and years of education were only weakly related to fixation patterns while playing roulette or slots games. Unemployed players allocated fewer fixations over the chip-placement area (both while the roulette wheel was stationary and while it spun) and over the slot-reels while placing bets; they also tended to look away from the machine more while placing bets in roulette.
- Frequent machine players tended to look at the roulette wheel less frequently than infrequent users while playing roulette games; involvement in other forms of gambling tended to increase attention towards credit balance but was not otherwise linked to particular patterns of fixations.
- Finally, problems gamblers allocated fewer fixations to the roulette wheel while placing bets and while it spun compared to non-problem gamblers; and tended to look away from the machine more frequently; in slots games, problem gamblers looked more frequently at amount-won messages.

These data describe, for the first time, the distributions of machine players' overt attention while navigating roulette and slots games in a commercial settings. In general, fixation counts showed the least variability for moving visual features and events that are likely to capture attention automatically, such as spinning

roulette wheels or spinning slot-reels. However, fixations were also concentrated upon visual features and elements with relatively less 'attentional capture' such as the chip-placement-area while placing bets in roulette and looking at credit balances in both games. Associations between patterns of fixation and both frequency of past-month expenditure on B category machines and broader gambling involvement were modest, suggesting that most of the variability in eye-movements and fixations reflects players' navigation through the sequenced behaviours of placing bets and monitoring spinning roulette wheels or slot-reels in anticipation of game outcomes. Players with extensive machine experience tended to discount slightly the roulette wheel as a visual feature; while players with broader patterns of gambling activity looked at credit balances frequently, suggesting that such individuals are mindful of available credits.

Players with gambling problems allocated fewer fixations over the chip-placement-area while placing bets and while watching the wheel spun compared to non-problem gamblers, suggesting that placing of bets can be accomplished with less attentional focus. These individuals were also more likely to look away from the machine altogether, suggesting that, in roulette play, gambling problems might be associated with a loosened attentional focus to events elsewhere in the shop. However, in slots games, problems gamblers' attended to the reward signals of previous games (amount-won) when placing the next bets.

So far as we are aware, these data are the first to show that eye-tracking methodology has some potential to offer insights into machine-player interactions, and to provide a bias-free measure of individual differences in attention to games' visual features and events as a function of their experience with gambling machines, gambling background and vulnerability to gambling-related harms. This study offers a methodology for studying and optimizing the timing, placement and content of harm-minimization messaging.

Introduction

Much of the debate about gambling regulation (including in the United Kingdom; UK) continues to focus upon the association between the availability of Electronic Gambling Machines (EGMs) and gambling problems (Productivity Commission, 2010). However, the nature of this association remains uncertain (Blaszczynski, 2013). On the one hand, structural characteristics of games offered on machines – high rates of play, high-value stakes (Crewe-Brown, Blaszczynski, & Russell, 2013) and prizes (Rockloff & Hing, 2013), and volatility (Turner, 2011) – may increase the likelihood of players' sustaining gambling harms. On the other hand, the association could reflect the accessibility and use of EGMs by individuals at risk of gambling harms for other reasons (Blaszczynski, 2013; Currie et al., 2006; Dowling, 2005; Pickernell, Keast, Brown, Yousefpour, & Miller, 2013; Storer, Abbott, & Stubbs, 2009). Notwithstanding these uncertainties, harm-minimization measures have been implemented for EGMs in a number of jurisdictions (Gainsbury, Blankers, Wilkinson, Schelleman-Offermans, & Cousijn, 2014; Harris & Griffiths, 2016) and, in the UK, by the Association of British Bookmakers' (Code for Responsible Gambling/Player Protection (<https://www.abb.uk.com/new-abb-code-for-responsible-gambling-and-player-protection-2013/>)).

One way to learn more about the above issues is to understand better how players interact with EGMs; and to use eye-tracking to characterize players' visual attention across machine displays and consoles during sessions of play. One advantage of this method is that individuals are often unaware of their eye movements (Martinez-Conde, Macknik, & Hubel, 2004; Shepherd, Findlay, & Hockey, 1986) and, therefore, eye-tracking offers outcome measures that are not susceptible to participant- or observer-bias (that can arise with self-report questionnaires or direct observation). Eye-tracking has been used to measure patterns of eye movements in a range of applied environments including marketing, usability research (Duchowski, 2003); health warnings for tobacco (Kessels & Ruiter, 2012; Krugman, Fox, Fletcher, & Fischer, 1994; Peterson, Thomsen, Lindsay, & John, 2010; Strasser, Tang, Romer, Jepson, & Cappella, 2012; Wedel & Pieters, 2008) and alcohol use (Fox, Krugman, Fletcher, & Fischer, 1998; Melaugh

McAteer, Curran, & Hanna, 2015; Thomsen & Fulton, 2007), healthy food-purchasing (Graham & Jeffery, 2012), video-games (Zammitto & Steiner, 2014). For example, laboratory and field studies of tobacco purchasing behaviours have used eye-tracking to show (i) that visual attention is powerfully drawn to point-of-sale advertising and promotional material (Bansal-Travers, Adkison, O'Connor, & Thrasher, 2016); (ii) that attention towards warning messages can be minimal (Crespo, Cabestrero, Gzrib, & Quiros, 2007; Fischer, Richards, Berman, & Krugman, 1989; Krugman et al., 1994; Maynard et al., 2014; Peterson et al., 2010); (iii) that attention towards warning messages can be improved but involve complex interplay between the characteristics (e.g. visual contrast) of text, graphics and plain packaging (Fox et al., 1998; Krugman et al., 1994; Lochbuehler et al., 2016; Peterson et al., 2010); and (iv) that individuals' memory for health warnings is improved to the extent that they capture visual attention (Crespo et al., 2007; Fischer et al., 1989; Krugman et al., 1994; Strasser et al., 2012); see Wedel & Pieters (2008) for review.

Binde (2014) highlights eye-tracking as a potentially useful method to investigate individuals' attention towards gambling ads and promotions (Binde, 2014). However, there have been no peer-reviewed studies of eye-tracking with machine gambling or associated harm-minimization measures. EGMs deliver highly dynamic and salient configurations of visual (and auditory) stimuli that convey a rich variety of game features and gambling cues (Harrigan, Collins, Dixon, & Fugelsang, 2010) Eye-tracking offers an implicit, bias-free way to measure players' attention to these cues as they navigate through roulette or slots games.

There are at least two other benefits of exploring eye-tracking as a method to understand machine gambling. First, recent analyses of large datasets have characterized a range of transactions between players and EGMs in terms of stakes, net expenditure and session length, as well as linked situational (e.g. time of day) and geographical factors (Wardle, Ireland, Sharman, Excell, & Gonzalez-Ordenez, 2015). Furthermore, complementing earlier studies of small clinical samples of problem machine players (Breen & Zimmerman, 2002; O'Connor & Dickerson, 2003), other data have characterized some of the complex

transactions that might indicate problematic patterns of machine gambling in 'loyalty card' customers: higher stakes placed during frequent machine gambling sessions and broader patterns of gambling involvement (Wardle, Excell, Ireland, Ilic, & Sharman, 2015). Despite these advances, little is known about how EGM players attend to, and process, machine displays as a function of player experience and gambling involvement, the degree to which some visual features (or events) capture players' attention and, critically, the extent to which variability in attention is associated with potentially harmful patterns play.

Second, eye-tracking may offer methods to better understand how players interact with harm-minimization measures implemented in EGMs (Ladouceur & Sevigny, 2003, 2009; Parke, Harris, Parke, Rigbye, & Blaszczynski, 2014). For example, in addition to precommitments to expenditure- and time-limits (Blaszczynski, Gainsbury, & Karlov, 2014), pop-up messages may offer benefits as 'interrupt signals' to pause EGM games and support individuals in controlling their play (Stewart & Wohl, 2013). At the current time, the evidence for pop-up messages as effective harm-minimization measures in EGM play is moderate (Blaszczynski, 2013; Nower & Blaszczynski, 2010). However, they seem to work best with self-referential content that re-focuses players' thoughts towards their own behavior (Monaghan & Blaszczynski, 2010a) and when they have dynamic features rather than static features (Monaghan & Blaszczynski, 2010b). While retrospective reports suggest that pop-up messages are more memorable when positioned centrally (Gainsbury, Aro, Ball, Tobar, & Russell, 2015a), so far as we are aware, their development has not been informed by eye-tracking data. Learning more about EGM players' eye-movements and attention towards game displays could aid the design of messaging, and other interactive precommitment measures.

Eye-tracking as a method

The human eye makes approximately three movements (saccades) per second (Carpenter, 1999). Saccades are punctuated by periods of fixation which enhance the processing priority of a visual stimulus by positioning it within the part of the retina with the highest resolution, the fovea. Information is transmitted

through the optic nerve at speeds equivalent to around 875,000 bits per second (~12MB) per eye to the brain for further processing (Koch et al., 2006). Tracking the spatial and temporal distributions of fixations offers objective measures of important physiological and psychological processes (van Gompel, 2007; Wade & Tatler, 2005); for example, the number of fixations of an object can be read as an indicator of its attentional importance (Fitts, Jones, & Milton, 1950; Jacob & Karn, 2003). As such, eye-tracking can be used to measure 'overt' visual attention; that is, eye-movements that position high-priority visual stimuli within the fovea for further processing (Liversedge & Findlay, 2000; Steinmetz & Moore, 2012).

Historically, several methods (of varying intrusiveness) have been used to capture eye-movements (Duchowski, 2003). However, modern devices, such as the eye-tracking glasses employed in this study, use pupil-center corneal reflection (PCCR) to estimate gaze location. In these devices, LEDs transmit near-infrared light on to the eyes, and a camera captures its reflection from the cornea. This reflectance information is then used to estimate the location of the pupil center, and gaze direction and fixated area in the visual scene using a 3D eye-model algorithm (see <http://www.tobii.com/learn-and-support/learn/eye-tracking-essentials/how-do-tobii-eye-trackers-work/>). Eye-tracking using PCCR can be implemented in light, unobtrusive glasses that participants can wear comfortably. The resultant eye-gaze data is co-registered with videos of the visual scene to provide in situ behavioural measurements.

Our study

Here, we conducted an exploratory study to test eye-tracking as a way to understand how bookmaker customers attend to EGM displays in local bookmaker offices (LBOs) situated across North West of England, North East and North Wales. Through liaison with 4 bookmaker operators (see below), we recruited a sample of LBO customers who, first, completed a small number of questionnaires about their gambling history and other gambling activities and, then, completed a typical machine gambling session

with their own money while wearing eye-tracking glasses to capture fixation counts and playing (B2) roulette or (B3) slots games on Fixed-Odds-Betting Terminals (FOB-T) (Gambling Commission, 2012).

We had three specific objectives:

1. At a descriptive level, to use eye-tracking to characterise the distribution of fixation counts and, therefore, overt attention, over the game features of roulette (as a B2 game) and slots (as a B3 game);
2. To scope the extent to which the distribution of fixations over visual displays of roulette and slots differ as a function of a few selected demographic features, machine experience and broader gambling patterns.
3. Finally, to test the preliminary hypothesis that machine players with gambling problems show differences in fixation patterns over some visual features compared to machine players with fewer problems.

Methods

The experiment was approved by Bangor University Research Ethics Committee (School of Psychology). All participants provided written, informed consent.

Participants

One hundred and eighteen LBO customers were recruited through liaison with 4 operators (Coral, Betfred, William Hill and Ladbrokes). Individuals were eligible to participate if they reported normal or corrected vision/acuity and an absence of neurological illness and history of head injury. At the study outset, additional selection criteria were set by reference to the median game expenditures and session durations reported in a large survey of transactional data collected from 4 major operators in the United Kingdom (Wardle, Ireland, et al., 2015); the intention being to recruit customers who might generate eye-tracking

recordings long enough to afford detailed assessments of the eye-tracking methodology. LBO customers were eligible to participate if (a) their typical net expenditures-per-session were between £5 (the median expenditure reported in Wardle et al, 2015) (Wardle, Ireland, et al., 2015) and £70 (the 90th percentile) and (b) their typical gambling session durations were between 4min (the median length in Wardle et al, 2015) and 15min (the 90th percentile). Fifty three customers, satisfying these criteria, were identified by managers of 26 LBOs located within the North West of England and Wales; the managers arranging appointments with the researchers in the shops. In addition, another 65 customers who attended the LBOs to use the machines were recruited opportunistically while the researchers were present. These latter participants were not recruited with reference to the session-expenditure and duration criteria above.

Although we did not request, or have access to, participants' actual (and typical) expenditures-per-session and their (typical) session durations, all participants were asked to provide estimates. However, interpreting these numbers was problematic. Ten participants and 18 participants failed to provide identifiable expenditure-per-session estimates and session duration estimates, respectively. Instead, these participants provided only interval estimates (e.g. 'between £10 and £20' or '5min to 10min'), upper boundary or occasionally undefined estimates ('up to £20' or 'as long as it lasts'); these did not clearly satisfy or clearly fail to satisfy the criteria specified above. Nonetheless, of the remaining 49 operator-recruited participants, 2 reported expenditures-per-session that were identifiable as lower than £5 while 6 reported expenditures greater than £70. Similarly, of the 59 opportunistically-recruited participants who provided interpretable estimates, 2 reported expenditures clearly lower than £5 while 8 reported expenditures greater than £70.

Similarly, of the 45 operator-recruited and 56 opportunistically-recruited participants who provided interpretable estimates, 21 in each group reported session durations that were clearly longer than 15min. None of these participants reported session durations that were less than 4min. There were no statistically significant differences between the numbers of operator-recruited participants and opportunistically-

recruited participants who reported expenditures-per-session or session durations above or below the criteria set at the outset of the study (all χ^2 s < .9, p s \geq .418). The broader characteristics of participants recruited through the operators and those recruited opportunistically were very similar; however, the former group played their eye-tracking sessions with smaller starting stakes (£6.48 vs £9.71; p < .05). None of our participants used the Association of British Bookmakers' Player Protection measures (<https://www.abb.uk.com/new-abb-code-for-responsible-gambling-and-player-protection-2013/>).

Twenty seven whole-session eye-tracking recordings were removed because of (i) failure to calibrate the glasses (n = 14); (ii) lost calibration during the recording (where participants touched or removed the glasses; n = 2) (iii); poor quality recordings because of poor eye health (cataracts; n = 1; thick lens; n = 1); (iv) choice of game other than roulette or slots (e.g. Blackjack, Bingo, Virtual Greyhound Racing, Laquelle; n = 7); (v) participant non-compliance (n = 1); and (vi), corrupted eye-tracking files (n = 4).

This left 91 eye-tracking recordings that included a total of 59 games of roulette (B2 games) and 57 games of slots (B3) that could be prepared for further analysis. Fifty-two participants played roulette and 39 played slots. Only 4 participants played both roulette and slots while being recorded; 4 played 2 different roulette games; 7 played 2 slots games; 3 played 3 slots games; and, 1 participants played 6 slots games.

Demographic and psychometric measurements

Demographical information, including age, years of formal education and employment status, were collected. Overwhelmingly, our sample describe themselves as British-White but included one Asian individual, one Romanian individual and one Greek individual, precluding any analysis involving ethnicity. Participants were asked (i) whether they held operator loyalty cards (and frequency of use); (ii) how often they had visited LBOs in the previous 4 weeks, the typical time of day and reason for visiting; (iii) how often they had spent money playing gambling machines (to derive a measure of frequency of machine

play); and (iv), to indicate the number of other gambling products/forms that participants had spent money on in the previous 4 weeks (from a list of 19 items) (to derive a measure of broader gambling activity).

Participants completed the Problem Gambling Severity Index (PGSI)(to provide a measure of last-year gambling problems (PGSI)(Ferris & Wynne, 2001). The PGSI consists of a 9-item scale of salient manifestations of gambling problems (Ferris & Wynne, 2001). Each item carries a score of 0 to 3, providing an aggregate index score between 0 and 27. A Canadian population study of 25,000 gamblers demonstrated good validity for the distinction between non-problematic and problematic gamblers (scores ≥ 8) but recommended a distinction between low-risk ($1 \leq \text{scores} \leq 4$) and moderate-risk gamblers ($5 \leq \text{scores} \leq 7$) (Currie, Hodgins, & Casey, 2013). Here, there were insufficient numbers of participants to assess low- and moderate-risk participants separately. Therefore, we used the accepted binary categorisation of PGSI scores at the cut-off score of equal or greater than 8 (see below).

Participants also answered questions about their alcohol use, whether they had ever sought or consulted a psychologist or psychiatrist (to obtain a marker of general mental distress), and completed several other questionnaires about state affect and attentional function. In the main, the associations between these measures and the eye-tracking measures were modest; some of them will be reported separately.

Procedure

Following the taking of consent, acquisition of demographic and background information and the completion of the PGSI, participants were asked to try on a pair of Tobii 2 eye-tracking glasses (TOB-GP2 Premium; <http://www.tobii.com/product-listing/tobii-pro-glasses-2/>).

These glasses perform video-based eye-tracking using dark pupil and corneal reflections, sampling at a rate of 50 Hz (or one sample every 20ms). At the start of recording, a system guided one-point calibration was

performed to ensure accurate recording of eye-gaze data. Video footage of participants' visual fields was also recorded by the Tobii Pro Glasses 2. The on-board camera has a recording resolution of 1920 x 1080 pixels and a recording angle of 82° x 52°, recording at 50Hz. Eye-tracking data were relayed to a small recording unit clipped to participants' belt or person, saving the data to an SD card. Eye-gaze and scene video were transmitted wirelessly to a DELL Windows 8/8.1 Pro tablet, allowing the researchers to withdraw away from participants at the machine and to monitor compliance remotely.

Once comfortable, participants were invited to play their 'usual' session on a FOB-T/machine inside the shop using their own money and for as-long-a-duration as preferred. This could involve any roulette (B2) or slots game (B3) or switches between roulette and slots. Participants were free to cease playing when they wished (i.e. there was no minimal time period for play). On completion of the recording, participants were given £20 Amazon or Love2Shop vouchers, thanked for their participation, and discharged.

Data analysis

The final data set consisted of 94,535 fixations. These data were prepared for analysis in 5 stages:

(i) Screenshots of the games recorded were examined to identify areas of interest (AOIs) as the spatial areas around objects and visual features (e.g. roulette wheels). The validity of AOIs was cross-checked through consultation with the game development team of S-G gaming (<http://www.sg-gaming.com/>);

(ii) Since fixations are rapidly drawn towards movement in the visual field (Galletti & Fattori, 2003), the eye-tracked recordings of both roulette and slot games were divided into 2 segments: one while the roulette wheel or slots reels were stationary ('stationary states' during which players selected and placed bets or interacted with game features); and one while the roulette wheel or slots reels were spinning ('moving states' during which players watched the wheel/slot-reels spin while waiting to learn game outcomes,

looking elsewhere in the LBO or, at any rate, while being less likely to interact directly with the machine).

For slots, segments of recordings involving bonus features (that varied between games) were removed.

(iii) Fixations were identified as those with (a) dwell-times > 60ms and (b) velocity < 30°/s. Fixations closer to each other than 0.5° within 75ms were merged and counted singly. Fixation counts within each AOI across the recordings were then coded manually and independently by two researchers.

(iv) Given that recordings varied in length across participants, and that fixation counts will (inevitably) increase with recording length, fixation counts within each AOI were expressed as proportions of the total counts per recording in the stationary or moving data segments; i.e. they were expressed as the proportion of participants' fixations that fell within an AOI out of the total number of fixations counted per recording;

(v) *Selection of AOIs for analysis.* Visual inspection of the mean proportionate fixation counts across the 33 roulette AOIs and 34 slots AOIs were used to identify subsets of 11 AOIs that showed the greatest proportion of fixations or greatest variability in both the spinning or stationary game states. For roulette, these AOIs were chip-placement-area; credit-balance; the roulette wheel; odds information; amount-bet; the start/spin-button; winning-number; amount-won; previous-numbers; repeat-previous-bet; and; 'Off-device' (i.e. fixations away from the machine altogether). For slots, AOIs were amount-bet-per-spin; auto-play; change-bet; gamble-on feature; credit-balance; the slots-reels; the start/spin-button; the prize/top information-panel; the amount-won on winning plays; total-won; repeat-previous-bet; and 'Off-device'.

(vi) *Normalisation of proportionate fixation counts.* The proportions of fixation counts across AOIs (in the stationary and moving game states) provide indicators of overt visual attention towards the features of B2 and B3 displays. However, visual inspection of the proportionate fixation counts showed very high values for some AOIs and very low values for others. Saccades across the visual scene are constant (Duchowski,

2003). Consequently, under normal viewing conditions, fixations can (by chance) be expected to fall more frequently within large AOIs than small AOIs, increasing counts simply as a function of greater spatial extent. Similarly, a few AOIs (e.g. 'winning number' in roulette games and 'amount-won' in roulette and in slots games) appeared only infrequently in comparison to AOIs that were continuously visible, diminishing their fixation counts as a function of their time in view. Therefore, we corrected for some of these effects by dividing the raw proportionate fixation count of each AOI by a 'normalization factor': the product of two quantities that code an AOIs' spatial extent and the length of time it was visible during the recording:

1. a 'spatial correction factor' for an AOI as its proportion of the total display size (in pixels);
2. a 'temporal correction factor' for an AOI as the proportion of time it was visible across the recording.

This correction, while coarse, has the beneficial effect of re-weighting the data so that fixations of small AOIs or other AOIs, such winnings amounts, that appeared only intermittently gain stronger expression as a proportion of spatial extent and their availability. For example, consider two relatively small AOIs (the credit-balance and the amount-won). The raw proportion of fixation counts for the credit-balance in a game of slots might be 0.1799. Its spatial correction factor might be 0.0134 (since its extent was 9939 pixels out of the 74, 0538 for the visual display) while its temporal correction factor might be 1.0 (since it was available throughout the entire game). Dividing the raw proportion counts of 0.1799 by the product of the spatial and temporal correction factors (0.0134 x 1.0) generates a normalized fixation score of 13.42.

Now, take Amount-won AOI for roulette, with a raw proportionate fixation count of 0.0028. Its spatial correction factor might be 0.0054 (where, for example, its spatial extent in the display was 4109 pixels out 75,7212 pixels). Its temporal correction factor, however, might be 0.1086 (where, for example, it was visible for only 38s out of 353s of the recording). Dividing the raw proportion counts of 0.0027 by the product of the spatial and temporal correction factors (0.0054 x 0.1086 = 0.0543) generates a normalized

fixation score of 4.62. Thus, in this instance, the normalization process rescales the raw proportionate fixation counts so that fixations of a small or only occasionally visible AOI are comparable with slightly larger but continuously visible AOI. Cross-checks of the two researchers' estimates of the spatial and temporal correction factors for randomly selected AOIs demonstrated good consistency for roulette games [$r(596) = .96, p < .001$; $r(15) = .98, p < .001$] and slots games [$r(596) = 0.75, p < .001$; $r(15) = .81, p < .001$].

(vii) Finally, summary measures of game transaction data were coded as (a) total cash value staked in the recording; (b) total cash value returned; (c) total net value returned; (d) participants' mean balance during the recording; and (e) the maximum peak balance during the eye-tracking recording. These values were cross-checked across the participants' transaction data provided by the operators.

Multi-level modelling. Normalised fixation counts were used in exploratory analyses to assess differences in fixation patterns in the stationary and moving game states using 1-sample and paired t-tests and to assess, in a preliminary way, inter-participant differences in fixation patterns as a function of some basic demographic characteristics (i.e. gender and age), frequency of machine play, broader gambling involvement, transactional data, and indicators of gambling problems/harms. With a large number of dependent measures, the probability of Type I errors (false-positives) is high. Therefore, we confined our exploratory analysis to a restricted set of 4 AOIs for each of the roulette and slots games that accounted for the clear majority of fixations across the eye-tracked recordings but which also showed significant variability that might be linked to our predictor variables (see below). For roulette, the 4 AOIs were the chip-placement area; the roulette wheel; the credit-balance and Off-device; and, for slots games, the 4 AOIs were the slot-reels; the credit-balance; the amount-won (when it was presented) and Off-device.

Normalised fixation scores for these AOIs were entered into univariate General Linear Models (GLMs), with participant and game (where there was more than one per participant) included as random components

	N	Gender (M:F)	Age	Yrs of. educ.	Empl'd	Unempl'd	Ret'd	Other forms	PSGI	Median transaction values		
										Recording length	Total £s staked per recording	Net £s expenditure
Roulette	52	47:5	47.19(2.20)	11.90(0.33)	30	14	8	6.28(0.79)	6.44(0.80)	4'45(0.59s)	25.8(21.50)	£3.20(6.50)
Slots	39	22:11	41.92(2.53)	11.54(0.43)	27	8	8	5.15(0.44)	3.72(0.59)	5'32(0.96s)	16.20(9.63)	£5.00(5.76)

Table 1. Sample characteristics of LBO customers who contributed at least one eye-tracking recording while playing roulette or slots games (or both) on a B2 machine terminal. Mean yrs. of educ.= years of education; Empl'd= employed; Unempl'd= unemployed; Ret'd= retired; Other forms= other gambling forms summed over last 4 weeks; PGSI= Problem Gambling Severity Index (Ferris & Wynne, 2001). Gambling transaction data are expressed in medians: recording length; total £s staked in recording and net expenditure. Standard Errors in brackets.

of the intercept. To avoid over-fitting, two models were constructed. First, one model tested age, years of education, and employment (modelled as a categorical variable with 'unemployed', 'retired' and then 'employed' as a referent). There were too few females in the sample to test for gender differences. Second, another model tested for frequency of machine use and involvement in other gambling forms. (Additions to this model first tested other customer characteristics, such as whether or not participants held loyalty cards, as well as transactional data including the total value staked, net value returned, mean balance and maximum balance.) Finally, we included the presence of gambling problems, coded as a binary categorisation of PGSI scores with and 'non-problem' as the referent below a cut-off score of 8.

The above models yield β -coefficients and their standard errors. These were tested for statistical significance as t-statistics with estimated degrees of freedom. All statistical analyses were completed with the normalized fixation scores; however, the results described below and presented in the figures are expressed in percentages. We have picked out only those patterns of fixations that are both expressed in the raw proportion fixations and confirmed in the regression models run over the normalized fixation scores.

Results

Roulette

Fifty two participants contributed 56 roulette eye-tracking recordings. Their demographic and psychometric characteristics are shown in Table 1. This sample played for almost 5min, staking a median of £25.80, with a net expenditure of £3.20, and included 5 female, 14 unemployed and 8 retired participants; 18 participants scored as problematic gamblers (Currie et al., 2013; Ferris & Wynne, 2001).

Distribution of fixations. Fixation patterns in the stationary and moving states of roulette games are shown in Figure 1A and B, ordered from the most to the least-fixated AOI, left to right. (The insets show the normalised fixation scores). In stationary states (while placing bets), participants distributed 56.3% of their

fixations towards the chip-placement area (95% CIs: 52.7% to 60.0%) and 7.0% of their fixations towards the wheel (95% CIs: 5.3% to 8.7%). Participants' fixations of the credit-balance amounted to 7.2% of the total in the stationary state (95% CIs: 6.2% to 8.2%). This is comparable to the percentage fixations of the previous winning numbers (6.8%; 95% CIs: 4.9% to 8.7%) but significantly more than fixations of the current bet staked ('Amount-bet', 3.5%; 95% CIs: 2.8% to 4.3%), and the option to repeat the previous bet (2.0%; 95% CIs: 1.5% to 2.5%; $t(55) = 7.62 < t_{(55)} < 7.27, p < .0001$). Fixations of the games' odds information, winning numbers of the previous play, and amount won were negligible ($< 1.5%$). As against the above, participants looked away from the machine for about 13.5% of the time (95% CIs: 10.0% and 16.9%).

Unsurprisingly, in the moving states, participants' attention was drawn towards the roulette wheel as it spun, accounting for 75.1% of fixations (95% CIs: 69.4% to 80.8%), a significant increase compared to the stationary states ($t(55) = 12.61, p < .0001$). Fixations of the chip-placement area (at 17.3%; 95% CIs: 12.3% to 22.3%), credit-balance (at 2.1%; 95% CIs: 0.1% to 3.2%), previous winning number (1.2%; 95% CIs: 0.1% and 0.2%), and amount-bet (1.3%; 95% CIs: 0.0% and 0.2%) all showed significant reductions compared to their values in the stationary states ($3.20 < t_{(55)} < 5.88, \text{all } p < .0001$). Fixations away from the machine dropped by 11% to just 2.4% (95% CIs: 1.0% to 3.8%; $t(55) = 6.96, p < .0001$). Fixations of the odds information, winning number of the previous game, and start button were effectively zero.

Roulette fixations against participant characteristics. Next, fixations of the chip-placement area, roulette wheel, credit-balance and 'off-Device' were regressed against predictor variables that coded for demographics, machine gambling frequency, other gambling activities and gambling problems.

Demographic factors. Fixation patterns were not systematically related to age ($-0.099(.059) < \text{all } \beta < 0.104(.072)$) or years of education in either game state ($-0.408(.325) < \text{all } \beta < 0.019(.014)$). However, unemployed participants tended to look at the chip-placement area less often than employed participants

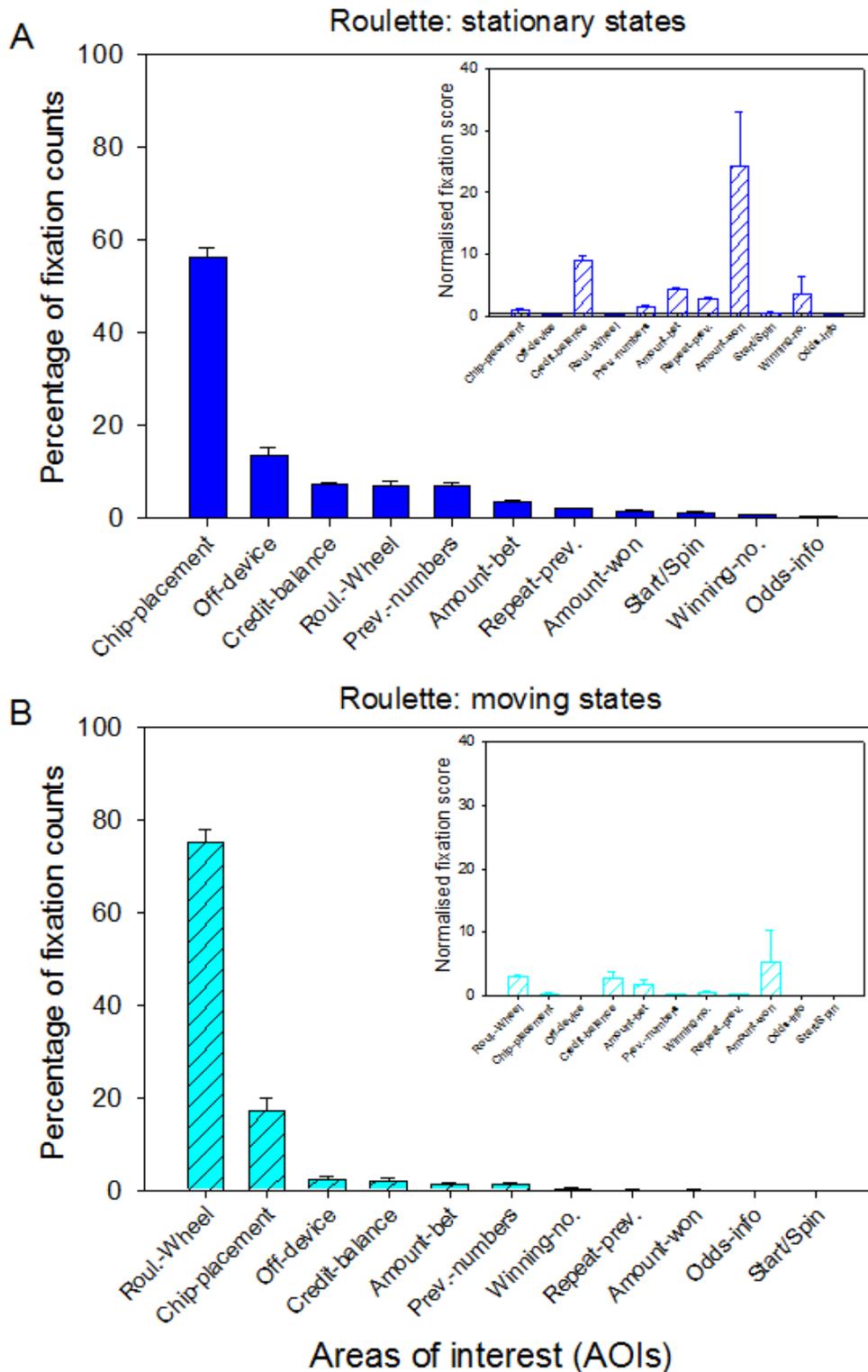


Figure 1. Mean fixation percentages, and standard errors, within 11 defined areas of interest (AOIs) acquired while 56 participants LBO customers played 59 B2 roulette games in situ on LBO gambling machine. AOIs are ordered from the most to the least-fixated AOIs, left-to-right. A Stationary game states (solid bars) while participants placed bets; B. Moving game states (hatched bars) while the Roulette Wheel spun. (Inset: the normalised fixation scores that reweight fixation counts as scores).

while placing bets ($\beta = -0.173(0.090)$; $t(45.830) = -1.913$; $p = .062$) and, significantly so, while watching the wheel spin (Appendix Figure 1B; $\beta = -0.260(0.116)$; $t(49.150) = -2.239$; $p = .0297$). Unemployed participants also looked away from the machine between plays significantly more frequently than employed participants while placing bets ($\beta = 0.103(0.042)$; $t(47.500) = 2.475$; $p = .017$).

Machine experience and gambling profile. Frequent machine players fixated the roulette wheel less often while placing bets (in the stationary game states) than infrequent machine players (see Table 2A; Appendix Figure 2A; $\beta = -0.184(0.062)$; $t(47.700) = -2.942$; $p = .005$) and while watching the roulette wheel spin (in the moving game states)(see Table 2B; Appendix Figure 2B; $\beta = -1.309(0.489)$; $t(48.700) = -2.677$; $p = .010$). In addition, while placing bets in the stationary game states, participants who reported a high number of other gambling activities looked at the credit-balance more than those reporting fewer gambling activities (Appendix Figure 3A; $\beta = 0.552(0.249)$; $t(51.000) = 2.221$; $p = .0308$).

Loyalty cards and transactional factors. Fixation patterns did not vary systematically between participants who held loyalty cards and those who did not in either the stationary or moving game states ($-1.744(1.988) < \text{all } \beta\text{s} < 1.962(1.478)$). Participants' fixations across the roulette AOIs did not show any systematic relationships with the total staked over the recording, final (net) return, mean credit- balance throughout the recording or maximum balance in either state ($-0.027(0.017) < \text{all } \beta\text{s} < 0.020(0.028)$).

Gambling problems. Participants with problematic patterns of gambling (indexed by PGSI scores ≥ 8) looked at the chip-placement area less often than participants with non-problematic gambling patterns while placing bets in roulette (Table 2A; Figure 2A; $\beta = -0.176(0.087)$; $t(47.260) = -2.02$; $p = .0489$) and while watching the wheel spin (see Figure 2B; $\beta = -0.227(0.114)$; $t(48.330) = -1.99$; $p = .0523$).

A				
<u>Stationary states</u>	Intercept	High frequency machine customer	Sum of other gambling activities	Problem-gambling
Chip-placement-area	1.164(0.073)	0.053(0.083)	-0.007(0.013)	-0.175(0.087)
Roulette-wheel	0.224(0.055)	-0.184(0.062)	0.009(0.010)	0.110(0.066)
Credit-balance	6.234(1.411)	-0.145(1.597)	0.552(0.249)	-1.118(1.676)
Off-device	0.136(0.036)	0.051(.041)	-0.007(0.006)	0.079(0.043)

B				
<u>Moving states</u>	I	High frequency machine customer	Sum of other gambling activities	Problem-gambling
Chip-placement-area	0.321(0.094)	0.202(0.108)	-0.005(0.017)	-0.227(0.114)
Roulette-wheel	3.336(0.431)	-1.309(0.489)	0.012(0.076)	0.037(0.514)
Credit-balance	1.824(1.856)	0.933(2.113)	0.194(0.327)	-0.813(2.222)
Off-device	0.015(0.015)	0.003(0.017)	0.000(0.003)	0.029(0.018)

Table 2. Regression coefficients (β s) and standard errors (SEs) for (normalised) fixation proportions within 4 defined areas of interest (AOIs) acquired while 52 participants played roulette games on B category machines in situ in LBOs. High frequency machine play= having spent money 'every day' or 'most days of the week' over the previous 4 weeks (compared to 'some of the time', 'rarely' or 'never'); sum of other gambling activities= the summed total of up to 19 land-based and online gambling forms participated in within the last 4 weeks; Problem-gambling= participants recording a Problem Gambling Severity Index score equal or greater than 8 (Ferris & Wynne, 2001).

A. Stationary states while participants placed bets; **B.** Moving states while the roulette wheel was spinning. Bold text: $p < .05$.

Slots

Thirty nine LBO customers contributed 57 slots eye-tracking recordings. Their demographic and psychometric characteristics are shown in Table 1; 15 were female, 8 unemployed and 2 retired participants; 18 participants scores as problematic gamblers (Currie et al., 2013; Ferris & Wynne, 2001). This sample of customers played for between 5 and 6 min, staking around £16.20 over the recordings.

Distribution of fixations. Eye-fixation in the stationary and moving states of the slots games are shown in Figure 3A and B. In both game states, participants allocated more fixations towards the slots-reels than any of other visual feature. Specially, while placing bets, participants distributed 53.6% of their fixations towards the reels (95% CIs: 48.2% and 58.9%) and 14.0% towards their credit balance (95% CIs: 11.3% and 16.6%); the latter comparable to the percentage of fixations directed away the machine at 13.4% (95% CIs: 9.4% and 17.5%). Of the remaining AOIs, participants looked most often at the amount won AOI (when presented) at 5.8% (95% CIs: 4.3% to 7.3%), a percentage significantly greater than the option to change stake at 3.4% (95% CIs: 2.3% to 4.5%), the information/prize panel at 2.7% (95% CIs: 1.3% to 4.1%), the amount currently bet at 2.6% (95% CIs: 1.6% and 3.7%) and the auto-play option at 2.1% (95% CIs: 1.2% and 2.9%) ($t(56) < 3.252$, all $p < .005$). Fixations of the start/spin button accounted for 1.8% (95% CIs: 1.0% to 2.8%). Fixations of the total won and gamble-on options were negligible.

In the moving states, once the reels had begun to spin, participants' fixations of the reels rose by another 38% compared to the stationary state to 91.7% of all fixations (95% CIs: 89.3% and 94.0%; $t(56) = -14.81$, $p < .0001$). Fixations of the credit-balance and fixations away from the machine altogether were diminished to 5.1% (95% CIs: 3% to 7.2%) and 1.1% (95% CIs: 0% to 2.0%) respectively, both significant reductions ($t(56) = 5.918$, $p < .0001$ and $t(56) = 6.029$, $p < .0001$). Fixations of the remaining game features – the option to change stake, auto-play, start/spin button, amount bet, total won and Gamble-On – capped at 1%.

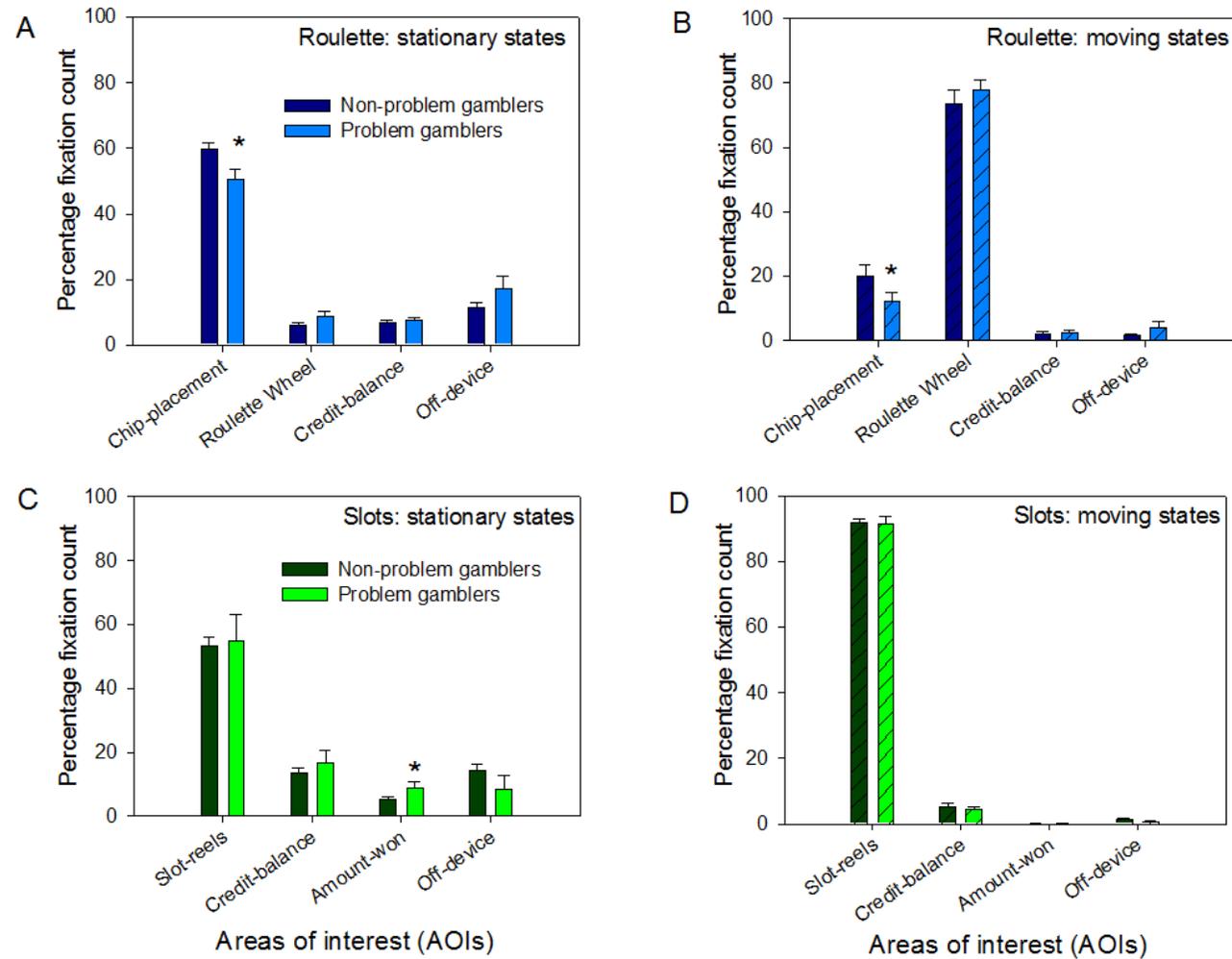


Figure 2. Fixation percentages for 4 areas of interest (AOIs) acquired while LBO customers played roulette (A and B; blue) and slots games (C and D; green) on B category machines as a function of problematic compared to non-problematic gambling. Problem-gambling= Problem Gambling Severity Index score equal or greater than 8 (Currie et al., 2013; Ferris & Wynne, 2001). Proportions are shown for stationary game states (A and C; while placing bets; solid bars) and moving states (B and D; while watching wheel or reels spin; hatched bars).

Slots fixations and participant characteristics. Fixations counts of 4 AOIs (slot-reels, credit-balance, amount-won and Off-device) were regressed against demographic features, machine gambling experience, participation in other gambling forms, summary transactions data, gambling problems (see Table 3).

Demographic factors. Participants' fixations of the slot-reels were slightly reduced with years of education in both the stationary game states and in the moving states although not quite significantly so ($\beta = -0.048(0.028)$; $t(32.180) = -1.717$, $p = .095$ and $\beta = -0.046(0.026)$; $t(41.460) = 1.745$, $p = .088$, respectively). Unemployed participants made fewer fixations of the slot-reels in the stationary states than employed participants (Appendix Figure 1C; $\beta = -0.374(0.170)$; $t(37.090) = -2.194$; $p = .035$).

Machine experience and gambling profile. Frequent machine users showed a near-significant trend to allocate more fixations towards the slot-reels in the stationary state compared to infrequent machine users although not quite significantly so (Appendix Figure 2C; $\beta_s = 0.221(0.128)$; $t(25.130) = 1.722$; $p = .098$). Otherwise, frequency of machine gambling was not associated with fixation patterns across the slots games (Table 3; $-6.6093(11.351) < \text{all } \beta_s < 0.133(0.117)$). Similarly, fixation patterns were not associated with the number of other gambling forms in the stationary or moving states ($-0.120(0.776) < \text{all } \beta_s < 1.611(1.975)$).

Loyalty cards and transactional factors. Loyalty card holders did not show any marked changes in the distribution of their fixations towards the game features or away from the machines in either of the stationary or moving states compared to participants without loyalty cards ($-0.463(0.768) < \text{all } \beta_s < 16.35(15.13)$). Similarly, as with the roulette games, fixations across the slot AOIs did not vary with the (i) total money staked over the eye-tracking recording; (ii) mean credit-balance throughout the recording or (ii) maximum balance in either state ($-0.083(0.464) < \text{all } \beta_s < 0.057(0.148)$). However, there was a very small reduction in fixations away from the machine while the slot-reels were spinning during sessions that delivered larger compared to smaller net returns ($\beta = -0.0007(0.0001)$; $t(43.120) = -6.001$; $p < .0001$).

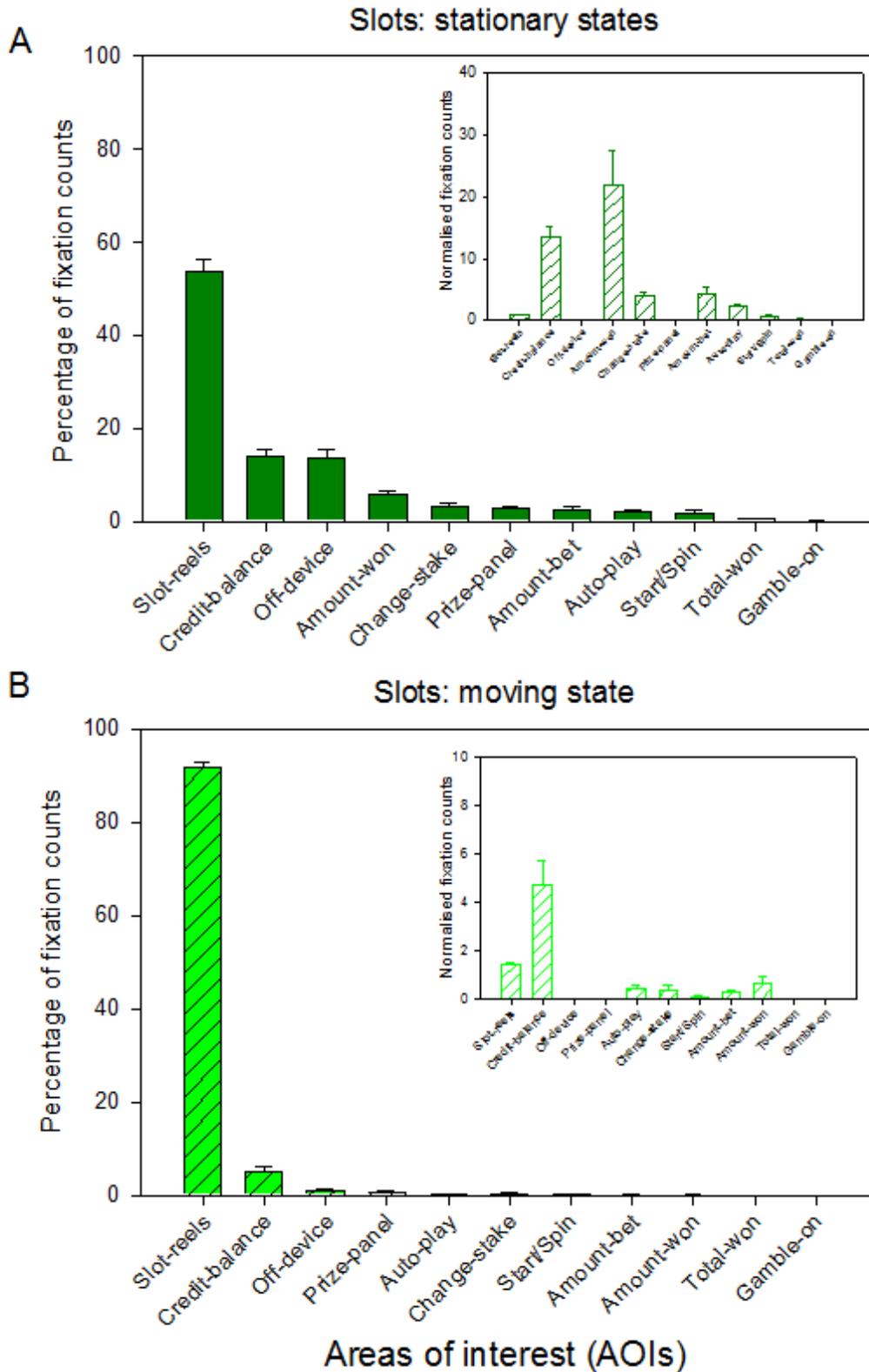


Figure 3. Mean fixation percentages, and standard errors, within 11 defined areas of interest (AOIs) acquired while 39 participants played 57 B3 slots games in situ on LBO machine. AOIs are ordered from the most to the least-fixated AOIs, left-to-right. A Stationary game states (solid bars) while participants placed bets on the machine; B. Moving game states (hatched bars) while the slots-reels spun. (Inset: the normalised fixation scores that reweight fixation counts as scores). * $p < .05$.

Fixation patterns and gambling problems. Participants with problematic patterns of gambling (i.e. PGSI scores ≥ 8) showed comparable fixation counts over the slot-reels and the credit-balances in both the stationary and moving game states (see Table 3). Fixations away from the machine were also comparable ($-0.029(0.176) < \text{all } \beta\text{s} < 2.629(6.057)$). However, problem-gamblers did allocate more fixations towards the amount won signals while selecting bets (see Figure 2C; $\beta = 52.746(15.384)$; $t(22.365) = 3.429$; $p = .002$).

Discussion

EGMs offer games with a rich variety of dynamic game features realised through arrays of powerful visual (and auditory) stimuli (Harrigan et al., 2010). To our knowledge, this study is the first to use eye-tracking to describe how gamblers attend to these stimuli in-situ of local bookmaker offices (LBOs).

Our design has several strengths. First, in contrast to a significant number of investigations of machine play involving (for example) student populations (Floyd, Whelan, & Meyers, 2006; Ladouceur & Sevigny, 2003), our sample consisted of LBO customers recruited on the basis of previous machine use or who had visited the LBO shops on that day to use EGMs. Second, our data collection took place in LBOs rather than laboratories so that, to some extent at least, our eye-tracking recordings will have captured the regular eye-movements and fixations driven by machine gambling in distracting, busy shop environments.

Third, we compensated our participants with Amazon or High Street vouchers (at a standard value of £20) and asked them to pay for their machine sessions using their own money rather than with operator credits. Possibly, our participants discounted the value of their stakes against the value of the voucher payments. However, while the median lengths of the data recordings were slightly longer than those of typical LBO sessions (4'45s and 5'32s for B2 and B3 games, respectively, compared to published estimates of 3'18s and 3'57s) (Wardle, Ireland, et al., 2015), or participants' net expenditures were reduced (£3.20 and £5.00

A				
Stationary states	Intercept	High frequency machine customer	Sum of other gambling activities	Problem-gambling
Slot-reels	0.826(0.142)	0.221(0.128)	-0.006(0.023)	-0.029(0.176)
Credit-balance	15.408(4.673)	-1.909(4.480)	-0.1203(0.776)	2.629(6.057)
Amount-won	7.918(11.957)	-6.609(11.351)	1.611(1.975)	52.746(15.384)
Off-device	0.134(0.043)	-0.018(0.038)	-0.000(0.001)	-0.000(0.059)
B				
Moving states	Intercept	High frequency machine customer	Sum of other gambling activities	Problem-gambling
Slot-reels	1.384(0.131)	0.135(0.117)	0.007(0.022)	-0.085(0.159)
Credit-balance	8.531(2.647)	-3.124(2.489)	-0.432(0.449)	0.548(3.366)
Amount-won	1.462(0.731)	-0.960(0.646)	-0.102(0.118)	0.804(0.897)
Off-device	0.009(0.010)	-0.008(0.009)	0.001(0.002)	-0.007(0.012)

Table 3. Regression coefficients (β s) and standard errors (SEs) for (normalised) fixation proportions within 4 defined areas of interest (AOIs) acquired while 39 participants played slots games on category B machines in situ in LBOs. High frequency machine play= having spent money 'every day' or 'most days of the week' over the previous 4 weeks (compared to 'some of the time', 'rarely' or 'never'); sum of other gambling activities= the summed total of up to 19 land-based and online gambling forms participated in within the last 4 weeks; Problem-gambling= participants recording a Problem Gambling Severity Index score equal or greater than 8 (Ferris & Wynne, 2001).

A. Stationary states while participants placed bets; **B.** Moving states while the roulette wheel was spinning. Bold text: $p < .005$.

compared to £6.31 and £6.37). This suggests that our recordings captured relatively low-expenditure machine sessions. However, leaving this possibility aside, these design features of our study enhance its so-called 'ecological validity' (Anderson & Brown, 1984) and its potential to inform the field.

Finally, our statistical analyses incorporated a 'purpose-built', rigorous normalization procedure to re-weight the fixations counts of small visual features (and their AOIs) or visual features that appeared intermittently against larger visual features or those visual features that were visible throughout the recording. We have highlighted only those findings that are evident in both raw fixation counts (in the text and figures) and which remain statistically robust following our normalization procedure.

Our results include three key findings:

First, and for the first time, these data describe the distributions of machine players' overt attention while navigating roulette and slots games, either in real commercial gambling environments. Roulette affords a larger range of betting options than slots games, and this is expressed clearly in their comparative fixation counts. While placing bets in roulette (in the stationary game states), participants allocated just over half of their fixations towards the chip-placement-area but only 7% to the stationary roulette wheel. However, while watching the wheel spin (in the moving states), this balance of attention reversed dramatically, with fixations of the chip-placement area falling to 17% but fixations of the wheel increasing to over 75%. By contrast, in slots games, 53% of player fixations fell upon the reels while placing bets, rising to 91% while the reels spun; indicating that players' attention was especially dominated by the slots reels in games' moving states; possibly, reflecting their greater apparent velocity than spinning roulette wheels.

Participants' attention towards their credit-balance was also increased in the slots games compared to roulette: 14% (while placing bets) and 5.3% (while watching the reels spin) compared to counts of 7.2%

and 2.1% respectively, possibly reflecting the higher frequency of credit adjustments per unit time in slots-games. By contrast, shifts of attention away from the machine were comparable in roulette and slots games; at just over 13% while placing bets in both, but dropping to 2.4% and 1.1% while watching the wheel and reels spin respectively, suggesting comparable levels of attentional capture across B2 and B3 games.

In general, the 95% confidence intervals thrown around the mean percentage of fixations tended to show the narrowest range for moving game features that are likely to capture and draw attention from other locations 'exogenously' (Doshi & Trivedi, 2012; Galletti & Fattori, 2003), such as spinning roulette wheels (a range of 11.4%) or spinning slot-reels (a range of 4.7%). However, the confidence intervals were also constrained for visual features with relatively less attentional capture such as the chip-placement area while placing bets in roulette (7.3%), looking at credit balances in both game states in both games (3.3%) and even looking away from the machines altogether (6.1%). Most likely, these constrained distributions of fixations reflects participants' navigation through sequenced series of behaviours to play the games; e.g. inspection of certain features, (such as the chip-placement area) when placing bets to monitoring the displays (while the roulette wheel or slots-reels spin). Nevertheless, our exploratory analyses suggest that eye-tracking over EGM play is sensitive to potentially important differences in player characteristics.

Demographic features and gambling profile

Significant evidence indicates that gambling participation and gambling problems can vary across demographic groups and with socio-cultural factors (Wardle et al., 2011). Here, we found that, controlling for age and years of education, unemployed players' showed fewer fixations of the chip-placement area in roulette games (in both states), but also tended to look away from the machine more frequently, compared to employed participants. Unemployed participants also showed fewer fixations of the slot-reels while placing bets. These findings need to be treated with some caution because of the low number of unemployed participants in both the roulette and slots samples. Survey data suggest that unemployed status

is associated with more likely EGM play in multiple venues and more vulnerable to gambling-related harms (Wardle, Sutton, Philo, Hussey, & Nass, 2013). Possibly, our unemployed participants were more frequent visitors to particular LBOs than our employed participants and, therefore, more likely to 'break off' from their ongoing machine play to talk to other customers and/or attend to events elsewhere in the shop. In addition, EGM gambling is more frequent in individuals with lower levels of educational attainment compared to individuals with comparatively higher levels of attainment (Wardle et al., 2011; Wardle et al., 2013). Here, participants with more years of education showed only a statistically non-significant tendency to make fewer fixations of the slot-reels (in both game states) than participants with fewer years, suggesting that slots play in the former group may be weakly associated with less attentional focus of the slot-reels but, possibly, greater involvement with other interactive game features.

Frequency of EGM play (Currie et al., 2006; Wardle et al., 2011), as well as broader gambling activities (Laplante, Nelson, Labrie, & Shaffer, 2009), is linked to increased rates of gambling problems. In this study, associations between different patterns of fixation across visual features and both frequency of past-month expenditure on B category machines and broader gambling activities were modest. Nonetheless, frequent machine players showed fewer fixations of the roulette wheel (in both game states), suggesting that individuals with extensive machine experience tend to discount the roulette wheel as a game feature. By contrast, machine play frequency made little difference to the allocation of fixations in the slots games, probably reflecting the smaller repertoire of betting options and features compared to roulette. Finally, while playing roulette, participants with broader patterns of gambling activity than machines tended to look at credit balances more frequently than those with restricted gambling patterns, especially while placing bets. This suggest that individuals who gamble in ways other than EGMs are mindful of available credit.

Eye-tracking and gambling problems

Finally, substantial evidence suggest an association between machine gambling and the incidence of gambling problems (Breen & Zimmerman, 2002; McCormick, Delfabbro, & Denson, 2011; Storer et al., 2009); however, this association remains poorly understood (Blaszczynski, 2013; Dowling, 2005).

Gambling problems involve a heightened attentional bias towards, and emotional responses to, gambling-related stimuli (Balodis, Lacadie, & Potenza, 2012; Brevers, Cleeremans, Tibboel, et al., 2011; Potenza et al., 2003), with some evidence that people with gambling problems show more rapid saccades and longer dwell-times over gambling related cues (Brevers, Cleeremans, Bechara, et al., 2011). Here, in actual LBO environments (and controlling for frequency of previous machine play and extent of other gambling activities), individuals with gambling problems allocated fewer fixations over the chip-placement-area while placing bets and while watching the wheel spun compared to non-problem gamblers. Possibly, problem gamblers find placing of bets can be accomplished with less attentional focus. However, these individuals were more likely to look away from the machine altogether, suggesting that, in roulette play, gambling problems is associated with a broadening of attentional focus to events elsewhere in the shop.

Problematic patterns of slots play have been linked to heightened experiences of absorption, slowing shifts of attention to stimuli spatially displaced from the machine (Diskin & Hodgins, 1999) and distracted states involving, in extremis, a lost sense of time and place (Schüll, 2012; Stewart, & Wohl, 2013). Here, we found that problem gamblers distributed more fixations over the signals of amount-won on previous (winning) games. This suggests that, notwithstanding heightened absorption, problems gamblers' overt attention is captured by the reward signals of play outcomes as they consider their next bets.

These preliminary findings suggest that eye-tracking methods can be used to investigate changes in overt attention towards game features in both Category B roulette and slots games. Future studies will be able to use the above methodology to extend the current findings by achieving tighter control of potential

confounding variables; for example, comparing visual fixation between problem and non-problem gamblers matched for frequency of playing (i.e., familiarity and practice).

Eye-tracking and harm-minimization measures

Finally, the present data may inform the development of responsible gambling measures, visible clocks and pop-up messaging as a way to pause play and support individuals in controlling their play (Blaszczynski et al., 2014; Monaghan & Blaszczynski, 2010a, 2010b; Nower & Blaszczynski, 2010). Pop-up messages appear to have their greatest effects with dynamic rather than static features (Gainsbury et al., 2015a; Monaghan & Blaszczynski, 2010b) and while carrying self-referential content to refocus players' thoughts on their own behavior (Monaghan & Blaszczynski, 2010a; Stewart & Wohl, 2013). Pop-up messages also appear to be most memorable when centrally placed in EGM displays (Gainsbury et al., 2015a), possibly reflecting peoples' bias to attend to the central features of visual scenes (He & Kowler, 1989). First, our data demonstrate that it should be possible to use eye-tracking methods to quantify how much overt attention machine players pay to harm-minimization measures, such as visible clocks and pop-up messages; and to assess the strength of associations between patterns of fixations (as overt attention) and betting behaviors in different groups of gamblers (e.g. those at risk or not at risk of gambling harms).

Second, the proportionate fixation counts calculated here for each AOI captures the probability that machine players' fixations fall upon particular visual features in either the stationary game states (while players are placing bets) and moving states (while the roulette wheel or the slot-reels are spinning). AOIs with high percentage fixation counts indicate game features that command more attention than AOIs with low percentages of fixation counts. Thus, these likelihoods could be used to understand why some form of messaging might have greater impacts than others and in certain groups. For example, pop-up messages that emphasize expenditure may have larger behavioural impacts than messages with other content (Gainsbury, Aro, Ball, Tobar, & Russell, 2015b). Here, we observed that individuals with broader pattern

of gambling involvement (beyond B category machines) looked more frequently at their credit balance while placing bets, especially in roulette, suggesting that credit or expenditure-based messages delivered in stationary states may have more efficacy in these individuals than in other groups of gamblers.

Study limitations

We acknowledge that our study has several limitations. First, although our sample size seems to have been large enough to specify eye-movements over different visual features of roulette and slots games with reasonable precision, it was not large enough to support anything other than exploratory analyses of individual differences in relation to demographic, customer history or clinical factors. In particular, we were not able to test for important differences in the effects of gender or ethnicity, both of which have been linked to rates of gambling problems in larger surveys (Wardle et al., 2011; Wardle et al., 2013).

Second, the selection of participants with expenditures-per-session and session durations that fell between the median and 90th percentile values reported by Wardle et al, 2015 was applied only to the 53 participants identified by local LBO managers but not the 65 participants recruited opportunistically. This raises the possibility of lower or more variable expenditures and session durations in the latter compared to the former participant groups. Consistent with this, the participants recruited by the LBO managers played with smaller starting stakes than the participants recruited opportunistically. While the majority of both the operator-recruited and opportunistically-recruited participants (and to a similar extent) self-reported that their typical expenditures-per-session fell within our pre-specified criteria, their estimated session durations were mostly longer. Therefore, future studies of eye-tracking in EGM play should seek to access actual player-tracked expenditures and session durations to achieve better control of machine involvement.

Third, we acknowledge that our data do not tell us anything about eye-movements around the recently implemented Responsible Gambling/Player Protection (<https://www.abb.uk.com/new-abb-code-for->

responsible-gambling-and-player-protection-2013/)(Miers, 2015). None of our participants elected to use these measures, and dismissed them with only a very small number of fixations of the protection features. Most likely, the process of introducing our protocol in the LBOs and calibrating the glasses diverted some participants from using the protection measures when they would otherwise have done so; it is hard to be certain. However, just as eye-tracking in the present study provides new information about how people attend to visual features in roulette and slots games, it could in future be used to understand the role of attention in using Player-Protection measures, testing their efficacy, perhaps, leading to better design.

Fourth, eye-tracking affords multiple outcome measures (Duchowski, 2003). Here, we focused upon the fixation counts of AOIs drawn over roulette and slots game features, as a measure of how important a visual might be in terms of how much attention it can draw (Fitts et al., 1950; Jacob & Karn, 2003). However, we could have looked at dwell-times or even transitions between AOIs. Many eye-tracking outcome measures are highly covariant (Henderson, 2003), making the value of these other measures uncertain. Nonetheless, it is possible that there are important inter-individual differences in the *length of time* that eye-gaze remains positioned over visual EGM features as a function of vulnerability to gambling harms and/or absorption that further work can explore with this study's dataset. Finally, we acknowledge that, while our normalization procedure and statistical analysis corrected for the confounding effects that some visual features were much smaller than others, or were displayed for shorter intervals of time than others, it did not correct for differences in visual saliency (e.g. luminance, texture) or the effects of auditory stimuli that can influence the processing of visual information (Keetels & Vroomen, 2011).

Notwithstanding these limitations, this is the first investigation of eye-tracking to characterize EGM players' (overt) attention to the visual features of roulette and slots games in real commercial (bookmaker) environments. Most of the variability in the distribution eye fixations reflects players' navigation through the sequenced behaviours of placing bets and the monitoring the machine displays for play outcomes.

Nevertheless, these data also suggest that, controlling for frequency of machine use and gambling involvement, eye-tracking over EGM play is sensitive to important differences in player characteristics, including their vulnerability to gambling-related harms, perhaps offering opportunities to improve the design of harm-minimization measures and their evaluation in the field.

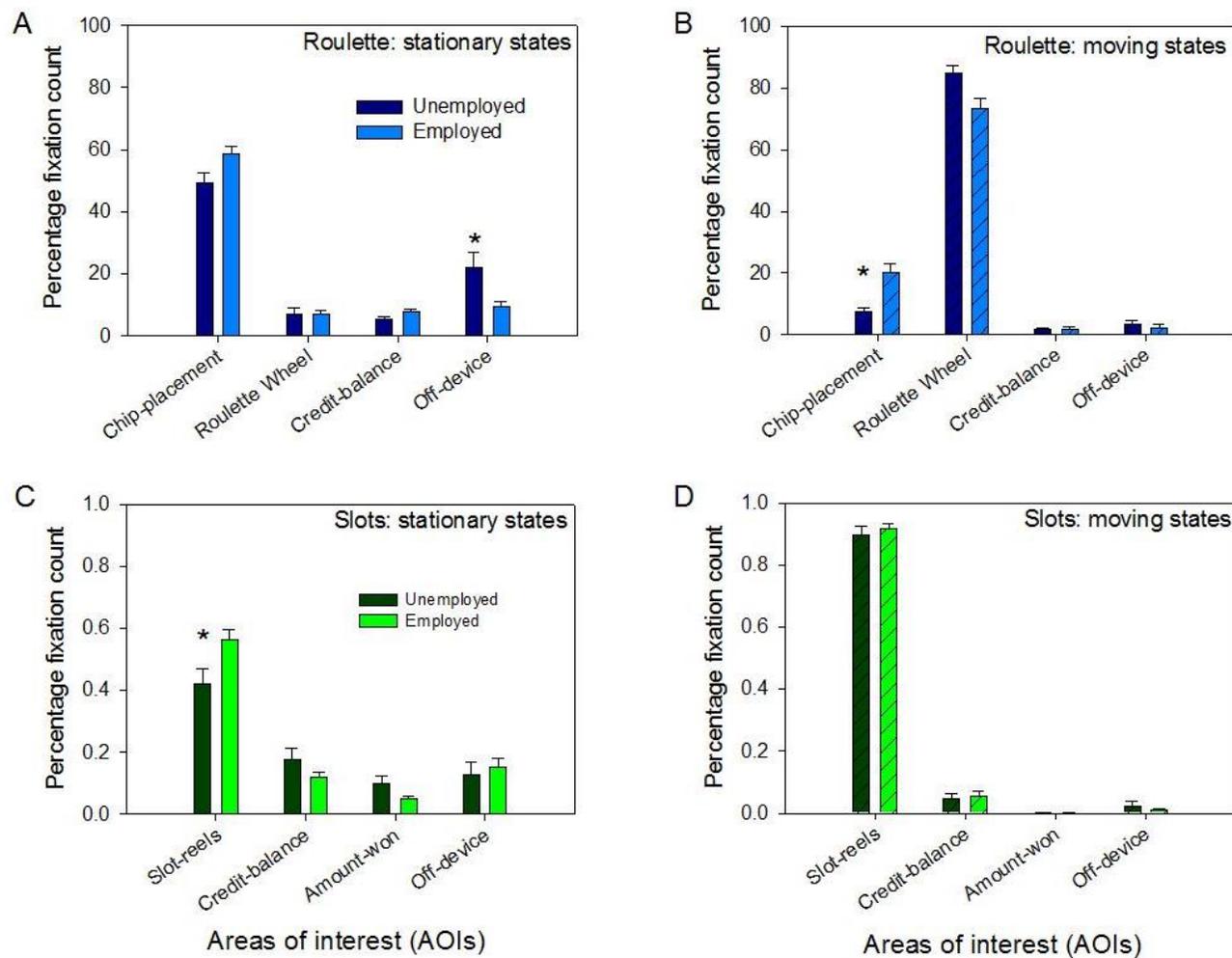
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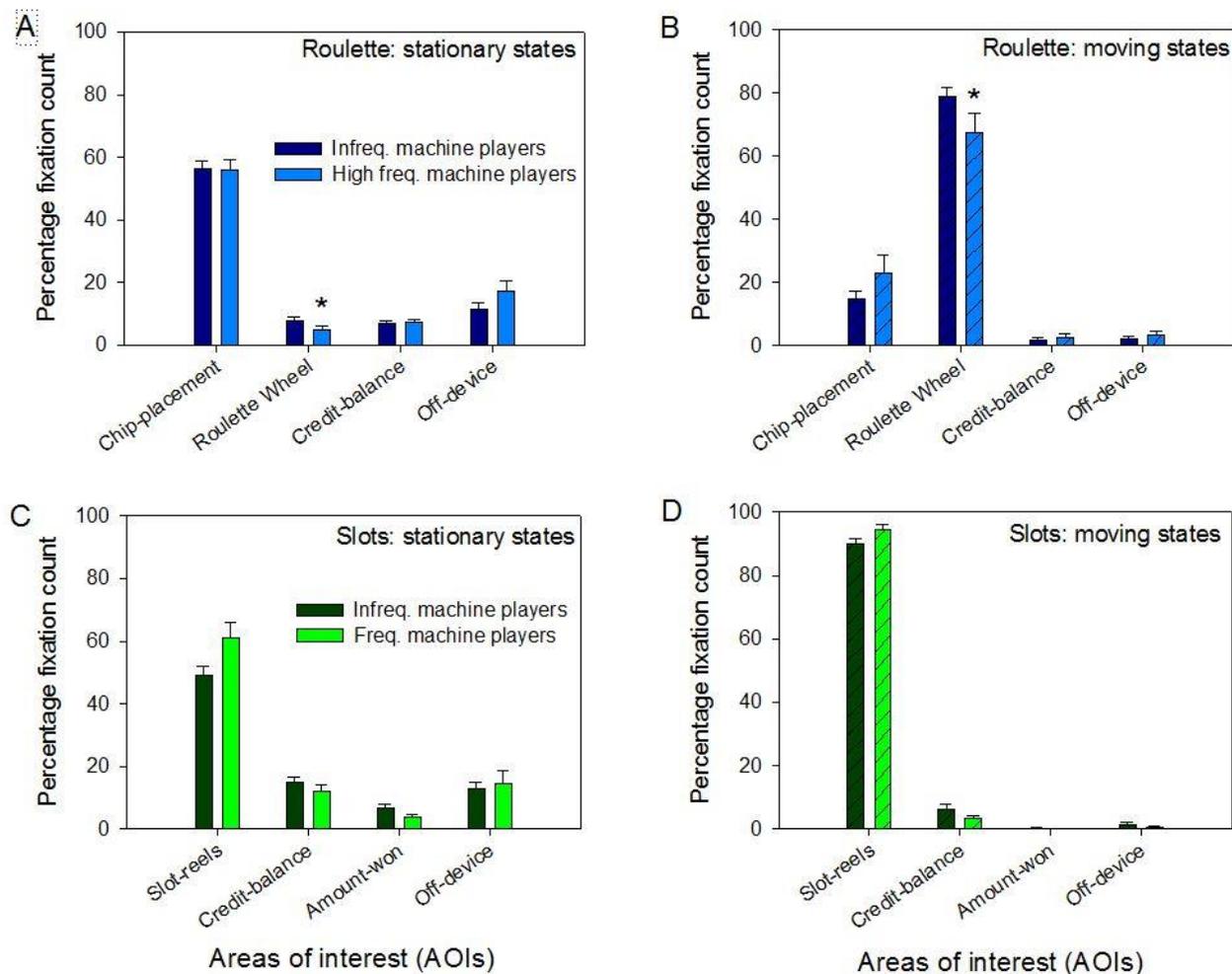
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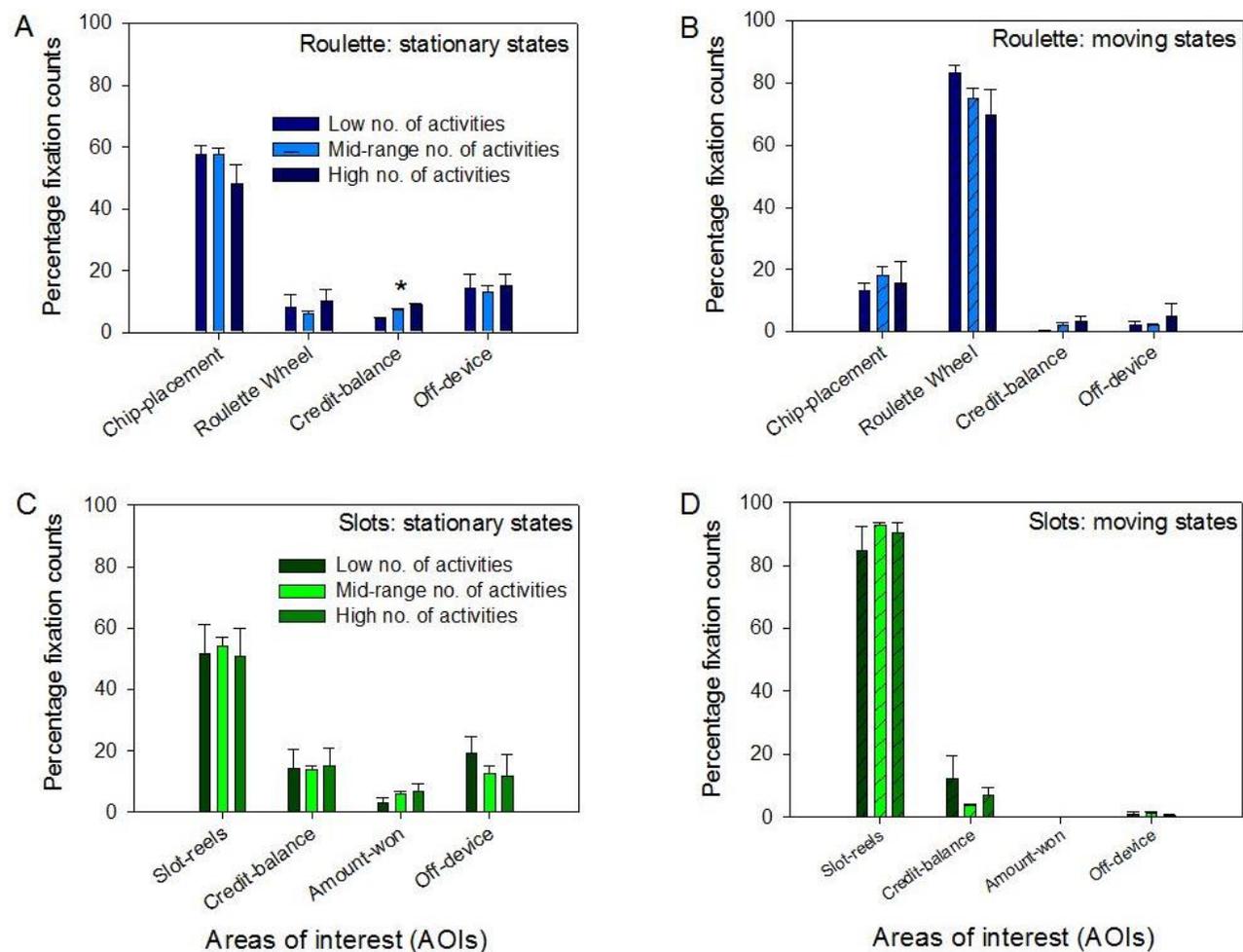
Appendix



Appendix Figure 1. Fixation percentages within 4 defined areas of interest (AOIs) acquired while LBO customers played roulette (A and B; blue) and slots games (C and D; green) on B category machines as a function of employment status (unemployed/employed). Proportions are shown for stationary game states (A and C; while placing bets; solid bars) and moving game states (B and D; while watching wheel or reels spin; hatched bars). * $p < .05$.



Appendix Figure 2. Fixation percentages within 4 defined areas of interest (AOIs) acquired while LBO customers played roulette (A and B; blue) and slots games (C and D; green) on B category machines as a function of frequency of machine play. High frequency machine play= having spent money 'everyday' or 'most days of the week' over the previous 4 weeks (compared to 'some of the time', 'rarely' or 'never'). Proportions are shown for stationary game states (A and C; while placing bets; solid bars) and moving game states (B and D; while watching wheel or reels spin; hatched bars). * $p < .05$.



Appendix; Figure 3. Fixation percentages within 4 defined areas of interest (AOIs) acquired while LBO customers played roulette (A and B; blue) and slots games (C and D; green) on B category machines as a function of other gambling activities, as the summed total of up to 19 land-based and online gambling forms in the last 4 weeks. For illustrative purposes, the sample is grouped as those with summed activities less than 1 standard deviation (SD) below the sample mean (Low); by those with summed activities greater than 1 SD more than the mean (High) and the remainder (Mid-range). Proportions are shown for stationary game states (A and C; while placing bets; solid bars) and moving states (B and D; while watching wheel or reels spin; hatched bars). *p < .05.