*Journal of Gambling Issues*
Volume 42, Month 2019
http://igi.camh.net/doi/pdf/xxxx
DOI: http://dx.doi.org/xxx-xxxx-xx

# That's what you get for waking up in Vegas: Fatigue and alcohol consumption are associated with the duration of gambling sessions

Hannah Briony Thorne,[1] Matthew Browne,[2] Matthew Justus Rockloff,[2] & Sally Anne Ferguson[1]

[1] Central Queensland University, School of Health, Medical and Applied Sciences, Adelaide, South Australia, Australia
[2] Central Queensland University, School of Health, Medical and Applied Sciences, Bundaberg, South Australia, Australia

## Abstract

Fatigue and intoxication can impair people's thinking, including their decision-making and assessments of risk. However, little research has specifically examined whether links exist between episodes of gambling, sleep restriction and alcohol consumption. Gambling often occurs in environments where alcohol is served and opening hours are long, making potential interactions between intoxication, fatigue and gambling relevant for exploration from a harm reduction standpoint. The current study tracked the gambling, alcohol consumption and sleep patterns of an online sample of regular gamblers and drinkers ($N$ = 132, 28% female) for six days using online diaries. Results confirm that the three behaviours are related at the individual level; with significant between-subjects correlations between gambling and sleep ($r$ = –.20), gambling and alcohol consumption ($r$ = .22), and sleep and alcohol consumption ($r$ = –.19). However, no strong or reliable within-subjects (day by day) relationships were found. That is, although more intense gamblers slept less and drank more, they were no more likely to drink relatively more or sleep relatively less, on the same days which they gambled. We also observed a negative auto-correlation effect for each behaviour: engaging in more of one behaviour on one day is associated with a reduction of the same behaviour the following day. This result suggests that individual-level traits, rather than contextual or environmental effects, are responsible for observed co-morbidities between these health-related behaviours. Further, that gambling consumption, like alcohol and sleep, is subject to satiation and refractory effects.

**Keywords:** gambling, sleep, alcohol, harm minimization, decision-making

## Résumé

La fatigue et l'intoxication peuvent nuire à la faculté de penser, notamment à la prise de décisions et à l'évaluation des risques. Cependant, peu de recherches ont particulièrement tenté de découvrir s'il existait des liens entre des épisodes de jeu, une privation de sommeil et une consommation d'alcool. Le jeu se produit souvent dans des lieux où l'on sert de l'alcool et les heures d'ouverture sont longues; ces endroits sont donc propices à l'exploration des interactions potentielles entre l'intoxication, la fatigue et le jeu, du point de vue de la réduction des méfaits. La présente étude a suivi les tendances de jeu, de consommation d'alcool et de manque de sommeil d'un échantillon en ligne de joueurs et de buveurs réguliers ($N$ = 132, 28% de femmes) pendant six jours à l'aide de journaux en ligne. Les résultats confirment que les trois comportements sont liés sur le plan individuel, avec des corrélations significatives entre les sujets, notamment entre le jeu et le sommeil ($r$ = –.20), le jeu et la consommation d'alcool ($r$ = 0,22) et le sommeil et la consommation d'alcool ($r$ = –0,19). Cependant, aucune relation intrasujet forte ou fiable (jour après jour) n'a été constatée. Autrement dit, même si les joueurs plus actifs dormaient moins et buvaient plus, ils n'étaient pas plus susceptibles de boire relativement plus ou de dormir moins les jours où ils jouaient. Nous avons également observé un effet d'autocorrélation négatif pour chaque comportement : s'engager intensément dans un comportement le même jour est associé à une réduction du même comportement le jour suivant. Ce résultat laisse croire que les traits individuels, plutôt que les effets contextuels ou environnementaux, sont responsables des comorbidités observées entre ces comportements liés à la santé. De plus, les comportements liés au jeu, comme la consommation d'alcool et le manque de sommeil, sont sujets à des effets de saturation et à des effets réfractaires.


---

## Introduction

Minimizing harm from gambling is a topic of interest for many governments and NGOs, with recent research suggesting that many persons who do not fit the criteria for problem gambling are nonetheless experiencing significant harm from their gambling (Browne, Greer, Rawat, & Rockloff, 2017). Fatigue and intoxication can produce a negative impact on the way people think, including on their decision-making, which can in turn lead to poor gambling-related outcomes (Kyngdon & Dickerson, 1999; Noy et al., 2011). However, little research has addressed the interaction between alcohol consumption, sleep restriction, and gambling, and whether this combination of factors contributes to gambling harm. Furthermore, few studies have investigated relationships between gambling, alcohol and sleep restriction in a real-world context. Most research has examined individual differences; finding that persons who typically drink more and sleep less also tend to gamble more intensively. This situation raises the question of whether or not these observed between-subjects

differences are because of episodic effects, e.g., inebriation contributing to uncontrolled gambling; or instead gambling environments fostering the consumption of alcohol. The alternative is a trait-based explanation, in which co-occurrence in individuals is because of individual differences, such as socio-economic status or behavioural impulsivity, that cause them to pursue all of these activities.

## Background

**Alcohol and Gambling**. Population studies have consistently suggested those persons who have problems with alcohol are also more likely to experience problems with gambling. Persons who gamble are commonly categorised into risk segments depending on their likelihood of experiencing problems with gambling, e.g., no-risk (including non-gamblers), low-risk, moderate-risk, and problem gamblers, all according to the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001). A US-based national telephone survey conducted for the National Gambling Impact Study Commission found that problem gamblers are seven times more likely to be abusing alcohol than non-gamblers and low-risk gamblers (Gerstein, Hoffmann, & Larison, 1999). In Australia, the Victorian Gambling Study reported that almost half of problem gamblers had clinically significant levels of alcohol abuse, compared to 14% of no-risk gamblers (Billi, Stone, Marden, & Yeung, 2014). Similarly, the Danish Health and Morbidity Survey suggested that problem gamblers were significantly more likely to exceed the Danish Government's sensible drinking guidelines of 21 standard drinks per week for males and 14 for females (Algren, Ekholm, Davidsen, Larsen, & Juel, 2014). Just over 35% of problem gamblers exceeded these sensible drinking guidelines, compared to only 11.9% of non-problem gamblers. These studies across multiple jurisdictions show that a relationship does exist between alcohol abuse and gambling. However, the cross-sectional surveys shed no light upon the question of whether these comorbidities are because of the common influence of shared traits, or rather the direct influence of situational and episodic factors.

The relationship between alcohol consumption and gambling on an acute level has been explored through past experimental studies. One experiment examining EGM gambling with real money suggested that, compared to the control group, moderate alcohol consumption by probable problem gamblers leads to longer EGM gambling sessions and a non-significant trend toward power-betting (the option to increase the amount wagered on an outcome after being shown half of the spin result). Interestingly, no significant differences were found for non-pathological gamblers (Ellery, Stewart & Loba, 2005). Following a similar experimental paradigm, Ellery and Stewart (2014) found that alcohol consumption, compared to control beverage consumption, resulted in increased rates of "doubling up" (choosing to bet on a bonus game following a regular win) when gambling on an EGM but, again, only in probable problem gamblers. A similar experiment with a within-subjects manipulation demonstrated that following alcohol consumption, participants took less time to make decisions on a simulated blackjack task and lost all their "money" (points) more quickly than when they had not consumed alcohol (Phillips & Ogeil, 2007).

This expedited loss of all gambling funds, as well as placing larger average bets, was also found in a large study (n=130) comparing alcohol consumption with a placebo beverage (Cronce & Corbin, 2010). These experimental studies offer strong evidence for the role of alcohol in inducing impaired control when gambling but also perhaps more so in vulnerable populations.

However, despite highly similar testing protocols and important results for our understanding of how acute alcohol consumption affects gambling, these studies differ markedly in their findings in terms of which gambling behaviours are actually affected. Certain studies indicate an increase in average bet size but no significant difference in time on device (Cronce & Corbin, 2010). Other studies suggest increased time on device but no difference in overall spend or bet size (Ellery et al., 2005). Yet another study indicates increase bonus betting (or "risky" betting) but no increase in mean bet size or time on device (Ellery & Stewart, 2014). Other studies still demonstrate no significant differences in any gambling measures between alcohol consumption and placebo conditions (Breslin, Sobell, Cappell, Vakili, & Poulos, 1999; Corbin & Cronce, 2017). In addition, which of these behaviours that were exacerbated by alcohol consumption are likely to lead to real world gambling harm is also difficult to ascertain from the results? A more real-world paradigm, such as behavioural tracking, may offer insights into which of these gambling behaviours is the most likely when consuming alcohol.

Longitudinal studies examining the link between alcohol consumption and gambling harm offer suggestive evidence on cause and effect in the real world. The first general population prospective study of problem and non-problem gamblers, conducted in New Zealand, indicated that a substantial number of those experiencing problems with gambling in 1991 were no longer experiencing problems with gambling in 1998. However, problem gamblers who also engaged in hazardous drinking in 1991 were more likely to remain problem gamblers in 1998 rather than to recover (Abbott, Williams, & Volberg, 2004). This fact suggests that alcohol may contribute to the maintenance of gambling problems over the long term. Alternatively, hazardous use of both alcohol and gambling products may in fact both be indicators of an underlying vulnerability that is prejudicial to recovery.

Evidence has emerged that an underlying vulnerability may explain the co-occurrence of gambling and alcohol problems. Goodwin, Browne, Rockloff and Donaldson (2015) found that some people have a generalised tendency to over-consume many unhealthful products. This trait-like tendency towards over-consumption is a useful explanation for covariance in the use of high salt foods, cigarettes, drugs, gambling and alcohol. This trait perspective in turn suggests that co-occurrence of these behaviours is not because of direct relationships between these activities (e.g., drinking while gambling), but rather because of influence of "third variables," such as behavioural impulsivity, at the individual level affecting the use of all these potentially unhealthful products.

**Sleep and Gambling**. A handful of large population panel studies have found significant positive correlations between sleep restriction and gambling problems. One such study (Parhami et al., 2012) compared severe problem gamblers not currently seeking treatment (historically classified as pathological gamblers by meeting between 5 to 10 of the DSM-IV criteria for pathological gambling) to problem gamblers not currently seeking treatment (meeting 1–4 of the DSM-IV criteria) and recreational gamblers (non-problem gamblers). Parhami et al. (2012) found that non-treatment seeking severe and problem gamblers had significantly poorer quality of sleep than recreational gamblers. Severe non-treatment-seeking problem gamblers also reported significantly more daytime sleepiness than problem and recreational gamblers. Although not significant, a linear-trend of decrease in quality of sleep and increase in daytime sleepiness was observed when comparing the three groups: recreational, problem, and severe non-treatment-seeking problem gamblers. The authors of the study believe that this progressive relationship between problem gambling severity and negative sleep outcomes is likely to exist as a significant finding if investigated with a larger sample size (Parhami et al., 2012).

Good reasons can be located to suspect a direct structural relationship between sleep restriction (i.e., lack of sleep) and gambling at the episodic level. It may be that gambling late at night disturbs sleep, or that stress because of gambling harm leads to poor sleep, or both. However, it is also possible that an underlying trait, such as that reported by Goodwin and colleagues (2015), may be responsible for the over-consumption of reward-oriented stimuli, such as gambling; and lesser prioritisation of non-reward-oriented stimuli, of which sleep may be one. Unfortunately, little research has taken place concerning why sleep problems are more common in problem gamblers (Parhami et al., 2012).

In examining the temporal pattern of sleep and gambling behaviour, no experimental studies examining the effect of gambling on subsequent sleep quality or quantity have been published. However, experimental studies investigating the effect of sleep deprivation on gambling behaviour have been conducted using proxy measures, such as the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994), to measure gambling decisions. Studies using the IGT to study the effects of sleep deprivation on decision making have shown that as little as one night of sleep deprivation (23 hours of continual wakefulness) leads to persons making poorer decisions (Killgore, Grugle, & Balkin, 2012). That is, a tendency does exist for sleep deprived individuals to favour short-term over long-term gains. This practice is found within subjects, i.e., individuals that had previously been exposed to the IGT and learned to choose the advantageous deck of cards still select the long-term disadvantageous deck when sleep deprived. Moreover, after a recovery sleep, participants go back to favouring long-term gains over short-term gains and long-term losses. This effect has been replicated over a range of time periods of sleep deprivation, including 49, 51 and 75 hours of total sleep deprivation (Killgore, Balkin, & Wesensten, 2006; Killgore, Lipizzi, Kamimori, & Balkin, 2007). These results suggest that sleep deprivation leads to a decision making strategy disproportionately

influenced by large gains. Large losses are ignored or given less weight than in normal decision making (Killgore, et al., 2012).

Continuous forms of gambling, similarly to the IGT, consist of short term gains in the form of intermittent large wins, interspersed with continuous small wagers and associated small losses. This pattern usually results in an overall net loss at the end of a gambling session. In relating this type of gambling to the IGT, those that engage in "healthy" gambling set spend limits for themselves, thus making the advantageous choice to cease gambling once their limit is reached. For example, no-risk and low-risk gamblers often begin gambling with a set stake, such as $20, and may walk away once that stake has been lost. Those that have problems with gambling often bet more than they can afford to lose and chase losses (PGSI; Ferris & Wynne, 2001), thus making disadvantageous choices, similar to those that choose the long-term losses IGT card deck. Studies showing that sleep deprivation results in decision making deficits when using the IGT may, therefore, mean that gambling while sleep deprived may in turn lead to increased gambling-related harm in the community.

### Aim of Present Study

The aim of the present study was to examine the relationship between gambling, sleep restriction and alcohol use in a longitudinal design. An online diary was used to track participants' alcohol use, gambling, and sleep patterns over six days to investigate whether a relationship functions between these three behaviours.

The current study examined whether a link exists between episodes of gambling, sleep and alcohol consumption, which can include common environmental influences, such as the availability of alcohol and gambling opportunities, as well as direct impacts of one behaviour on another, as depicted in Figure 1. We anticipated that there will be a circular link in that consuming more alcohol while gambling will lead to longer gambling sessions and shorter sleep duration on the following day, while shorter sleep duration will subsequently lead to longer gambling sessions and increased alcohol consumption. The ecological momentary assessment (EMA) design style of the current study can help determine which explanation is most plausible for any discovered links between these three behaviours.

## Method

### Participants

Participants were recruited via Amazon's Mechanical Turk, which is an online panel provider/crowdsourcing marketplace. The Amazon service, based in the United States, provides a crowd-share marketplace for online work. Mechanical Turk allows individuals and organizations to post online surveys that workers can complete for small cash amounts or Amazon credit. The validity of Mechanical Turk's online panels have been studied by researchers in the areas of psychology and social science and, more specifically, in substance use and gambling; and have been found to be more

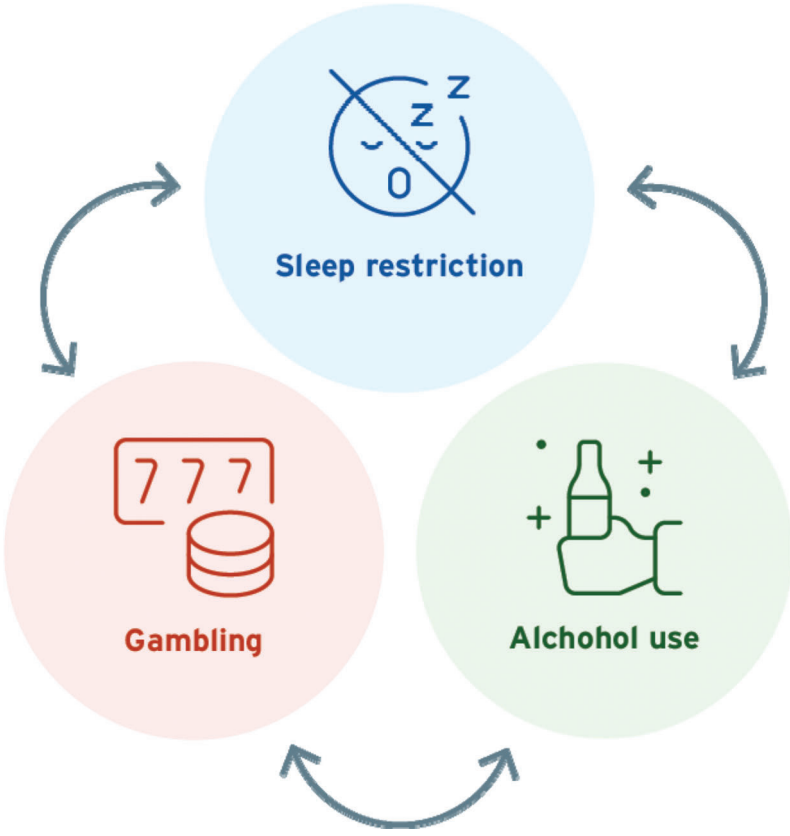


*Figure 1.* A depiction of a potential tri-directional relationship between gambling, alcohol use and sleeprestriction.

demographically diverse than undergraduate university samples. Furthermore, American studies have shown Mechanical Turk samples to be broadly representative of the American population (Buhrmester, Kwang, & Gosling, 2011; Kim & Hodgins, 2017).

The current study period ran for six days, but participants were free to withdraw at any time. Participants were compensated US$0.80 for the initial screening questionnaire and US$0.50 per survey that they completed thereafter, which was rated as a fair and effective compensation level in the context of the US minimum wage and the relative time commitment required (Kim & Hodgins, 2017). The study was conducted in late November, 2016. The 176 persons who volunteered and who were eligible subsequently gave their informed consent and completed the initial survey. Of those persons, 132 consented to recontact (75% consent rate). All participants were over the age of 18 years and were regular gamblers and drinkers (once or more drinks per week). The justification for this inclusion criteria was to ensure that a large proportion of the participants would be likely to gamble and consume alcohol during the study period in order for meaningful data to be collected. Nevertheless, the research did not specifically target persons with gambling or alcohol problems. US-based Helpline information was included in the study information for those concerned about their gambling or drinking. The study was approved by the Central Queensland University (Australia) Human Ethics Committee (Project Number H16/06-161).

A breakdown of the demographics of the followed-up sample is shown in Table 1. Of the 132 participants, over 70% were male. Ages ranged from 19 to 57 years with a mean age of 32. Over half the sample (58.8%) consumed alcohol two to three times per week, with the remaining participants consuming alcohol four or more times per week (41.2%). The majority of participants gambled two to three times per week (51.5%). The majority of participants were classified either as married (39.4%) or as single, never married (36.4%). For over 90% of the sample English was the language spoken at home.

Table 1
*Participant demographics*

| | n | % |
|---|---|---|
| Age range | | |
| 18–19 | 1 | 0.8 |
| 20–24 | 14 | 10.6 |
| 25–29 | 46 | 34.8 |
| 30–34 | 35 | 26.5 |
| 35–39 | 11 | 8.3 |
| 40–44 | 9 | 6.8 |
| 45–49 | 7 | 5.3 |
| 50–54 | 7 | 5.3 |
| 55–59 | 2 | 1.5 |
| Gender | | |
| Male | 93 | 70.5 |
| Female | 37 | 28 |
| Alcohol consumption frequency | | |
| 2–3 times per week | 77 | 58.8 |
| 4 or more times per week | 54 | 41.2 |
| Gambling frequency | | |
| 2 to 4 times per month | 1 | 0.8 |
| 2 to 3 times per week | 68 | 51.5 |
| 4 to 5 times per week | 34 | 25.8 |
| 6 or more times per week | 29 | 22 |
| Relationship status | | |
| Married | 52 | 39.4 |
| Widowed | 1 | 0.8 |
| Divorced | 4 | 3 |
| Separated | 1 | 0.8 |
| Domestic partnership or civil union | 7 | 5.3 |
| Single but cohabiting with a significant other | 18 | 13.6 |
| Single, never married | 48 | 36.4 |
| Main language spoken at home | | |
| English | 123 | 93.2 |
| Other | 8 | 6.1 |
| Aboriginality | | |
| Aboriginal/& Torres Strait Islander | 13 | 9.8 |
| Non-aboriginal | 118 | 89.4 |

## Procedure

Eligible participants first completed a screening questionnaire. Questionnaire topics included demographics, and were based on the Consumption Screen for Problem Gambling (CSPG; Rockloff, 2012), the AUDIT-C measure of hazardous drinking (Bush, Kivlahan, McDonell, Fihn & Bradley, 1998), and the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman & Kupfer, 1989). Those subjects who consented to recontact were then prompted daily for seven days by email messages to complete a daily online diary. Because of a technical issue on the seventh day, data from that day was discarded, leaving six days of high integrity data to analyse. Each daily diary was open for 24 hours only from 3:00 a.m. to 2:59 a.m. US Eastern Standard Time (EST) and asked participants to recall their previous day's activity, i.e., yesterday. Participants recorded the current time of day and total time spent sleeping, drinking alcohol and gambling. The opening and closing times for the survey were chosen to reduce the likelihood of participants referring to the same "waking" day when they were recalling the previous day's activities.

## Data Analysis

Analyses were conducted using the R statistical package. Participants indicated the time they had slept in their previous main sleep and naps in 12–hour time. This figure was then converted to 24-hour time using the formula below (Paterson, Browne, Ferguson & Dawson, 2016) to obtain a total sleep time for main sleep and total sleep time for naps. Data were screened for human error and inputs that obviously exceeded logical norms were adjusted, for example, when participants may have selected "p.m." instead of "a.m." resulting in a sleep time of over 24 hours.

$$\left\{ \begin{array}{ll} 24 - t_{sleep} + t_{wake} & if \quad t_{sleep} > t_{wake} \\ t_{wake} - t_{sleep} & \quad\quad t_{sleep} \leq t_{wake} \end{array} \right\}$$

Non-parametric correlations were employed because of mild violations of normality assumptions in the behavioural variables. Data were first averaged at the participant level. Between-subjects correlations were calculated on this data set. Subtraction of the participant means from the daily observations yielded relative differences within subjects. Within-subjects correlations were calculated from these deviations. Therefore, these statistics represented independent sources of between- and within-subjects co-variation in the original dataset.

# Results

Table 2 presents between-subjects correlations between sleep restriction, gambling, and alcohol consumption. Overall, persons who gambled more also consumed more alcohol, were more likely to nap during the day, and more likely to sleep less during their main overnight sleep when aggregated across days. More specifically, Table 2 indicates that on average, persons who gambled more also slept less overnight; persons who gambled more, drank more; persons who drank more, napped more; and persons who drank more, slept less overnight.

Table 2
*Relationship between time spent sleeping, gambling, napping and number of standard drinks consumed: Between-subjects correlations*

| | 1. Sleep Duration | 2. Gambling Duration | 3. Drinks Consumed | 4. Napping Duration |
|---|---|---|---|---|
| 1. Sleep Duration | - | | | |
| 2. Gambling Duration | –.20* | - | | |
| 3. Drinks Consumed | –.19* | .22* | - | |
| 4. Napping Duration | –.09 | .03 | .15* | - |

* $p < .05$.

Putting aside individual differences, we found a significant difference between the number of hours slept on days in which someone gambled ("gambling day") compared to days in which they do not gamble ("non-gambling day"). On a day when somebody gambles, on average they sleep for seven hours ($M = 7.01$, $SD = 1.85$) compared to about seven hours and twenty minutes ($M = 7.36$, $SD = 1.64$) when they do not gamble, $t(526) = 2.47$, $p = .0137$).

These findings are similar with respect to alcohol consumption. Participants consumed just over three and a half standard drinks, on average, on days when they gambled ($M = 3.62$, $SD = 5.41$) compared to two and a half standard drinks on days when they did not gamble ($M = 2.55$, $SD = 3.47$), $t(420) = 2.81$, $p = .0051$.

Table 3 indicates the effect of the amount of time subjects spent gambling. Within-subjects correlations between time spent gambling, time spent sleeping, time spent napping and the number of standard drinks consumed show a small but significant relationship between time spent gambling and the number of standard drinks consumed. Surprisingly, as shown in the last row of Table 3, participants did not gamble more, sleep less and drink more on weekend (Friday and Saturday) nights than weeknights. A significant negative correlation between weekend drinking and weekend gambling was found.

Lastly, lagged correlations were calculated to predict day-by-day changes in gambling, alcohol consumption and sleeping from the prior day's values. Results demonstrated that when relating behaviours of one day to that of the previous day, each behaviour is only significantly correlated with that same behaviour. There was a negative correlation of –.14 between the amount of time spent sleeping over one 24-hour period compared to the previous 24-hour period. There was also a negative correlation of –.23 between the number of standard drinks consumed one day compared to the previous day. Finally, there was a negative correlation of –.28 between the amount of time spent gambling one day compared to the previous day. However, when examining the relationship between gambling and engaging in the other behaviours, it was evident that consuming more or less alcohol or obtaining more or less sleep did not in fact predict the next day's gambling duration.

Table 3
*Relationship between time spent sleeping, gambling, napping and number of standard drinks consumed: Within-subjects correlations*

| Variables | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Sleep Duration | - | | | | |
| 2. Gambling Duration | –.06 | - | | | |
| 3. Drinks Consumed | –.03 | .08* | - | | |
| 4. Napping Duration | –.13 | –.01 | .03 | - | |
| 5. Fri/Sat Period | –.01 | –.03 | –.08* | .00 | - |

*$p < .05$.

## Discussion

The results indicated that gambling, sleep and alcohol consumption were related, but that this relationship is primarily because of between-subjects differences. This fact was evidenced by the co-occurrence of behaviours within individuals but the lack of lagged-correlations, i.e., a time-based predictive relationship, between the three variables. This finding supported a trait-based, rather than an episodic-based, explanation for the co-occurrence of these behaviours. The discovery was consistent with previous research that proposes that behaviours such as gambling and drinking form part of an attraction to supernormal stimuli, and that this interest is symptomatic of a consumptiveness trait (Goodwin et al., 2015). Similarly, traits such as impulsiveness have been linked to the overconsumption of gambling and alcohol (Lawrence, Luty, Bogdan, Sahakian & Clark, 2009) and poor quality and quantity of sleep (McGowan & Coogan, 2018). The current study pointed to a trifecta of unhealthy behaviours occurring in certain individuals: increased gambling, increased drinking, and decreased sleep quantity and/or quality. These findings also supported longitudinal studies that have found links between alcohol abuse and gambling (Abbott et al., 2004) and gambling and sleep restriction (Parhami et al., 2012). However, this study is the first to look at all three behaviours in tandem across multiple days of measurement.

Though primarily because of individual differences, we did find that on days that persons gamble, they sleep significantly less. This determination was contrary to our hypothesis that there would be a lagged effect—that sleeping less one day would predict more gambling and alcohol use the next day. However, it is an interesting observation nonetheless. We also found that on days when persons gamble they drink significantly more. This relationship was not explained by a "weekend effect"; the tendency to drink more and sleep less on a Friday or Saturday night. In fact, we found that the opposite is true: a small negative correlation did exist between drinking and weekend days. Young persons are drinking at historically low levels (Livingston, 2014; Raninen, Livingston & Leifman, 2014), which may be changing traditional weekend binge patterns of alcohol consumption. As the majority of our sample was under 35 years of age, it is possible that our data reflects changing

attitudes to alcohol. Alternatively, the lack of a weekend effect may illustrate the breakdown of traditional work schedules, with higher proportions of the population engaging in non-standard work hours/days (Australian Bureau of Statistics, 2012). Moreover, the co-occurrence of gambling, alcohol consumption and sleep restriction, and the absence of a weekend effect, indicates that these activities are intrinsically linked outside of the usual realm of leisure time activities, at least for regular (weekly) gamblers and drinkers.

When excluding individual differences, and examining within-subjects day-to-day cross- and lagged- correlations, we found little association between the three variables. However, there was a negative episodic effect for each singular behaviour, illustrating that engaging in one behaviour does not result in more or less engagement in a different behaviour the following day but does result in less engagement in the same behaviour the following day. Consuming more alcohol or sleeping more one day with the effect of doing less of that same behaviour the following day can be attributed to physiological drivers or "hangover" effects. However, these physiological drivers are not present in gambling, and yet this behaviour had the strongest negative lagged correlation. That gambling one day could have a satiating effect, leading to a lesser degree of gambling the following day, is counter to literature describing binge gambling over multiple days (Nower & Blaszczynski, 2003). This satiating effect warrants further study as it is a novel finding in stimuli, such as gambling, that are vulnerable to behavioural addiction.

The EMA design of the present study allowed the time-course of the three behaviours to be examined day-by-day. Despite our results suggesting that one behaviour did not predict a different behaviour day-by-day, this null result should nevertheless not be seen as confirmation of a lack of a functional relationship between these variables. Instead, it demonstrates that the time-course of the relationships do not resolve themselves across one full day. For instance, it could be the case that alcohol consumption could influence subsequent gambling consumption over the time period of a few hours. Thus, this finding prompts us to think differently about the scale of the time-course of these behaviours. Rockloff et al. (2018) demonstrated that playing a simulated mobile gambling game one week led to an increase in real gambling the next week, illustrating a longer than expected time-course for simulated gambling influencing real gambling. The current results suggest that chronic sleep loss or alcohol consumption may play a greater role than acute sleep restriction or alcohol consumption in predicting gambling. This assertion is supported by Belenky and colleagues (2003) who demonstrated a dose-response relationship in performance-based tasks in response to increasing amounts of sleep restriction over seven days. The existence of a longer time-course in the relationship between sleep and gambling is especially relevant to our understanding of gambling given the increasing prevalence of chronic sleep restriction in modern society, with nearly half of Americans obtaining less than the recommended amount of sleep needed for optimal performance (National Sleep Foundation, 2008). Future studies should explore the relationship between sleep, gambling and alcohol over a longer time period than that

which was used in the current study to capture the cumulative effects of sleep loss or alcohol consumption.

## Limitations

As with other self-report studies, this study is limited by participants' accurate recall about events that occurred the previous day. The method utilised reduces reporting inaccuracies that rely on longer timeframes, but we also concede that it can be difficult for persons to recall accurately the numbers of drinks they may have consumed, the amount of time for which they gambled, and their total sleep time. In the future, asking participants to engage in real-time reporting of their drinking and gambling behaviour, possibly through a mobile phone application or another type of experience-sampling, may improve the accuracy of data collection. We also acknowledge that a longer data collection period, for example, one month, might offer greater insights into these behaviours.

The sample was recruited from Amazon Mechanical Turk, and whereas a 2017 study reported similarities between Mechanical Turk samples and samples recruited elsewhere, such a connection may in fact not have been the case in the current study (Buhrmester et al., 2011; Kim & Hodgins, 2017). In addition, the sample size of the current study restricted us from looking at the differences in gambling forms and modes. It may be that engaging in certain forms of gambling, such as sports betting for example, may enjoy a greater impact on the amount of alcohol one consumes, but because of the sample size we were unable to investigate these differences. In addition, the mode that one uses to gamble, be it via the Internet or in a gambling venue, may have an impact on factors such as alcohol consumption. The sample size may also have affected the statistical strength of the associations between sleep restriction, alcohol and gambling. Additionally, work and lifestyle factors were not taken into consideration in this study which may have an impact on people's sleep and consumption choices.

Finally, the authors recommend further work be undertaken to investigate causation, such as experimental studies that manipulate gambling, alcohol and sleep restriction. This type of applied research would offer great insights into how the current gambling environment influences gambling. Gambling policy-makers, as well as treatment providers and consumers themselves, would greatly benefit from this type of real-world research.

## Conclusion

Gambling environments are often accessible late into the night and provide ready access to alcohol. Moreover, fatigue and intoxication are known to affect decision-making. The current study examined real-life gambling, sleeping-duration and alcohol consumption across a six-day period. The results suggest that a relationship does operate between these three behaviours across persons and across days. Those persons who persistently spend more time gambling, more time drinking alcohol or

less time sleeping, are likely to also engage in the other activities. Moreover, on the particular days when persons gamble, drink or are sleep restricted, they are more likely to engage in the other activities. In the future, different timeframes for measurement may reveal the distinct causal path that links these three behaviours in a cycle of reinforcing action.

## References

Abbott, M. W., Williams, M. M., & Volberg, R. A. (2004). A prospective study of problem and regular nonproblem gamblers living in the community. *Substance Use & Misuse*, *39*, 855–884. doi:10.1081/JA-120030891. Retrieved from: https://doi.org/10.1081/JA-120030891

Algren, M. H., Ekholm, O., Davidsen, M., Larsen, C. V. L., & Juel, K. (2014). Health behaviour and body mass index among problem gamblers: Results from a nationwide survey. *Journal of Gambling Studies*, *31*, 547–556. doi:10.1007/s10899-013-9437-y

Australian Bureau of Statistics (2012). *Working time arrangements.* Canberra, Australia: The Author. Retrieved from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/6342.0

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*, 7–15. doi: 10.1016/0010-0277(94)90018-3. Retrieved from: https://culturecog.blog/wp-content/uploads/2018/05/Bechara-etal-1994.pdf

Belenky, G., Wesensten, N. J., Thorne, D. R., Thomas, M. L., Sing, H. C., Redmond Balkin, … T. J. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. *Journal of Sleep Research, 12*, 1–12. doi:10.1046/j.1365-2869.2003.00337.x

Billi, R., Stone, C. A., Marden, P., & Yeung, K. (2014). *The Victorian Gambling Study: A longitudinal study of gambling health in Victoria: 2008–2012.* Victoria, Australia: Victorian Responsible Gambling Foundation. Retrieved from: file:///C:/Users/TEMP.OWNER-HP.001/Downloads/Research-report-longitudinal-study-gambling-and-health-victoria-20082012.pdf

Breslin, F. C., Sobell, M. B., Cappell, H., Vakili, S., & Poulos, C. X. (1999). The effects of alcohol, gender, and sensation seeking on the gambling choices of social drinkers. *Psychology of Addictive Behaviors*, *13*, 243–252. doi:10.1037/0893-164X.13.3.243

Browne, M., Greer, N., Rawat, V., & Rockloff, M. (2017). A population-level metric for gambling-related harm. *International Gambling Studies*, *17*, 1–14. doi:10.1080/14459795.2017.1304973

Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data? *Perspectives on Psychological Science: A. Journal of the Association for Psychological Science*, *6*, 3–5. doi:10.1177/1745691610393980

Bush, K., Kivlahan, D. R., McDonell, M. B., Fihn, S. D., & Bradley, K. A. (1998). The audit alcohol consumption questions (audit-c): An effective brief screening test for problem drinking. *Archives of Internal Medicine*, *158*, 1789–1795. doi:10.1001/archinte.158.16.1789

Buysse, D. J., Reynolds, C. F., III, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213. doi:10.1016/0165-1781(89)90047-4

Corbin, W. R., & Cronce, J. M. (2017). Effects of alcohol, initial gambling outcomes, impulsivity, and gambling cognitions on gambling behavior using a video poker task. *Experimental and Clinical Psychopharmacology*, *25*, 175–185. doi:10.1037/pha0000125

Cronce, J. M., & Corbin, W. R. (2010). Effects of alcohol and initial gambling outcomes on within-session gambling behavior. *Experimental and Clinical Psychopharmacology*, *18*, 145–157. doi:10.1037/a0019114. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3039524

Ellery, M., & Stewart, S. H. (2014). Alcohol affects video lottery terminal (VLT) gambling behaviors and cognitions differently. *Psychology of Addictive Behaviors*, *28*, 206–216. doi:10.1037/a0035235

Ellery, M., Stewart, S. H., & Loba, P. (2005). Alcohol's effects on video lottery terminal (VLT) play among probable pathological and non-pathological gamblers. *Journal of Gambling Studies*, *21*, 299–324. doi:10.1007/s10899-005-3101-0

Ferris, J., & Wynne, H. (2001). *The Canadian Problem Gambling Index: Final report.* Ottawa, ON: Canadian Centre on Substance Abuse. Retrieved from: http://ccgr.ca/sites/default/files/CPGI-Final-Report-English.pdf

Gerstein, D. R., Hoffmann, J., Larison, C., Elgenman, L., Murphy, S., Palmer, A., …& Sinclair, S. (1999). *Gambling impact and behavior study: Report to the National Gambling Impact Study Commission*. Chicago, IL: National Opinion Research Center at the University of Chicago. Retrieved from: http://www.norc.org/PDFs/publications/GIBSFinalReportApril1999.pdf

Goodwin, B. C., Browne, M., Rockloff, M., & Donaldson, P. (2015). Do gamblers eat more salt? Testing a latent trait model of covariance in consumption. *Journal of Behavioral Addictions*, *4*, 170–180. doi:10.1556/2006.4.2015.022

Killgore, W. D. S., Balkin, T. J., & Wesensten, N. J. (2006). Impaired decision making following 49 h of sleep deprivation. *Journal of Sleep Research*, *15*, 7–13. doi:10.1111/j.1365-2869.2006.00487.x

Killgore, W. D. S., Grugle, N. L., & Balkin, T. J. (2012). Gambling when sleep deprived: Don't bet on stimulants. *Chronobiology International*, *29*, 43–54. doi:10.3109/07420528.2011.635230

Killgore, W. D. S., Lipizzi, E. L., Kamimori, G. H., & Balkin, T. J. (2007). Caffeine effects on risky decision making after 75 hours of sleep deprivation. *Aviation, Space, and Environmental Medicine*, *78*, 957–962. doi:10.3357/ASEM.2106.2007

Kim, H. S., & Hodgins, D. C. (2017). Reliability and validity of data obtained from alcohol, cannabis, and gambling populations on Amazon's Mechanical Turk. *Psychology of Addictive Behaviors*, *31*, 85–94. doi:10.1037/adb0000219

Kyngdon, A., & Dickerson, M. (1999). An experimental study of the effect of prior alcohol consumption on a simulated gambling activity. *Addiction*, *94*, 697–707. doi:10.1046/j.1360-0443.1999.9456977.x

Lawrence, A. J., Luty, J., Bogdan, N. A., Sahakian, B. J., & Clark, L. (2009). Impulsivity and response inhibition in alcohol dependence and problem gambling. *Psychopharmacology*, *207*, 163–172. doi:10.1007/s00213-009-1645-x

Livingston, M. (2014). Trends in non-drinking among Australian adolescents. *Addiction*, *109*, 922–929. doi:10.1111/add.12524. Retrieved from: https://ndarc.med.unsw.edu.au/sites/default/files/newsevents/events/Livingston%20young%20drinkers%20in%20Australia.pdf

McGowan, N. M., & Coogan, A. N. (2018). Sleep and circadian rhythm function and trait impulsivity: An actigraphy study. *Psychiatry Research*, *268*, 251–256. doi:10.1016/j.psychres.2018.07.030

National Sleep Foundation (2008). *2008 Sleep in America Poll: Summary of findings.* Washington, DC: Author. Retrieved from: https://www.sleepfoundation.org/sites/default/files/2018-11/2008_POLL_SOF.pdf

Nower, L., & Blaszczynski, A. (2003). Binge gambling: A neglected concept. *International Gambling Studies*, *3*, 23–35. doi:10.1080/14459790304589

Noy, Y. I., Horrey, W. J., Popkin, S. M., Folkard, S., Howarth, H. D., & Courtney, T. K. (2011). Future directions in fatigue and safety research. *Accident Analysis & Prevention*, *43*, 495–497. doi:10.1016/j.aap.2009.12.017

Parhami, I., Siani, A., Rosenthal, R. J., Lin, S., Collard, M., & Fong, T. W. (2012). Sleep and gambling in a community sample of gamblers. *Journal of Addictive Diseases*, *31*, 67–79. doi:10.1080/10550887.2011.642754

Paterson, J. L., Browne, M., Ferguson, S. A., & Dawson, D. (2016). Prior sleep and perceptions of risk when driving. *Sleep and Biological Rhythms*, *14*, 295–301. doi:10.1007/s41105-016-0058-6

Phillips, J. G., & Ogeil, R. P. (2007). Alcohol consumption and computer blackjack. *The Journal of General Psychology*, *134*, 333–353. doi:10.3200/GENP.134.3.333-354

Raninen, J., Livingston, M., & Leifman, H. (2014). Declining trends in alcohol consumption among Swedish youth: Does the theory of collectivity of drinking cultures apply? *Alcohol and Alcoholism*, *49*, 681–686. doi:10.1093/alcalc/agu045

Rockloff, M. J. (2012). Validation of the Consumption Screen for Problem Gambling (CSPG). *Journal of Gambling Studies*, *28*, 207–216. doi:10.1007/s10899-011-9260-2

Rockloff, M., Greer, N., Armstrong, T., Thorne, H., Langham, E., Browne, M., … & Li, E. (2018). *Mobile EGMs Apps: The perfect substitute or the perfect storm?* Victoria, Australia: Victorian Responsible Gambling Foundation. Retrieved from: https://responsiblegambling.vic.gov.au/documents/407/Mobile-EGMs-Apps.pdf

*******

Submitted December 12, 2018; accepted July 24, 2019. This article was peer reviewed. All URLs were available at the time of submission.

For correspondence: Hannah Brioni Thorne, Ph.D. Candidate., School of Health, Medical and Applied Sciences, Central Queensland University, 44 Greenhill Rd, Wayville SA 5034, Australia. Email: h.thorne@cqu.edu.au

Competing interests: The authors have not received direct funding from the gambling-industry at any time, and declare no competing interests for the present research.

Ethics approval: The study was approved by the Central Queensland University (Australia) Human Ethics Committee (Project Number H16/06-161).

Acknowledgements: The authors gratefully acknowledge research funding and support by Central Queensland University for the conduct of this study. All findings and conclusions are the sole responsibility of the authors.