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Statistical risk warnings in gambling

PHILIP W.S. NEWALL*
Experimental Gambling Research Laboratory, School of Health, Medical and Applied Sciences, CQUniversity, Melbourne, VIC 3000, Australia
LUKASZ WALASEK
Department of Psychology, University of Warwick, Coventry, CV4 7AL, UK
ARMAN HASSANNIAKALAGER
University of Bath, Claverton Down, Bath, BA2 7AY, UK
ALEX M.T. RUSSELL
Experimental Gambling Research Laboratory, School of Health, Medical and Applied Sciences, CQUniversity, Sydney, NSW, Australia
ELLIOT A. LUDVIG
Department of Psychology, University of Warwick, Coventry, CV4 7AL, UK
MATTHEW BROWNE
Experimental Gambling Research Laboratory, School of Health, Medical and Applied Sciences, CQUniversity, Bundaberg, QLD, Australia

Abstract: Gambling is considered a public health issue by many researchers, similarly to alcohol or obesity. Statistical risk warnings on gambling products can be considered a public health intervention that encourages safer gambling while preserving freedom of consumer choice. Statistical risk warnings may be useful to gamblers, given that net gambling losses are the primary driver of harm and that gambling products vary greatly in the degree to which they facilitate losses. However, there is some doubt as to whether statistical risk warnings are, in their current form, effective at reducing gambling harm. Here, we consider current applications and evidence, discuss product-specific issues around a range of gambling products and suggest future directions. Our primary recommendation is that current statistical risk warnings can be improved and also applied to a wider range of gambling products. Such an approach should help consumers to make more informed judgements and potentially encourage gambling operators to compete more directly on the relative 'price' of gambling products.

* Correspondence to: Experimental Gambling Research Laboratory, School of Health, Medical and Applied Sciences, CQUniversity, 120 Spencer St, Melbourne, VIC 3000, Australia. Email: p.newall@cqu.edu.au

Introduction

Many researchers recommend treating gambling as a public health issue, a perspective that encompasses a wide spectrum of interventions to reduce the population's exposure to the risk of gambling-related harm (Browne *et al.*, 2016; Bowden-Jones *et al.*, 2019; Orford, 2019; van Schalkwyk *et al.*, 2019; Wardle *et al.*, 2019). Warning labels are a class of intervention that have been used across several public health domains, such as warnings about alcohol content and safe consumption limits and calorie labelling on food packaging. In both of these other domains, warning labels are combined with other public health interventions, including restrictions on price and product availability (Nuffield Council on Bioethics, 2007). For example, in 2018, the UK introduced a tax on sugary beverages (Thornton, 2018), which aimed to increase the price and discourage the consumption of drinks with the highest sugar content levels. In gambling, a recent example of a restrictive public health intervention is a reduction of the maximum bet on UK electronic gambling machines from £100 to £2 a spin (Casey, 2018).

By comparison, warning labels represent a public health intervention that does not restrict consumer choice (Nuffield Council on Bioethics, 2007). Better product-relevant information, such as a red traffic light label indicating that a food product is high in calories (VanEpps *et al.*, 2016a) or has poor nutritional content (Kanter *et al.*, 2018), can inform and guide consumer choice towards relatively safer options. Better consumer information can also potentially shape product development, as it encourages firms to provide products that will look attractive under the labelling system, such as healthy salads. For example, the introduction of colour-coded energy performance certificates for UK homes has provided sellers with a greater incentive to invest in energy improvements (Comerford *et al.*, 2016). In UK gambling, the academic advisory board to the industry regulator, the Gambling Commission, has recently advised that the clear and consistent provision of warning labels could form one key metric in a proposed safer gambling operator league table (Advisory Board for Safer Gambling, 2020).

By comparison to the examples from the previous paragraph, many current gambling warning labels do not provide consumers with information that can yield an informed comparison of relevant products. Some warning labels are extremely generic (e.g., in Australia, 'Gamble responsibly'; in the UK, 'When the fun stops, stop'; or in Ontario, 'Play smart'). These labels provide little information to meaningfully guide consumers (Newall *et al.*, 2019c) and might be ignored due to sheer repetition of content (Lole *et al.*, 2019). Other gambling warning labels warn gamblers only about the product they are currently using, an approach that has been most consistently applied to electronic

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gambling machines (Wohl *et al.*, 2014; Ginley *et al.*, 2017; McGivern *et al.*, 2019). This product-specific approach fails to enable informed comparisons of relevant products by not providing comparable cross-product information.

The rest of this article considers the issue of statistical risk warnings in gambling, an approach specifically designed to enable cross-product comparisons of product risk. First, underlying conceptual similarities between the approach suggested and current public health approaches towards alcohol and food will be compared. The next section introduces the conceptual similarity between standard drink and calorie labelling with the theoretical loss in gambling, while emphasizing issues unique to gambling. The rest of the article reviews theoretical loss in gambling, using two economically significant products of electronic gambling machines and sports betting as examples of a distinction that has previously been made between non-skilled and skilled gambling (Turner *et al.*, 2003). In each case, we will begin with current knowledge regarding statistical risks and their communication through warning labels. We will then move on to a discussion of product-specific issues, as the given gambling products do raise unique issues regarding the communication of theoretical loss. Each section then provides recommendations for further product-specific research. A discussion section then concludes with the argument that a consistent and behaviourally informed approach to statistical risk warnings in gambling can provide one input to a multidimensional public health approach to gambling (Browne *et al.*, 2016; Bowden-Jones *et al.*, 2019; Orford, 2019; van Schalkwyk *et al.*, 2019; Wardle *et al.*, 2019).

Product labelling on alcohol and food packaging

Alcohol labelling is one closely related approach from related public health domains to the statistical risk warnings proposed here for gambling products. All alcohol products contain some amount of pure ethanol. A higher total consumption of pure ethanol exposes the consumer to greater risk of alcohol-related harm. In some jurisdictions, this is communicated primarily through the percentage concentration of alcohol, called alcohol by volume (ABV). In theory, a consumer could multiply the ABV of what they are drinking by the total amount drunk to derive an estimate of their consumption of pure ethanol.

However, some metrics aim to perform this concentration by volume calculation for consumers. A given amount of pure ethanol is communicated as a given number of 'standard drinks' in the USA and Australia or as a 'unit' of alcohol in the UK. These metrics allow consumers to easily compare the consumption of a glass of wine with a larger but less concentrated glass of beer – products varying both in terms of concentration and volume of ethanol (Hobin *et al.*, 2017). Effective communication of product risk

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always involves elements of consumer psychology. The field of alcohol research continues to debate how to best communicate product risk by providing simple and effective heuristics that are consistent with medical evidence underlying healthy drinking ranges. As in risk communication more broadly (Garcia-Retamero & Cokely, 2017), it has been argued that graphical aids could help drinkers to better comprehend this information than the ABV and standard drink information in current use (Blackwell *et al.*, 2018).

Front-of-pack food labels inform customers about the overall energy content (calories) and the nutritional composition of food products. Early reviews of food labelling observed that many consumers feel confused and overwhelmed by the wealth of information found on nutrition labels (Cowburn & Stockley, 2005; Campos *et al.*, 2011). In an attempt to improve people's understanding of the healthiness of different foods, the UK has adopted 'traffic light' warning labels, which use green, amber and red colours to highlight the relative amount of fat, saturates, sugars and salt in 100 g of a given food product (Kanter *et al.*, 2018). Some experimental research has indicated that summarizing calorie information via a traffic light system can nudge consumers towards healthier food choices (VanEpps *et al.*, 2016a) in an effect that is not substantively improved via the added provision of numerical calorie counts (Downs *et al.*, 2015). Overall, the weight of evidence across restaurant and supermarket settings (VanEpps *et al.*, 2016b; Bleich *et al.*, 2017; Dubois *et al.*, 2020) suggests that food labelling, either graphic or numeric, can have some beneficial effects on food choices. Although measurable, these effects are also limited, suggesting that other approaches are needed in conjunction in a public health approach towards obesity (Nuffield Council on Bioethics, 2007).

Theoretical loss in gambling

Theoretical loss is the statistical average result that occurs from any given gambling scenario. Different gambling products can present unique challenges with respect to the calculation and communication of theoretical loss, but all gambling products are sold to the vast majority of gamblers with some implied theoretical loss embedded. Roulette is a relatively simple gambling game that can be used to demonstrate the principle of theoretical loss. European roulette wheels have 18 black slots, 18 red slots and 1 green slot. A \$10 bet on either black or red will win \$10 profit if the roulette ball ends up in a slot of that colour and will otherwise return nothing. Theoretical loss is calculated by multiplying the payoff of each outcome by its probability. Since each slot is equally likely, a \$10 bet will on average lose the gambler $(18/37 \times \$10) + (19/37 \times -\$10) = -\$0.27$. Over time, gamblers' losses on European roulette will converge towards 2.7% of all money bet, which is known as the 'house

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edge'. If they make 50 such bets over the course of an hour, then the average cost of this entertainment activity is $13.50 per hour.

Theoretical loss can therefore be expressed as follows:

$$\text{Theoretical loss} = \text{house edge} \times \text{total amount bet}$$

Although much gambling is motivated by the thrill of the potential of winning, in the long run all gamblers exposed to a positive house edge will lose money, due to the statistical law of large numbers (Dekking *et al.*, 2005). Of relevance to statistical risk warnings in gambling, theoretical loss can therefore be applied to all gambling products, and it is a useful metric for product harm, given that actual losses represent a reliable predictor of gambling-related harm (Markham *et al.*, 2014, 2016). Furthermore, the provision of transparent pricing information could foster competition in product offerings with potential longer-term benefits to gamblers. The theoretical loss of any gambling transaction represents the expected 'price' that is paid by the gambler over the long term. Currently, the true cost of gambling is obscured to gamblers, who naturally attend to the 'noisy' short-run sequences of their wins and losses. Making theoretical loss more salient to gamblers has the knock-on effect of providing gambling operators with more incentive to compete on price. However, there are at least two major challenges to employing theoretical loss for gambling product warnings.

First, some gambling forms, such as electronic gambling machines, are not consumed in discrete units of consumption, like a bottle of beer, but can be gambled on continuously, with re-staking of winnings. This can make theoretical loss difficult to calculate, which also depends on the speed, stakes and time spent gambling. These challenges may make it simpler to communicate statistical gambling risk via the house edge, which is conceptually related to the ABV in alcohol.

Second, the volatility of gambling means that theoretical loss is only a relevant statistic in the long run, and short-run results may differ from this statistic. Gambling products with a highly skewed payoff schedule converge surprisingly slowly to their average expected return (Browne *et al.*, 2015). By comparison, the calories in a cheeseburger are consumed with certainty. Gamblers may simply be paying more attention to their short-run wins and losses than the long-run implications of their bets. Some preliminary data suggest that a qualitative warning about the volatility of gambling may serve as a useful addition to a numerical statistical risk warning (Newall *et al.*, 2020c).

Theoretical loss in non-skilled gambling

A non-skilled gambling game is one in which chance is the only determinant of long-term outcomes, where gamblers do not have any real ability to learn a

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better strategy over time or to apply skill (Turner *et al.*, 2003). The house edge input to theoretical loss can therefore be calculated with precision in non-skilled gambling games, making these an easier introduction to the topic of statistical risk warnings than skilled gambling games. Roulette, scratch cards, lotteries, craps, bingo and traditional slot and electronic gambling machines are all non-skilled games (Turner *et al.*, 2003), although some electronic gambling machines that introduce a small element of skill are being brought to market (Delfabbro *et al.*, 2019).

Current knowledge

The house edge of electronic gambling machine games can be altered in a way that is not immediately obvious to gamblers (Schüll, 2012). A natural question therefore is whether gamblers can by themselves detect differences in the house edge across seemingly identical games. A laboratory study involving a long period of 60 hours of play found that gamblers could discriminate between two identical games with radically different house edges of 2% and 15% (Dixon *et al.*, 2013). However, in most electronic gambling machine environments there will be many potential games on offer, and so 60 hours of play across two games may not correspond to the typical gambler's experience. Indeed, field studies conducted on casino floors suggest that gamblers cannot differentiate between differences of up to 8.9% in the house edge on seemingly identical games, a differential that can have a marked impact on the actual long-term losses experienced by players (Lucas & Spilde, 2019). This suggests that electronic machine gamblers may benefit from well-designed statistical risk warnings.

In the UK, statistical risk information is provided for electronic gambling machines (Gambling Commission, 2012), albeit hidden far down on help screens that most regular machine gamblers have never even seen (Collins *et al.*, 2014). In addition, the information is communicated in both the UK and other jurisdictions, such as Australia (Beresford & Blaszczynski, 2019), via the 'return-to-player' percentage, which represents the average percentage of money returned per gamble. However, as has been suggested (Eggert, 2004), the return-to-player percentage is an inefficient risk communication metric compared to the house edge.

A return-to-player percentage of 90% is equivalent to a house edge of 10%, since in both cases 10% of all money bet is lost on average (Parke *et al.*, 2016). In practice, return-to-player information might be communicated via the label, 'This game has an average percentage pay-out of 90%', a statement that only 6 out of 20 regular gamblers could interpret correctly in one study: 'For every £100 bet on this game about £90 is paid out in prizes' (Collins *et al.*, 2014).

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Some results show that gamblers display a better understanding of this information when it is given in terms of the house edge. Specifically, 66.5% of gamblers correctly understood a house edge statement of, 'This game keeps 10% of all money bet on average', compared to 45.6% of those given a return-to-player statement (Newall *et al.*, 2020a). Furthermore, gamblers perceived a lower chance of winning when given house edges of between 5% and 15% than when given equivalent return-to-player statements ranging from 95% to 85% (Newall *et al.*, 2020a). Taken together, these results imply that gamblers have a more informed and less optimistic interpretation of the winning chances when given house edge information compared to the more widely used return-to-player information.

However, these results pertain only to the house edge rather than the theoretical loss, which is the product of the house edge and the total amount bet. Some preliminary evidence suggests that gamblers' perceived chances of winning in a hypothetical scenario do not differ when the house edge is instead restated in terms of the theoretical loss (e.g., 'This game keeps £10 for every £100 bet on average; Newall *et al.*, 2020b). Personalized theoretical loss information, however, which reflects a gambler's stakes and speed of play, may be able to improve upon this result.

Some results suggest that numerical statistical risk warnings could be improved via qualitative information about the volatility of gambling. Specifically, a study has investigated the effects of adding the following 'volatility statement' information to return-to-player or house edge percentages (Newall *et al.*, 2020c):

> It takes millions of plays for a gambling game to tend towards its average return. A gambling game will not return a minimum value of prizes in any given period of gambling.

This additional text reduced gamblers' perceived chances of winning in both the house edge and return-to-player conditions, with the lowest perceptions occurring in the house edge and volatility statement condition. House edge information was again correctly understood better than return-to-player percentages (Newall *et al.*, 2020c). This study suggests that improved statistical risk warnings in gambling could be constructed that communicate both the mean (house edge) and variance (volatility) of the relevant distribution of payoffs.

Graphs can often communicate risk better than numbers (Garcia-Retamero & Cokely, 2017). Some research has explored the possibility of proxying variations in return-to-player information on scratch cards with a star rating system (Walker *et al.*, 2019). The study by Walker and colleagues found that participants put more weight on a star rating system of 1–5 stars when it

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was used instead of return-to-player percentages of 67.89–68.39% (with the 67.89% scratch card given one star and the 68.39% card given five stars). However, it is unclear as of yet how such a graphical rating system could be consistently applied across all non-skilled gambling games, given that a variation of 0.5% in the house edge is relatively small, and in the abovementioned study was represented by a difference of four stars in the graphical display.

Product-specific issues

It has been argued that regulations intended to help inform consumers may be interpreted by firms in ways that do not genuinely help consumers (Page, 2019). Evidence from UK online casinos is consistent with this view. The UK gambling regulator requires online casinos to make 'information that may reasonably be expected to enable the customer to make an informed decision about his or her chances of winning *must be easily available*' (Gambling Commission, 2017, emphasis added). The return-to-player percentage and the house edge are two of the four allowed formats for providing this statistical risk information. As previously discussed, of these two, the house edge is better for consumers, although not necessarily the best of all statistical risk communication formats (Newall *et al.*, 2020a). A field study of 363 online roulette games across 26 major UK online operators found that none used the house edge, while a return-to-player warning label was found on 98.3% of games. Furthermore, 95.5% of return-to-player statements used the smallest font size on the screen, 99.7% used the lowest level of text boldness from the screen and 16.8% used acronyms in place of the term 'return-to-player' (e.g., 'RTP is 97.2973%'; (Newall *et al.*, 2020d). This suggests that current UK regulations are insufficient to ensure that statistical risk information is made sufficiently prominent and understandable to gamblers.

There are two distinct ways that a gambler can be exposed to a high theoretical loss. The first way is to make bets at high house edges. The second way is to bet at a lower house edge, but to bet so much money that the total amount of theoretical loss is still substantial. This second reason is why high-speed electronic gambling machines are considered a dangerous form of gambling (Schüll, 2012). Furthermore, electronic gambling machines involve the automatic reinvestment of winnings. In these games, say $100 could be inserted by the gambler, who could then easily bet much more than $100 total before losing everything, since intermediate wins are automatically reinvested into the account total. Electronic gambling machine gamblers in particular seem to misunderstand that house edges apply to the total amount bet, rather than the amount of money inserted (Harrigan *et al.*, 2017). This unique danger of repeat gambling games raises unique concerns for statistical risk warnings.

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Multiple possible interventions exist for electronic gaming machines. The UK government chose to reduce the maximum bet amounts on UK electronic gambling machines from £100 to £2 from April 2019, which might be effective, but does also reduce consumer freedoms (Casey, 2018). One possible freedom-preserving intervention would be to prevent the automatic reinvestment of winnings (Byrne & Russell, 2019) in order to reduce confusion about the relationship between theoretical loss and amount bet versus the amount of money inserted. This cash pay-out of winnings by default may further act as a potential nudge for gamblers to consider stopping gambling.

In theory, an interactive display could be created for electronic gambling machines that dynamically calculates the entire statistical distribution of potential outcomes. This display could, for example, use data of the game's house edge, the gambler's current bet size and their betting frequency to forecast theoretical loss over different hypothetical session lengths. Furthermore, the display could be augmented to show the 95% confidence interval of possible results over this forecasted sequence of gambling, therefore providing a graphical measure of statistical volatility.

Recommendations for future research

One further remaining issue is the extent to which statistical risk warnings can modify gambling behaviour, rather than mere perceptions of winning. One Canadian study showed that the provision of more information on slot machines, including a categorical label for the house edge (represented as 'Hold %: very low/low/high/very high'), had little effect on gambling behaviour (Harrigan *et al.*, 2017). However, the efficacy of this intervention may have been affected by how this information was presented, including the usage of categorical groupings and the term 'hold percentage', which may not have been the clearest way of describing the underlying concept. Additional interventions, such as an interactive display, may have enhanced the efficacy of this warning label.

Theoretical loss in skilled gambling

The provision of statistical risk information is more complicated in skilled gambling games, where theoretical loss is also influenced by the gambler's choices (Turner *et al.*, 2003). However, this added level of complexity also introduces an additional avenue via which gamblers can be directed towards lowering their theoretical loss. For example, the game of blackjack has a known 'basic strategy', which provides the lowest-loss play for any of the game's potential states. This basic strategy is simple enough to be printed on a small card or

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leaflet, yet many regular blackjack players deviate from the basic strategy suboptimally. These deviations may cost regular gamblers large sums of money over time, and yet these gamblers can appear unwilling on their own to learn a simple and demonstrably better strategy (Wagenaar, 1988). Some gamblers in skilled games such as poker can in fact also produce theoretical gains (Sklansky & Malmuth, 1998). These skilled gamblers are not the intended subjects of statistical risk warnings, as they have likely already mastered the underlying concepts.

Given that each skilled gambling game has its own unique strategic considerations, the remainder of this section will focus on the economically important 'fixed-odds' sports betting market. In fixed-odds sports betting, a gambling operator (the bookmaker) posts a set of odds for an upcoming sports event ahead of time, setting the terms at which gamblers bet against the bookmaker (Buchdahl, 2003). Sports betting is a skilled gambling form, where the judicious selection of bets has the potential to earn long-run profits, albeit this potential is not always tolerated by gambling operators, who tend to prevent profitable gamblers from betting (Kaunitz *et al.*, 2017). Fixed-odds sports betting is established in the UK, is growing in Australia (Queensland Government, 2019) and could grow rapidly in the USA given a recent Supreme Court ruling (Supreme Court of the United States, 2017). In the UK and Australia, sports betting has been associated with a high level of gambling marketing saturation (Newall *et al.*, 2019a). Of relevance to statistical risk warnings, fixed-odds sports betting is also associated with large and predictable variations in the house edge.

Current knowledge

Two replicable patterns of variation in the house edge in soccer betting have been found (Hassanniakalager & Newall, 2019). The first pattern is that bet types with more potential events are associated with higher house edges. The second pattern is that bets with longer odds in some bet type are associated with larger house edges than bets with shorter odds. Both patterns appear roughly additive (non-interacting), and both patterns mean that bets with longer odds are associated with higher house edges.

A soccer match has three main outcomes: home win, draw and away win. Bets on these outcomes, called 'home–draw–away' here, are perhaps the most established type of soccer betting (Kuypers, 2000). But bookmakers also quote odds on more specific outcomes, such as the home team to win 1–0, 2–0, etc., called the 'correct score' bet type here. The odds on any correct score bet must be longer than the odds of that team winning, since winning by a specific score line is a subset of the event of that team winning.

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If the odds quoted across these two bet types were equivalent, it should be possible to replicate the returns of a 'home win' bet using only correct score bets (assuming that, in practice, only a finite number of score lines can realistically occur). But this is not possible, as the odds quoted on correct score bets are less generous than home–draw–away bets, producing a higher house edge on correct score bets, as shown either by odds inconsistencies (Newall, 2015, 2017) or betting simulations (Dixon *et al.*, 2004; Hassanniakalager & Newall, 2019). This pattern has been observed across a broad range of soccer bet types (Ayton, 1997; Forrest, 2008; Newall, 2015, 2017).

In a home–draw–away bet, one team will usually be predicted to be more likely to win the match (the 'favourite'), and thus a bet of a fixed size on that team will come with a smaller potential payoff. The team with longer odds is called the 'longshot'. In fixed-odds soccer betting, longshots are associated with higher house edges than favourites (Cain *et al.*, 2003; Graham & Stott, 2008; Vlastakis *et al.*, 2009; Deschamps & Gergaud, 2012; Constantinou & Fenton, 2013; Buhagiar *et al.*, 2018; Hassanniakalager & Newall, 2019). This pattern has broadly been found in other sports betting markets, perhaps most consistently in horse racing (Snowberg & Wolfers, 2010), although some exceptions exist (Vaughan Williams, 1999). This pattern has also been found in the odds quoted by a bookmaker on Twitter in response to actual customer enquiries for custom bets (Newall *et al.*, 2019d).

Variation in the house edges across these different soccer bets is large, varying from a low of around 5% for home–draw–away bets (Newall, 2015) to highs of over 50% for certain bets at long odds (Hassanniakalager & Newall, 2019). This high degree of variation in the house edge exceeds what can be found in any one non-skilled gambling form, providing a strong rationale for the provision of statistical risk warnings in sports betting.

The preponderance of 'odds advertising' in gambling advertising, where the odds on specific bets in relation to some upcoming sporting event are highlighted, is another reason to consider statistical risk warnings in sports betting (Newall *et al.*, 2019a). Odds advertising around soccer in the UK has been found to be skewed towards bets with long odds and high house edges (Newall, 2015), with this tendency becoming more pronounced over time (Newall *et al.*, 2019b).

In fixed-odds sports betting, house edges are variable, depending on market demand and supply. This is unlike most non-skilled gambling forms, where house edges are fixed (e.g., at 2.7% for European roulette). This means that if a significant group of sports bettors can be nudged to be more responsive to price, then all sports bettors might conceivably benefit from greater market incentives to offer bets with more generous odds (and therefore lower house edges). Home–draw–away bets, for example, have become

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much more fairly priced since the late 1990s, as this market has been transformed by Internet gambling and regulatory changes (Forrest, 2008). Current house edges on home–draw–away bets are today roughly half (Buhagiar *et al.*, 2018) their average value of 10.5% in the late 1990s (Kuypers, 2000).

Product-specific issues

In fixed-odds sports betting, the bookmaker posts a number of 'odds' before each event corresponding to the risk/reward ratio of betting on various outcomes. Odds can be communicated in different ways, but they always translate into some implied probability of the event happening (Cortis, 2015). For example, the British fractional odds system uses two numbers (e.g., '3/1'), where the first number represents the profit from a successful bet of a stake of the second number. In the European decimal odds system, a single number is used to express the total return from a successful bet of stake \$1. Decimal odds of 4 and fractional odds of 3/1 are equivalent, since both bets return a profit of \$3 if successful (Cortis, 2015). Both of these odds can also be converted into an implied probability of 0.25. The bookmaker's goal to prevent bettors from profiting is to set odds such that the implied probability is greater than the event's actual probability.

Since fixed-odds sports betting involves forecasts of unique events, additional work and often assumptions are required to estimate the information relevant to statistical risk warnings (probabilities can be estimated with more certainty in non-skilled gambling games, such as roulette). The most certain method would be to use historical data from an industry operator, but these data are rarely shared with researchers (Cassidy *et al.*, 2013). More approximate methods exist, which give largely similar results to each other. The first approximate method is simply to add up the implied probability from the odds for each potential event. The sum of implied probabilities will always exceed 1, which is necessary for a bookmaker that makes imperfect forecasts and wants to set implied probabilities that are greater than actual probabilities for all events (Cortis, 2015). The excess of implied probabilities beyond 1 is called the 'overround', which can then be normalized to provide an estimate of the house edge (Kuypers, 2000). This method has the benefit of being applicable even to single sporting events, but it requires the assumption that bookmakers set odds in a defensive way (Stark & Cortis, 2017), so that they make a sure profit no matter which outcome occurs, which may not be true in practice (Levitt, 2004). Another approximate method is to simulate the returns from some betting strategy across a larger sample of past sporting events (Hassanniakalager & Newall, 2019). This method can simulate the

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returns under different assumptions of sports bettor behaviour, but it requires more historical data to work with, which may not necessarily provide the best estimate of current returns if the market has recently changed.

One unresolved issue is how best to regulate the disclosure of house edges in sports betting so as to preclude the incentive to game these disclosures. If bookmakers are given a range of potential calculation techniques, they would still have an incentive to use the technique that provides the lowest estimated house edge. For example, if house edges are based on historical data, then bookmakers could choose time windows that do not accurately reflect the current odds on offer or temporarily increase their odds at the end of a reporting period to inflate how attractive their odds seem going forward. If house edges are based on simulated betting returns, then bookmakers could potentially trial many simulations in-house and use the simulation that again provided the lowest estimated house edge.

We believe that historical loss rates given over some recent time period would be the most relevant to sports bettors. A standardized formula, which does not give operators any leeway to pick favourable subsets of data, seems the best approach. A fixed formula based on the last $\$x$ amount of money bet on a market (and corresponding $\$y$ amount lost, where y/x = the house edge) appears robust to gaming, while providing incentives for bookmakers to maintain favourable odds.

House edge information could be applied for each separate bet type, since, for example, the house edge is higher on correct score than home–draw–away bets in soccer. House edge statements could also be applied to subsets of a given bet type in order to reflect the fact that bets at longer odds tend to have higher house edges. An overall figure could be given for correct score bets, for example, with an additional figure given for correct score bets at odds of 19/1 or longer. Such a statistical risk warning system would capture both predictable patterns of variations in the house edge in soccer betting.

Recommendations for future research

We know of no previous studies that have explored the effect of statistical risk warnings on skilled gambling behaviour. Given the high and currently obscured variation in house edges in fixed-odds sports betting, it is possible that risk warnings might be effective here. It may, however, prove difficult to change skilled gambling game behaviour, as non-skilled gambling game behaviour has thus far proven to be (Harrigan *et al.*, 2017). It is also unknown whether in-play sports betting, which can be considered a high-frequency repeated gambling form, produces similar illusions regarding the total amount of money bet as electronic gambling machines do (Harrigan *et al.*,

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2017). The potential for interactive displays should also be considered for skilled gambling. If a sports bettor chooses to make a potential bet size on a given bet, then a popup display could notify the bettor of the corresponding theoretical loss, rather than requiring the bettor to estimate this value based on their bet size and displayed house edge.

The provision of historical house edges would also benefit sports betting researchers, who generally do not have access to industry data (Cassidy *et al.*, 2013). At present, research in this area involves a number of steps and approximating assumptions that would not be necessary with the mandatory disclosure of detailed historical house edge information. This would help researchers' attempts to replicate findings across different sports betting markets. Better access to data would also speed up the process of understanding the determinants of gamblers' losses in other skill-based gambling games.

Discussion

Many researchers recommend treating gambling as a public health issue (Browne *et al.*, 2016; Bowden-Jones *et al.*, 2019; Orford, 2019; van Schalkwyk *et al.*, 2019; Wardle *et al.*, 2019). Statistical risk warnings emphasizing theoretical loss are, like standard drink or calorie labelling, only one potential element to a public health approach to gambling. But as in alcohol and food, they could play a useful and minimally invasive role in conjunction with other health promotion initiatives (Nuffield Council on Bioethics, 2007). Improving current statistical risk warnings and introducing novel and comparable statistical risk warnings for additional gambling products could help gamblers to make better-informed product choices. Information about either the theoretical loss or the house edge can provide gamblers with a clear view of how much they can expect to lose over the long term. The provision of transparent pricing information could foster price competition between operators with potential longer-term benefits to gamblers.

Just like a public health approach to alcohol or other risky products, we recommend that any implementation of statistical risk warnings should be considered alongside other potential interventions, such as more restrictive changes to the gambling product experience (Palmer du Preez *et al.*, 2016; Byrne & Russell, 2019; Stevens & Livingstone, 2019), attempts to improve gamblers' decision-making skills more broadly (Williams & Connolly, 2006; Broussard & Wulfert, 2019), personalized interventions for those who have suffered high losses (Jonsson *et al.*, 2019) and product-specific warnings for uniquely harmful products (Ginley *et al.*, 2017).

The specific format and presentation of warning messages can profoundly affect consumer responses (Bar-Gill, 2019). Therefore, policymakers should

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be sure to implement current best practices in format and presentation. Potential industry responses to warning message requirements are another reason for policymakers to enforce best practices. It has been argued that many firms might do the minimum to comply with the letter rather than the spirit of regulations intended to help inform consumers (Page, 2019). Evidence from warning labels in UK online casinos is consistent with this view (Newall *et al.*, 2020d). Statistical risk warnings in sports betting could similarly be undermined if operators are allowed freedom around the presentation or selection of statistical information.

Although we have argued for theoretical loss as the key statistical issue regarding gambling products, economists also highlight how the volatility of returns can also impact consumer welfare. That is, even if losses to operators were removed, highly volatile games will tend to result in very few players making large wins, but the large majority of players losing their total stake. Even in the case of zero net group losses, diminishing marginal welfare benefits derived from wins means that net harm can accrue to gamblers. It has been noted that gamblers tend to bet smaller amounts on high-variance bets, perhaps as a natural reaction to this aspect of product risk (Feess *et al.*, 2014). Although relevant to consumer welfare, the volatility issue is unlikely to counteract product labelling regarding theoretical loss/house edge, given that higher-variance products also tend to have higher house edges (Turner, 2011). However, the volatility of gambling products is a unique issue that requires further research (Newall *et al.*, 2020c).

Any enhanced consumer disclosure does run the risk of either unintended consequences (Bar-Gill, 2019) or 'backfire' effects (Stibe & Cugelman, 2016). Standard drink alcohol labels may, for example, be used by teenagers to consume as much alcohol as possible given their budget (Wells *et al.*, 2009). In statistical risk warnings for gambling products, there is, according to one argument, a potential indirect route for backfiring. All else being equal, gambling products with lower house edges allow gamblers to go on longer winnings runs. Since problem gamblers tend to remember big wins, it has been argued that lower house edge gambling products might therefore be the most harmful to gamblers (Harrigan & Dixon, 2010). In the present context, this consideration suggests that improved statistical risk warnings might shift gamblers and operators towards lower house edge products, which may then cause more harm due to an increased rate of winning streaks. Although the relationship between the house edge and winning streaks is true, this argument does neglect other relevant considerations. Loss chasing is another aspect of problem gambling (Ferris & Wynne, 2001; Zhang & Clark, 2020), and lower house edge products should also induce a lesser need to chase losses, which should also reduce harm. Backfire effects

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could plausibly happen through a number of channels, however, so due caution should always be exercised.

Further research should continue to explore the various product-specific issues surrounding statistical risk warnings. Continuous gambling products such as electronic gambling machines allow for money to be bet repeatedly, which can cause confusion regarding the total amount of money staked (Harrigan *et al.*, 2017). This confusion could potentially be corrected in a number of ways. Preventing the automatic reinvestment of winnings is one potential method (Byrne & Russell, 2019). Another method could be to create an interactive display forecasting a gambler's theoretical loss and corresponding 95% confidence interval of potential returns based on their current machine settings (stake level, betting frequency, etc.). For sports betting, a more pressing issue might be studies exploring the extent to which sports bettors' choices are modified when house edge information is given for different bet types.

Conclusion and recommendation

Although more research is always beneficial, we will make the following recommendations based on the evidence so far. Jurisdictions that currently disclose the return-to-player percentage on non-skilled gambling games should benefit from switching to the house edge and by making this information more prominent. House edge information should also be beneficial in sports betting and should be provided both at point of use and in sports betting marketing. Statistical risk warnings can be a useful input to a multifaceted public health approach to gambling.

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References

Advisory Board for Safer Gambling. (2020), Progress report on the national strategy to reduce gambling harms. Retrieved from https://www.rgsb.org.uk/PDF/ABSG-Progress-Report-2020.pdf

Ayton, P. (1997), 'How to be incoherent and seductive: Bookmakers' odds and support theory', *Organizational Behavior and Human Decision Processes*, **72**(1): 99–115.

Bar-Gill, O. (2019), 'Smart disclosure: Promise and perils', *Behavioural Public Policy*, doi:10.1017/bpp.2019.24

Beresford, K. and A. Blaszczynski (2019), 'Return-to-player percentage in gaming machines: Impact of informative materials on player understanding', *Journal of Gambling Studies*, doi:10.1007/s10899-019-09854-z

Blackwell, A. K., K. Drax, A. S. Attwood, M. R. Munafò and O. M. Maynard (2018), 'Informing drinkers: Can current UK alcohol labels be improved? *Drug and Alcohol Dependence*, **192**, 163–170.

Bleich, S. N., C. D. Economos, M. L. Spiker, K. A. Vercammen, E. M. VanEpps, J. P. Block, . . . C. A. Roberto (2017), 'A systematic review of calorie labeling and modified calorie labeling interventions: Impact on consumer and restaurant behavior', *Obesity*, **25**(12): 2018–2044.

Bowden-Jones, H., C. Dickson, C. Dunand and O. Simon (2019), Harm reduction for gambling: A public health approach. doi:10.4324/9780429490750

Broussard, J. D. and E. Wulfert (2019), 'Debiasing strategies for problem gambling: Using decision science to inform clinical interventions', *Current Addiction Reports*, **6**(3): 175–182.

Browne, M., E. Langham, V. Rawat, N. Greer, E. Li, J. Rose, . . . T. Best (2016), *Assessing gambling-related harm in Victoria: A public health perspective*, Melbourne: Victorian Responsible Gambling Foundation.

Browne, M., M. J. Rockloff, A. Blaszcynski, C. Allcock and A. Windross (2015), 'Delusions of expertise: The high standard of proof needed to demonstrate skills at horserace handicapping', *Journal of Gambling Studies*, **31**(1): 73–89.

Buchdahl, J. (2003), *Fixed odds sports betting: Statistical forecasting and risk management*, London, UK: High Stakes Publishing.

Buhagiar, R., D. Cortis and P. W. S. Newall (2018), 'Why do some soccer bettors lose more money than others? *Journal of Behavioral and Experimental Finance*, **18**(2018): 85–93. doi:10.1016/j.jbef.2018.01.010

Byrne, C. and A. Russell (2019), 'Making EGMs accountable: Can an informative and dynamic interface help players self-regulate', *Journal of Gambling Studies*,

Cain, M., D. Law and D. Peel (2003), 'The Favourite–Longshot bias, bookmaker margins and insider trading in a variety of betting markets', *Bulletin of Economic Research*, **55**(3): 263–273.

Campos, S., J. Doxey and D. Hammond (2011), 'Nutrition labels on pre-packaged foods: A systematic review', *Public Health Nutrition*, **14**(8): 1496–1506.

Casey, J. (2018), UK government confirms FOBT change now set for April 2019. Retrieved from https://www.gambling.com/news/uk-government-confirms-fobt-change-now-set-for-april-2019-1674400

Cassidy, R., C. Loussouarn and A. Pisac (2013), *Fair game: Producing gambling research - the goldsmiths report*, London: Goldsmiths, University of London.

Collins, D., S. Green, J. d'Ardenne, H. Wardle and S. Williams (2014), *Understanding of return to player messages: Findings from user testing*, London: NatCen Social Research.

Comerford, D., I. Lange and M. Moro (2016), The supply-side effects of energy efficiency labels. Working papers 2016–01. Retrieved from https://ideas.repec.org/p/mns/wpaper/wp201601.html

Constantinou, A. C. and N. E. Fenton (2013), 'Profiting from arbitrage and odds biases of the European football gambling market', *The Journal of Gambling Business and Economics*, **7**(2): 41–70.

Cortis, D. (2015), 'Expected values and variances in bookmaker payouts: A theoretical approach towards setting limits on odds', *The Journal of Prediction Markets*, **9**(1): 1–14.

Cowburn, G. and L. Stockley (2005), 'Consumer understanding and use of nutrition labelling: A systematic review', *Public Health Nutrition*, **8**(1): 21–28.

Dekking, F. M., C. Kraaikamp, H. P. Lopuhaä and L. E. Meester (2005), *A modern introduction to probability and statistics: Understanding why and how* Springer Science & Business Media.

Delfabbro, P., D. King and S. M. Gainsbury (2019), 'Understanding gambling and gaming skill and its implications for the convergence of gaming with electronic gaming machines', *International Gambling Studies*, doi:10.1080/14459795.2019.1662824

Deschamps, B. and O. Gergaud (2012), 'Efficiency in betting markets: Evidence from English football', *The Journal of Prediction Markets*, **1**(1): 61–73.

Dixon, M. J. and P. F. Pope (2004), 'The value of statistical forecasts in the UK association football betting market', *International Journal of Forecasting*, **20**(4): 697–711.

Dixon, M. J., J. A. Fugelsang, V. V. MacLaren and K. A. Harrigan (2013), 'Gamblers can discriminate 'tight' from 'loose' electronic gambling machines', *International Gambling Studies*, **13**(1): 98–111.

Downs, J. S., J. Wisdom and G. Loewenstein (2015), 'Helping consumers use nutrition information: Effects of format and presentation', *American Journal of Health Economics*, **1**(3): 326–344.

Dubois, P., P. Albuquerque, O. Allais, C. Bonnet, P. Bertail, P. Combris, . . . P. Chandon (2020), 'Effects of front-of-pack labels on the nutritional quality of supermarket food purchases: Evidence from a large-scale randomized controlled trial', *Journal of the Academy of Marketing Science*, doi:10.1007/s11747-020-00723-5

Eggert, K. (2004), 'Truth in gaming: Toward consumer protection in the gambling industry', *Maryland Law Review*, **63**(2): 217.

Feess, E., H. Müller and C. Schumacher (2014), 'The favorite–longshot bias and the impact of experience', *Business Research*, **7**(2): 217–234.

Ferris, J. and H. J. Wynne (2001), *The Canadian problem gambling index: Final report*, Ottawa, ON: Canadian Centre on Substance Abuse.

Forrest, D. (2008), Soccer betting in Britain. In D. B. Hausch and W. T. Ziemba (eds), *Handbook of sports and lottery markets*, Elsevier, pp. 421–446. doi:10.1016/B978-044450744-0.50023-8

Gambling Commission. (2012), Machine standards category B2. June 2012. revision 2. Retrieved from https://www.gamblingcommission.gov.uk/PDF/Machine-standards-category-B2.pdf

Gambling Commission. (2017), Remote gambling and software technical standards. Retrieved from https://www.gamblingcommission.gov.uk/pdf/Remote-gambling-and-software-technical-standards.pdf

Garcia-Retamero, R. and E. T. Cokely (2017), 'Designing visual aids that promote risk literacy: A systematic review of health research and evidence-based design heuristics', *Human Factors*, **59**(4): 582–627.

Ginley, M. K., J. P. Whelan, R. A. Pfund, S. C. Peter and A. W. Meyers (2017), 'Warning messages for electronic gambling machines: Evidence for regulatory policies', *Addiction Research & Theory*, **25**(6): 495–504. doi:10.1080/16066359.2017.1321740

Graham, I. and H. Stott (2008), 'Predicting bookmaker odds and efficiency for UK football', *Applied Economics*, **40**(1): 99–109.

Harrigan, K. A. and M. Dixon (2010), 'Government sanctioned "tight" and "loose" slot machines: How having multiple versions of the same slot machine game may impact problem gambling', *Journal of Gambling Studies*, **26**(1): 159–174.

Harrigan, K. A., D. Brown and K. Barton, R. (2017), *Classification of slot machines in Ontario: Providing relevant information to players*, Guelph, Ontario, Canada: Gambling Research Exchange Ontario.

Hassanniakalager, A. and P. W. S. Newall (2019), 'A machine learning perspective on responsible gambling', *Behavioural Public Policy*, doi:10.1017/bpp.2019.9

Hobin, E., K. Vallance, F. Zuo, T. Stockwell, L. Rosella, A. Simniceanu, . . . D. Hammond (2017), 'Testing the efficacy of alcohol labels with standard drink information and national drinking guidelines on consumers' ability to estimate alcohol consumption', *Alcohol and Alcoholism*, **53**(1): 3–11.

Jonsson, J., D. C. Hodgins, I. Munck and P. Carlbring (2019), 'Reaching out to big losers: A randomized controlled trial of brief motivational contact providing gambling expenditure feedback', *Psychology of Addictive Behaviors*, **33**(3): 179–189.

Kanter, R., L. Vanderlee and S. Vandevijvere (2018), 'Front-of-package nutrition labelling policy: Global progress and future directions', *Public Health Nutrition*, **21**(8): 1399–1408.
Kaunitz, L., S. Zhong and J. Kreiner (2017), 'Beating the bookies with their own numbers-and how the online sports betting market is rigged', *arXiv Preprint arXiv:1710.02824*,
Kuypers, T. (2000), 'Information and efficiency: An empirical study of a fixed odds betting market', *Applied Economics*, **32**(11): 1353–1363.
Levitt, S. D. (2004), 'Why are gambling markets organised so differently from financial markets? *The Economic Journal*, **114**(495): 223–246.
Lole, L., E. Li, A. M. Russell, N. Greer, H. Thorne and N. Hing (2019), 'Are sports bettors looking at responsible gambling messages? An eye-tracking study on wagering advertisements', *Journal of Behavioral Addictions*, **8**(3): 499–507.
Lucas, A. F. and K. Spilde (2019), 'A deeper look into the relationship between house advantage and reel slot performance', *Cornell Hospitality Quarterly*, **60**(3): 270–279.
Markham, F., M. Young and B. Doran (2014), 'Gambling expenditure predicts harm: Evidence from a venue-level study', *Addiction*, **109**(9): 1509–1516.
Markham, F., M. Young and B. Doran (2016), 'The relationship between player losses and gambling-related harm: Evidence from nationally representative cross-sectional surveys in four countries', *Addiction*, **111**(2): 320–330.
McGivern, P., Z. Hussain, S. Lipka and E. Stupple (2019), 'The impact of pop-up warning messages of losses on expenditure in a simulated game of online roulette: A pilot study', *BMC Public Health*, **19**(1): 822.
Newall, P. W. S. (2015), 'How bookies make your money', *Judgment and Decision Making*, **10**(3): 225–231.
Newall, P. W. S. (2017), 'Behavioral complexity of British gambling advertising', *Addiction Research & Theory*, **25**(6): 505–511. doi:10.1080/16066359.2017.1287901
Newall, P. W. S., C. Moodie, G. Reith, M. Stead, N. Critchlow, A. Morgan and F. Dobbie (2019a), 'Gambling marketing from 2014 to 2018: A literature review', *Current Addiction Reports*, **6**(2): 49–56. doi:10.1007/s40429-019-00239-1
Newall, P. W. S., A. Thobhani, L. Walasek and C. Meyer (2019b), 'Live-odds gambling advertising and consumer protection', *PLoS One*, doi:10.1371/journal.pone.0216876
Newall, P. W. S., L. Walasek and E. A. Ludvig (2020a), 'Equivalent gambling warning labels are perceived differently', *Addiction*, doi:10.1111/add.14954
Newall, P. W. S., L. Walasek and E. A. Ludvig (2020b), 'Percentage and currency framing of house-edge gambling warning labels', *International Journal of Mental Health and Addiction*, doi:10.1007/s11469-020-00286-0
Newall, P. W. S., L. Walasek and E. A. Ludvig (2020c), 'Risk communication improvements for gambling: House-edge information and volatility statements', *Psychology of Addictive Behaviors*, doi:10.1037/adb0000695
Newall, P. W. S., L. Walasek, E. A. Ludvig and M. J. Rockloff (2020d), Nudge versus sludge in gambling warning labels. https://psyarxiv.com/gks2h
Newall, P. W. S., L. Walasek, H. Singmann and E. A. Ludvig (2019c), Testing a gambling warning label's effect on behavior. Retrieved from https://psyarxiv.com/dxfkj/
Newall, P. W. S., L. Walasek, R. Vázquez Kiesel, E. A. Ludvig and C. Meyer (2019d), Betting on intuitive longshots. Retrieved from psyarxiv.com/nk6tw
Nuffield Council on Bioethics. (2007), *Public health: Ethical issues*, UK: Cambridge Publishers.
Orford, J. (2019), *The gambling establishment: Challenging the power of the modern gambling industry and its allies*, Routledge.
Page, L. (2019), 'Disclosure for real humans', *Behavioural Public Policy*, doi:10.1017/bpp.2019.23

Palmer du Preez, K., J. Landon, M. Bellringer, N. Garrett and M. Abbott (2016), 'The effects of pop-up harm minimisation messages on electronic gaming machine gambling behaviour in new zealand', *Journal of Gambling Studies*, **32**(4): 1115–1126.

Parke, J., A. Parke and A. Blaszczynski (2016), *Key issues in product-based harm minimisation: Examining theory, evidence and policy issues relevant in Great Britain*, London: Responsible Gambling Trust.

Queensland Government. (2019), Australian gambling statistics. 1992–93 to 2017–18. 35th edition. Retrieved from https://www.qgso.qld.gov.au/issues/2646/australian-gambling-statistics-35th-edn-1992-93-2017-18.pdf

Schüll, N. D. (2012), *Addiction by design: Machine gambling in Las Vegas*, Princeton, New Jersey: Princeton University Press.

Sklansky, D. and M. Malmuth (1998), *Gambling for a living: How to make $100,000 a year*, Las Vegas, Nevada: Two Plus Two Publishing.

Snowberg, E. and J. Wolfers (2010), 'Explaining the Favorite–Long shot bias: Is it risk-love or misperceptions? *Journal of Political Economy*, **118**(4): 723–746.

Stark, D. and D. Cortis (2017), 'Balancing the book: Is it necessary and sufficient? *The Journal of Gambling Business and Economics*, **11**(1): 1–6.

Stevens, M. and C. Livingstone (2019), 'Evaluating changes in electronic gambling machine policy on user losses in an Australian jurisdiction', *BMC Public Health*, **19**(1): 517.

Stibe, A. and B. Cugelman (2016), Persuasive backfiring: When behavior change interventions trigger unintended negative outcomes. In A. Meschtscherjakov, B. De Ruyter, V. Fuchsberger, M. Murer and M. Tscheligi (eds), *Persuasive technology*, Springer, pp. 65–77.

Supreme Court of the United States. (2017), Murphy vs. national collegiate athletic association. Retrieved from https://www.supremecourt.gov/opinions/17pdf/16-476_dbfi.pdf

Thornton, J. (2018), The UK has introduced a sugar tax, but will it work? Retrieved from https://www.lshtm.ac.uk/research/research-action/features/uk-sugar-tax-will-it-work

Turner, N. E. (2011), 'Volatility, house edge and prize structure of gambling games', *Journal of Gambling Studies*, **27**(4): 607–623.

Turner, N. E., B. Fritz and B. Mackenzie (2003), 'How to gamble: Information and misinformation in books and other media on gambling', *Journal of Gambling Issues*, (**9**)

van Schalkwyk, M. C. I., R. Cassidy, M. McKee and M. Petticrew (2019), 'Gambling control: In support of a public health response to gambling', *Lancet (London, England)*, **393**(10182): 1680–1681. doi:10.1016/S0140-6736(19)30704-4

VanEpps, E. M., J. S. Downs and G. Loewenstein (2016a), 'Calorie label formats: Using numeric and traffic light calorie labels to reduce lunch calories', *Journal of Public Policy & Marketing*, **35** (1): 26–36.

VanEpps, E. M., C. A. Roberto, S. Park, C. D. Economos and S. N. Bleich (2016b), 'Restaurant menu labeling policy: Review of evidence and controversies', *Current Obesity Reports*, **5**(1): 72–80.

Vaughan Williams, L. (1999), 'Information efficiency in betting markets: A survey', *Bulletin of Economic Research*, **51**(1): 1–39.

Vlastakis, N., G. Dotsis and R. N. Markellos (2009), 'How efficient is the European football betting market? Evidence from arbitrage and trading strategies', *Journal of Forecasting*, **28**(5): 426–444.

Wagenaar, W. A. (1988), *Paradoxes of gambling behaviour*, Lawrence Erlbaum Associates, Inc.

Walker, A. C., M. Stange, M. J. Dixon, D. J. Koehler and J. A. Fugelsang (2019), 'Graphical depiction of statistical information improves gambling-related judgments', *Journal of Gambling Studies*, doi:10.1007/s10899-019-09860-1

Wardle, H., G. Reith, E. Langham and R. D. Rogers (2019), 'Gambling and public health: We need policy action to prevent harm', *BMJ*, **365** doi:10.1136/bmj.l1807

Wells, S., K. Graham and J. Purcell (2009), 'Policy implications of the widespread practice of 'pre-drinking' or 'pre-gaming' before going to public drinking establishments – are current prevention strategies backfiring? *Addiction*, **104**(1): 4–9.

Williams, R. J. and D. Connolly (2006), 'Does learning about the mathematics of gambling change gambling behavior? *Psychology of Addictive Behaviors*, **20**(1): 62–68.

Wohl, M. J., A. Parush, H. A. S. Kim and K. Warren (2014), 'Building it better: Applying human–computer interaction and persuasive system design principles to a monetary limit tool improves responsible gambling', *Computers in Human Behavior*, **37**, 124–132.

Zhang, K. and L. Clark (2020), 'Loss-chasing in gambling behaviour: Neurocognitive and behavioural economic perspectives', *Current Opinion in Behavioral Sciences*, **31**, 1–7.

https://doi.org/10.1017/bpp.2020.59 Published online by Cambridge University Press