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Does Alcohol Consumption Increase Risk-Taking while Gambling? A Systematic Review and Meta-Analysis

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DOES ALCOHOL CONSUMPTION INCREASE RISK-TAKING WHILE GAMBLING? A SYSTEMATIC REVIEW & META-ANALYSIS

by

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Abstract

Alcohol is often consumed while gambling and drinking while gambling has fueled considerable discussion about the effects of alcohol consumption on risk taking and wagering intensity. Laboratory studies designed to test this argument have not provided conclusive answers. A contributing factor for these ambiguous findings among studies may be their attention to different levels of blood alcohol concentration (BAC) among participants. The effects of BAC on risk taking while gambling has yet to be evaluated. We completed a systematic review and meta-analysis of the literature. Eighteen articles (N = 1,611) meeting inclusion criteria were identified. The overall Hedges' g value for differences in risk-taking between groups consuming and not consuming alcohol was 0.32, 95% CI [0.23, 0.42], $p < .001$. Analyses revealed a negative linear relation between BAC (range: 0.052 to 0.090%) and risk taking while gambling. A curvilinear relation between BAC and risk taking while gambling was also found. The highest Hedges' g values were associated with an approximate BAC of 0.06%. Gambling while moderately intoxicated (~0.05-0.07% BAC) appeared to lead to greater risk taking when compared to higher intoxication levels while still revealing significantly higher risk taking compared to no alcohol consumption. Further research exploring risk-taking and gambling behaviors at varying levels of intoxication, particularly below 0.06% BAC, could provide insight into the complex relation between these behaviors. The studies published to date only considered risk-taking while BAC was ascending. Questions about how descending BAC impacts gambling and risk-taking remains untested. These findings have potential implications for the treatment of gambling disorder as well as responsible gambling policies.

Does Alcohol Consumption Increase Risk-Taking while Gambling?

A Systematic Review & Meta-Analysis

Alcohol is often available at gambling venues and, depending on the jurisdiction, freely provided to patrons who are actively gambling (Blaszczynski et al., 2011). Given that alcohol impairs executive function (e.g., Spinola et al., 2017), there has been considerable discussion about increases in gambling intensity due to alcohol consumption (Caneto et al., 2018; Sagoe et al., 2017). As a result, responsible gambling practices often call for promoting responsible alcohol use when gambling (Blaszczynski et al., 2011; Shaffer et al., 2019). Laboratory studies designed to test this argument have not provided a clear understanding of the effects of alcohol on gambling behavior. Some studies found that alcohol consumption led to an increase in risk-taking while gambling (Cronce & Corbin, 2010) and others a decrease (Wagner et al., 2018). Yet, others found no effect on risk-taking while gambling (Corbin & Cronce, 2017). The present study aimed to clarify results in this literature by conducting a systematic review and meta-analysis examining the effect of alcohol and the role of blood alcohol concentration (BAC) on risk-taking while gambling.

Gambling is any activity that includes an element of risk, specifically risking something of value, such as money, on events where the outcome is at least partially determined by chance (Mishra et al., 2010; Welte et al., 2015; Whelan et al., 2007). Given that some experience harm due to their risk taking, state-sponsored casino operators adopted responsible gambling policies (such as warning messages, self-exclusion programs and safeguards to prevent underage gambling; Blaszczynski et al., 2011; Shaffer et al., 2019). Gambling-related harm refers to any adverse consequences (e.g., financial harm, relationship problems) experienced as a direct result of gambling engagement (Browne et al., 2016; see Langham et al., 2015 for a full taxonomy of gambling-related harm). Researchers found that those experiencing greater amounts of harms scored higher on impulsivity measures and exhibited greater behavioral risk-taking (Mishra et al., 2010, 2017). Such studies illustrate that those who have a greater propensity for risk are more likely to experience gambling-related harms. These findings emphasize the importance of responsible gambling and responsible alcohol use practices, which aim to minimize potential harms to gamblers engaging in risk-taking behaviors.

Alcohol consumption is associated with reduced inhibition and impairment in information processing and motor coordination (Centers for Disease Control and Prevention (CDC), 2015). Consequently, drinking alcohol appears likely to increase risk taking while gambling and, consequently, gambling-related harm (Spinola et al., 2017). French and colleagues (2008) found that weekly or more frequent alcohol use is positively associated with gambling-related problems. Browne and colleagues (2019) surveyed residents of New South Wales and found that 41% who were at moderate to high risk for gambling-related problems either always or frequently consumed alcohol while gambling. Interestingly, 33% reported that they never consumed alcohol when gambling. Conolly and colleagues (2018) reported that 69% of individuals who consumed more than 14 alcoholic drinks per week gambled while 36% of nondrinkers gambled.

Despite this association, the direct effect of alcohol consumption on risk-taking while gambling remains unclear. Experimental studies conducted in a controlled context have examined the effects of alcohol on gambling behaviors by comparing those who consumed or did not consume alcohol before engaging in a gambling task (e.g., Sagoe et al., 2017; del Valle Vera et al., 2018). Several studies report that gamblers consuming alcohol bet at a faster pace, place larger bets, and spend more time and money gambling (e.g., Caneto et al., 2018; Cronce &

Corbin, 2010; Ellery et al., 2005). Other studies have found that alcohol consumption is unrelated to subsequent gambling behavior (Corbin & Cronce, 2017). In contrast, one study found that participants who consumed alcohol reduced their bet sizes and slowed their betting rate when the chances of winning were made salient, resulting in less money spent while gambling (Wagner et al., 2018). This unique finding may have been related to the influence of warning messages presented to participants. These contrasting results suggest that further examination of the effects of alcohol consumption on risk-taking while gambling is warranted.

One explanation for these inconsistent findings might be due to differences in alcohol dose, and related BAC levels, across different studies (Ellery & Stewart, 2014). For example, some experiments aim for a target BAC level of 0.06% (Corbin & Cronce, 2017; Wagner et al., 2018) while others aim for 0.08% (Caneto et al., 2018; Sagoe et al., 2017). Differences in the target BAC levels may result in differing physical and psychological effects (CDC, 2015; Monico, 2020). Intoxication begins to occur when the BAC is 0.02% as feelings of relaxation begin. Individuals who have a BAC level of 0.05% tend to speak louder, gesture more, experience blurry vision, and their judgment may be impaired. Those who have a BAC level of 0.08% exhibit noticeably slower reaction times and impaired depth perception. Their judgment, self-control, and reasoning may also be impaired due to alcohol’s effect on executive function (Guillot et al., 2010), increasing the likelihood of engaging in other risky behaviors (e.g., gambling; drunk driving). At a 0.10% BAC and above, reaction times are significantly slower, and coordination is impaired, increasing chances of injury. At these BAC levels, individuals are more likely to exhibit deficits in executive functions, such as planning and prioritizing (Montgomery et al., 2011).

Varying alcohol doses can alter neurotransmitter levels, which differentially affect behaviors regulated by the prefrontal cortex, such as risk-taking (Lyvers & Tobias-Webb, 2010; Montgomery et al., 2011). For example, manipulating dopamine levels in the prefrontal cortex results in a curvilinear effect such that small increases in dopamine improve performance on cognitive and attentional tasks in animal and human subjects, whereas large increases impair performance on these tasks (Robbins, 2005). Additionally, researchers have found a dose-response relation between alcohol and dopamine; ethanol stimulates the release of dopamine in the nucleus accumbens and prefrontal cortex (Yoshimoto et al., 1992). While dopamine is only one neurotransmitter affected by alcohol consumption, it may inform our understanding of the effect of BAC on risk-taking while gambling. Researchers have shown that low to moderate doses of alcohol in human subjects (~0.05-0.07% BAC) result in elevated dopamine transmission, which partially explains alcohol's reinforcing properties (Bowirrat & Oscar-Berman, 2005). Further, higher doses of alcohol (~0.08-0.10% BAC) correspond to larger increases in dopamine and are associated with impaired performance on executive functioning tasks (Guillot et al., 2010; Montgomery et al., 2011). Thus, alcohol-evoked modulation of prefrontal cortical dopamine provides a potential mechanism underlying the curvilinear relationship between alcohol consumption and risk-taking. Taken together, differences in behavior at varying BAC levels may contribute to the disparate findings across studies.

To address the relation between alcohol dose and risk-taking while gambling, a systematic review and meta-analysis of the extant experimental literature was conducted. It was hypothesized that there would be an effect of alcohol consumption on risk-taking while gambling. Given that increases in alcohol consumption impair performance on executive functioning tasks, higher BAC levels may lead to a greater amount of risk-taking. However, the literature examining the effects of alcohol on dopamine levels suggests a more nuanced relation. Therefore, both a linear and curvilinear relation between BAC level and risk-taking while gambling were tested. Finally, the present study aimed to explore the impact of BAC on specific risk-taking behaviors (e.g., money spent gambling, average bet size, number of risky choices).

Method

This review included studies published through April 2020 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). A flow diagram of study selection is displayed in Figure 1. Searches were conducted using a Boolean search strategy within PsycINFO. The search was conducted using the following keywords: ((gambling OR risk-taking OR decision-making) AND (alcohol OR ethanol OR drinking OR consumption)).

Inclusion and Exclusion Criteria

Studies were included if they (1) were peer reviewed published studies; (2) identified alcohol consumption as an independent variable; (3) included human subjects; and (4) used a gambling or risk-taking task to measure risk-taking while gambling. Tasks used to measure risk-taking while gambling included the Lane Risk-taking Task (Lane et al., 2004), Balloon Analogue Risk-Taking Task (BART; Rose et al., 2014), Iowa Gambling Task (IGT; de Valle Vera et al., 2018), and gambling tasks using lottery tickets (Wagner et al., 2018) and electronic gaming machines (EGMs; Cronce & Corbin, 2017; Ginley et al., 2016). Examples of dependent variables used to measure risk-taking while gambling included average bet size, time spent gambling, number of spins on EGMs, and number of risky choices (see Table 1). Studies were excluded from analyses if the researchers did not provide means and standard deviations for experimental and control condition comparisons that would allow calculation of effect sizes.

Literature Search

The initial search yielded 17,683 articles and all articles were initially reviewed for inclusion/exclusion at the abstract level. Based on the initial screening, 49 articles were identified for full-text review. TLH and GW then conducted the full text review to determine inclusion in the final review. The agreement rate was 94%, and discrepancies were resolved through a discussion between members of the research team. In total, 16 articles were selected to be included in the present review. One article consisted of 3 separate experimental studies. These studies were treated as 3 separate articles, resulting in k = 18 (Borenstein et al., 2009). Table 1 displays key study characteristics.

Data Extraction

Descriptive information, sample characteristics, and experimental data were extracted from each study. Extracted descriptive information included the study title, reference, study location, and publication year. The following sample characteristics were extracted: number of participants in each experimental condition, participants' average age in years, gender (% male), and number of standard drinks per week. Experimental data that were extracted included the following: experimental design (i.e., within-subjects, between-subjects), experimental conditions (i.e., alcohol, placebo (if present), and control), blood alcohol concentration for those in the experimental group, type of gambling or risk-taking task (i.e., tasks involving EGMs, BART, Lane risk-taking task, lottery task, and IGT), and risk-taking while gambling behavioral data (see Table 1 for a full breakdown of the variables extracted from each study).

Analytic Plan and Preliminary Analyses

When data needed for inclusion were not reported within the text of an article, corresponding authors were contacted with requests for this data. Of the 18 articles included, data were received from the authors of five articles. Four articles were excluded because insufficient statistical information was reported, and authors of those studies did not respond to data requests.

Comprehensive Meta-Analysis version 3.3070 was used for calculations of effect size. To meta-analyze alcohol dosage, a weighted mean was calculated for blood alcohol concentration for each study. To meta-analyze risk-taking while gambling, effect sizes were calculated for each study. Standardized mean differences of risk-taking while gambling behaviors between the experimental and control conditions were calculated when studies did not report effect sizes (Hedges' *g*; Hedges & Olkin, 1985). Hedges' *g* was selected because the sample sizes of some studies were relatively small. Weighted effect sizes were used to correct for sampling bias (Hedges & Olkin, 1985). If multiple variables were extracted, effect sizes calculated for each variable were averaged to yield a single effect size (Borenstein et al., 2009).

As shown in Table 1, studies varied in experimental design (i.e., within subjects, between subjects) and the task used to examine gambling and risk-taking behaviors, therefore a random effects model was selected. This decision was supported by a test of heterogeneity ($Q(17) = 30.37$, $p = .024$). The Q statistic was used to indicate heterogeneity and determine whether the effect sizes of the individual studies varied significantly around the overall mean summary effect size of all studies (Higgins et al., 2003). The proportion of variance accounted for by differences between the studies was estimated using the I^2 statistic. The I^2 statistic was interpreted as low (25%), moderate (50%), or high (75%; Higgins et al., 2003). Higher I^2 values suggest that there is significant heterogeneity indicating a random effects model is most appropriate. Significant heterogeneity also suggests that between effect size differences may be attributed to moderators. In the present study, the I^2 value was 44%, indicating that a moderate proportion of real variation among effect sizes exists. Therefore, speculation of the potential moderators (e.g., BAC levels, participant demographics) of this effect was warranted.

To determine whether there was a relation between experimental condition (i.e., alcohol or control condition) and risk-taking while gambling, a random effects model meta-regression was conducted. Condition assignment (i.e., alcohol, placebo (if present), or control) was regressed onto the Hedges' *g* values for experimental-control group comparison.

Separate meta-regressions were conducted to examine potential associations with risk-taking while gambling. Publication date, blood alcohol concentration level, and participant demographics (age, % male, number of drinks per week) for each study were regressed on to the Hedges' *g* values for experimental-control group comparison. Subgroup analyses and significance testing were conducted using the mixed effects model. For analyses examining the hypothesized relation between BAC and risk-taking while gambling, the alpha was set to .05. A Bonferroni corrected alpha of .006 was used for all exploratory analyses, which included a total of 8 separate meta-regressions and subgroup analyses.

Results

Study and Sample Characteristics

Eighteen articles, presenting 44 experimental-control group comparisons, were retained in this review (see Table 1). Of the 18 articles, 1 (k = 1, 6%) used a non-alcoholic drink control group, 14 (k = 14, 77%) used a placebo as the control group comparison, 1 (k = 1, 6%) used both a non-alcoholic drink control group and a placebo group, and 2 (k = 2, 11%) used low alcohol (BAC < .007%) control group. These studies were comprised of a total of 1611 participants. Sample sizes across studies ranged from 16 to 184 participants per study (M = 98.44, SD = 48.55, median: 104.50). Three of the studies were conducted in the United States (U.S.; k = 3, 17%), 3 in Canada (*k* = 3, 17%), 3 in Germany (*k* = 3, 17%), 3 in Australia (*k* = 3, 17%), 2 in the United Kingdom (U.K.; *k* = 2, 11%), 2 in Argentina (*k* = 2, 11%), 1 in Norway (*k* = 1, 5%), and 1 in the Netherlands (*k* = 1, 5%). Publication dates for the 18 studies ranged from 1999-2018. Participants' average age across these studies ranged from 20 to 36.47 years (*M* = 24.62, *SD* = 4.94, median: 22.97). The percentage of males ranged from 33 to 100% (*M* = 48.62, *SD* = 38.47, median: 48.91). The self-reported number of standard drinks participants consumed per week ranged from 3 to 14 (*M* = 9.65, *SD* = 3.69, median: 10.07). Number of standard drinks consumed per week were reported in 8 studies (*k* = 8, 50%).

To measure risk-taking while gambling, 10 of the 18 studies used electronic gambling machines (*k* = 10, 56%), 4 used the balloon analogue risk-taking task (BART; *k* = 4, 22%), 2 used the Lane risk-taking task (Lane et al., 2004; *k* = 2, 11%), 1 used the Iowa Gambling Task (*k* = 1, 5.5%), and 1 used a lottery task (*k* = 1, 5.5%).

Average blood alcohol concentration levels across studies ranged from 0.052% to 0.090% (*M* = 0.064, *SD* = 0.01, median: 0.060). Absorption times, or the delay between alcohol consumption and start of gambling, across studies ranged from 15 to 30 minutes (*M* = 19.62, *SD* = 5.94, median: 20).

Alcohol and Risk-taking

The overall Hedges' *g* value for the difference between groups consuming and not consuming alcohol was 0.32, 95% CI [0.23, 0.42], $p < .001$. A forrest plot of the effect sizes for alcohol consumption versus placebo or control beverage consumption with all risk-taking while gambling combined is displayed in Figure 2. The studies included here were moderately heterogeneous, $Q(17) = 30.37$, $p = .024$, $I^2 = 44.03$, with Hedges' *g* values ranging from 0.00 to 0.60.

Relation between BAC and Risk-taking

A meta-regression of Hedges' *g* values was performed on BAC levels (range: 0.052 to 0.090%) as a test of the linear relation between experimental and control groups. The meta-regression was significant, $p = .003$. The negative *Z*-value indicated a negative relation between these variables. Specifically, as BAC levels increased risk-taking while gambling decreased. This model explained approximately 68% of the variance between studies. A scatterplot of the relation between BAC level and risk-taking while gambling is displayed in Figure 3.

The present study aimed to explore how alcohol dose related to different indicators of risk-taking while gambling. To do this, the relations between BAC and Hedges' *g* values for average bet size, time spent gambling, money spent gambling, and risk-taking behaviors measured by risk-taking tasks (e.g., adjusted average number of pumps on BART task, number of risky choices in the Lane risk-taking task) were examined using scatterplots. It appeared that there was some evidence of curvilinear relationships between BAC and the Hedges' *g* values for these variables (see Figure 4). For example, a curvilinear relationship was revealed between BAC and the Hedges' *g* values for money spent gambling. As BAC increased, the Hedges' *g* values for money spent gambling increased until an approximate BAC of 0.065% was reached. After the BAC level exceeded 0.065%, the effect size values started to decline.

A curvilinear model was also tested using a method developed by Borenstein et al. (2015), which involved centering BAC to have a mean of zero. The curvilinear model was significant, $p = .02$, indicating that there is a relation between BAC and risk-taking while gambling. The highest effect size values were associated with an approximate BAC of 0.06%. Once BAC levels exceeded 0.06%, Hedges' g values for risk-taking while gambling started to decrease. This model explained approximately 69% of the variance between studies.

Meta-Regressions

Separate meta-regressions of risk-taking while gambling were also performed on publication date of the studies, age, the percentage of the sample who identified as male, and the number of drinks consumed per week by the sample. None of these meta-regressions were statistically significant (all *ps* > 0.006; see Table 2).

Subgroup Analyses

Comparisons were made to assess differences in risk-taking while gambling when studies were grouped by study location and the task used to measure risk-taking while gambling. None of these subgroup analyses were significant (all *ps* > .006; see Table 3).

Discussion

The literature to date has demonstrated that there are varying effects of alcohol on risk taking while gambling. The present meta-analysis addressed these varying effects by examining 18 studies containing 44 experimental-control effect size comparisons with a total of 1,611 participants. Alcohol consumption results in a significant increase in risk-taking while gambling (BAC range: 0.052 to 0.090%). Analyses revealed a negative linear relationship between alcohol consumption and Hedges' *g* values for risk taking while gambling, with 0.05%-0.07% BAC associated with the highest Hedges' *g* values. Once BAC exceeded 0.07%, Hedges' *g* values for risk taking while gambling decreased. These findings suggest that moderate to high levels of alcohol intoxication (0.05-0.07% BAC) results in the highest levels of risk taking and gambling behaviors. We also explored whether BAC moderated the relationship between alcohol consumption and risk taking while gambling. Specifically, we found that 0.05-0.07% BAC was associated with the greatest increase in risk taking while gambling, whereas BAC levels greater than 0.07% were associated a slight decrease in risk taking while gambling. These findings are consistent with the dopamine and alcohol literature suggesting that increased risk-taking at moderate BAC levels (0.05-0.07%) may be due to small increases in dopamine in the prefrontal cortex (Robbins, 2005; Yoshimoto et al., 1992).

One explanation for such results may be related to the targeted BAC levels. Initial analyses revealed a negative linear relation between BAC and Hedges' *g* values for risk taking while gambling. As BAC increased, Hedges' *g* values for risk taking while gambling decreased, indicating that as individuals reach higher levels of alcohol intoxication (0.07% BAC and above) they are less likely to engage in risk taking while gambling. Additionally, a significant curvilinear relationship between BAC and risk-taking while gambling was found. As BAC levels increase, Hedges' *g* values increase until an approximate BAC of 0.07% was reached. Once BAC levels exceeded 0.07%, Hedges' *g* values for risk-taking while gambling started to decrease, suggesting that moderate BAC levels (~0.05-0.07%) appear to be at the greatest likelihood for gambling risk. The highest effect was associated with a BAC between 0.06% and 0.065%, meaning participants were most likely to engage in the riskiest gambling behaviors at these BAC levels. Once participants' BAC level reached and exceeded 0.07%, the level of risk taking appears to decrease. The findings are consistent with research concluding a non-linear relation between dopamine and prefrontal cortex-regulated behaviors, such as risk-taking; small increases in dopamine increase behavior whereas high increases in dopamine impair behavior (Robbins, 2005). The findings of the present study are also consistent with Monico (2020) and Montgomery (2011); as BAC levels increase above 0.07%, individuals are more likely to exhibit significantly slower reaction times, impaired coordination, and deficits in executive functioning, such as planning and prioritizing. These deficits make engaging in risky gambling behaviors more difficult, which could explain the observed decrease in Hedges' *g* values associated with high BAC levels. Given the variability of findings in the existing literature, further research examining the dose-response effect of alcohol on risk taking while gambling is warranted.

The limitations for this review were mostly related to the methodologies used in the published studies. The studies to date have only evaluated a reasonable, but limited BAC range. Future research is needed to better understand how gambling changes at lower levels of alcohol intoxication. Further, the studies included in this meta-analysis measured risk-taking while gambling as BAC was initially ascending. Therefore, it is unclear how risk taking while gambling would be affected while BAC is descending or maintained at a specific level. Another limitation is that existing studies were designed to address the impact of alcohol consumption when compared to no alcohol consumption. Perhaps other experimental designs can be used to tease out the alcohol dose response and how the dose response might relate to different gambling experiences, such as a win streak, near misses, and losing streaks.

Finally, four studies did not meet inclusion criteria due to insufficient statistical information; however, it is worth considering the findings of these excluded studies. The findings of these studies were mostly inconsistent with this meta-analysis. First, Stewart et al. (2005) found that there were no significant differences between the alcohol (average BAC was 0.057%) and control conditions on time spent gambling. No other gambling behavior variables were reported for this study. Second, Gilman et al. (2012) concluded that those in the alcohol condition (average BAC was 0.07%) chose more risky options than safe options on the Lane risk-taking task. Third, Breslin et al. (1999) concluded that there were no significant differences in gambling behavior across experimental conditions (i.e., alcohol – average BAC was 0.078%, placebo, no alcohol). Fourth, Whitton and Weatherly (2009) compared American Indian and non-American Indian participants on gambling behaviors and randomly assigned all participants to either receive alcohol or a placebo beverage. While the researchers found significant differences in gambling behavior for ethnicity, no significant effect of alcohol consumption (average BAC was 0.071%) was observed.

The results could serve to inform responsible gambling policies. The results of the present study show that those who are moderately intoxicated (~0.05-0.07% BAC) are most likely to engage in risky gambling behaviors, which could lead to gambling-related harms. Therefore, we should reconsider the recommendations detailed by Blaszczynksi et al. (2011) with specific attention to policies to enforce responsible alcohol use by restricting sale of alcohol to patrons while gambling. Further, the present review found that BAC greater than .07% continues to be associated with increased risk taking although the effect does decrease. At these BAC levels, individuals experience deficits in judgment, decision-making, and motor coordination, putting them at risk for physical injury (Monico, 2020; Montgomery, 2011). It may also be beneficial for gambling venues to restrict the sale of alcohol to visibly intoxicated persons in addition to placing limits on the amount of alcohol freely provided to patrons while they are gambling.

The results also offer some recommendations for clinicians treating individuals with problem gambling and gambling disorder. First, alcohol use should be routinely assessed and monitored as it could be affecting clients' gambling behaviors. The Alcohol Use Disorder Identification Test (AUDIT) is a screening tool that could be used to track alcohol use and has been modified into a short form and validated (AUDIT-C; Bradley et al., 2003; Bush et al., 1998). Monitoring alcohol use for clients who are still engaging in gambling behaviors might be especially useful to determine whether alcohol might be affecting their gambling behaviors. Further, it might be beneficial for clinicians to provide psychoeducation to clients with problem or disordered gambling about the potential effects that alcohol and other substances could have on their risk-taking and gambling behaviors. It is imperative that treatment providers examine the connection between substance use and gambling behaviors to best enable therapeutic progress and minimize client dropout.

The present systematic review and meta-analysis is the first to examine the relation between alcohol consumption and risk-taking while gambling. The results revealed a significant effect of alcohol on risk taking while gambling. Further, a negative linear relation was found between BAC and risk taking while gambling, indicating as BAC level increased, Hedges' *g* values for risk taking while gambling decreased. A significant curvilinear relationship between BAC and risk-taking while gambling was also found. Specifically, moderate amounts of alcohol (~0.05-0.07%) were associated with the greatest likelihood of engaging in risky gambling behaviors, whereas larger amounts of alcohol (~0.07-0.09%) were associated with the lowest likelihood of engaging in risky gambling behaviors. For clinicians, these findings suggest that it is imperative to monitor alcohol consumption and other substance use in clients with gambling disorder throughout the course of treatment. For researchers, these findings support the need for additional laboratory investigations in this area to better understand how specific risk-taking and gambling behaviors are impacted by alcohol consumption.

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Table 1.
Study Characteristics

Study	Location	Sample Size (n)	Average Age (years)	Gender (% male)	Control or Placebo?	Regular Gambling/ Drinking	Experimental Group (BAC)	Type of Gambling/Risk -Taking Task	Dependent Variables Extracted
Balodis et al. (2011)	Canada	87	20.00	33	Both; Control = Non- alcoholic drink	No/Yes	0.09%	Lane	Risk-Taking Score
Caneto et al. (2018)	Argentina	51	22.98	NR	Placebo	No/Yes	0.08%	BART	Adjusted Average No. of Pumps
Corbin & Cronce (2017)	USA	162	22.62	74	Placebo	No/Yes	0.08%	Video Poker	Amt bet per trial; Total No. of trials played
Cronce & Corbin (2010)	USA	130	22.96	54	Placebo	Yes/Yes	0.07%	Slots	Amt bet per trial
Ellery et al. (2005)	Canada	44	34.55	68	Control: Non-alcoholic drink	Yes (Sample half disordered gamblers)/No	0.06%	Video Poker	Money spent; Time spent gambling
Ellery & Stewart (2014)	Canada	60	36.47	67	Placebo	Yes (Sample half disordered gamblers)/Yes	0.06%	Video Lottery Terminal	Bet size; Time spent playing; total money spent
Erskine Shaw et al. (2017)	UK	99	20.71	37	Placebo	No/Yes	0.07%	BART	Adjusted Average No of Pumps

Euser et al. (2011)	Netherlands	64	20.51	100	Placebo	No/Yes	0.08%	BART	Adjusted Average No. of Pumps
Kyngdon & Dickerson (1999)	Australia	40	20.70	100	Placebo	Yes/Yes	0.05%	Video Poker	Amt bet after losses; Amt bet after wins; Avg bet size; No. of trials played
Lane et al. (2004)	USA	16	32.13	50	Placebo	No/Yes	0.08%	Lane	No. of risky choices; earnings on task
Phillips & Ogeil (2007)	Australia	20	24.40	100	Placebo	Yes/Yes	.048%	Computer Blackjack	Amt wagered; Time spent gambling; Avg bet size
Phillips & Ogeil (2010)	Australia	16	21.60	100	Low dose alcohol control (average BAC = .003%)	Yes/Yes	.060%	Computer Blackjack	Avg bet per hand; time spent deciding to place bets; time spent choosing cards
Rose et al. (2014)	UK	142	20.33	47	Placebo	No/Yes	0.07%	BART	Adjusted avg. no. of pumps
Sagoe et al. (2017)[a]	Norway	184	22.01	49	Low dose alcohol control groups (average BAC group 2 = 0.006% & average BAC group 4 = 0.007%)	No/No	0.08% (group 1) 0.07% (group 3)	Slot Machine	Bet size; credits remaining; No. of sessions played
Vera et al. (2018)	Argentina	110	24.69	57	Placebo	Yes/Yes	0.06%	Iowa Gambling Task (IGT)	Total IGT score
Wagner et al. (2018) – Study 1	Germany	130	24.01	39	Placebo	No/No	0.064%	Slot Machine	No. of trials played; money lost

Wagner et al. (2018) – Study 2	Germany	128	26.72	61	Placebo	Yes/No	0.055%	Slot Machine	No. of trials played; money lost
Wagner et al. (2018) – Study 3	Germany	128	25.72	41	Placebo	No/No	0.052%	Lottery Task	No. of risky gambling choices

Note. “Non-alcohol drink” refers to control participants who were informed that they beverage they consumed was non-alcoholic. UK = United Kingdom; USA = United States of America; a. In this study, Sagoe et al. (2017) used four experimental groups. In group 1 participants were informed that they would receive alcohol and were given moderate amounts of alcohol. In group 2, participants were informed that they would receive alcohol and were given a low amount of alcohol. In group 3, participants were informed that they would receive a placebo and were given a moderate dose of alcohol. In group 4, participants were informed that they would receive a placebo and were given a low dose of alcohol. For entry into and analyses conducted using CMA, Version 3.070, group 1 (alcohol) and 2 (control/placebo) and group 3 (alcohol) and 4 (control/placebo) were compared.

Table 2

Results from Meta-Regressions for BAC, age, gender, drinks per week, and publication date

Covariate (number of studies)	Point Estimate	95% CI	Z-value	p-value
BAC (18)				
Slope	-11.19	-18.36, -4.02	-3.06	0.002
Intercept	1.04	0.57, 1.52	4.34	< .001
Age (18)				
Slope	0.01	-0.01, 0.03	0.71	0.48
Intercept	0.13	-0.42, 0.68	0.46	0.64
Gender (% male; 18)				
Slope	0.003	-0.002, 0.01	1.13	0.26
Intercept	0.16	-0.13, 0.46	1.09	0.27
Number of Drinks per Week (8)				
Slope	-0.02	-0.05, 0.02	-0.80	0.43
Intercept	0.43	0.02, 0.85	2.03	0.04
Publication Date (18)				
Slope	-0.01	-0.03, 0.003	-1.66	0.10
Intercept	28.75	-4.89, 62.39	1.68	0.09
Absorption Time (18)				
Slope	0.01	-0.01, 0.03	1.30	0.19
Intercept	0.10	-0.26, 0.45	0.54	0.59

Table 3

Results from subgroup analyses of tasks used to measure risk-taking while gambling and study location on risk-taking while gambling

Subgroup (# of studies)	Hedges' *g*	95% CI	*Q*-value	*p*-value
Risk-taking while gambling task (18)			3.20	0.53
BART (4)	0.26	0.09, 0.44		
EGM[a] (10)	0.35	0.22, 0.48		
IGT (1)	0.21	-0.18, 0.59		
Lane (2)	0.25	-0.22, 0.72		
Lottery (1)	0.60	0.23, 0.98		
Study Location (18)			20.63	0.004
Argentina (2)	0.19	-0.12, 0.50		
Australia (3)	0.53	0.37, 0.70		
Canada (3)	0.26	0.05, 0.47		
Germany (3)	0.52	0.35, 0.68		
Netherlands (1)	0.10	-0.38, 0.59		
Norway (1)	0.14	-0.03, 0.31		
United Kingdom (2)	0.27	-0.07, 0.60		
United States (3)	0.17	-0.02, 0.36		
Study Design (18)			3.90	0.048
Random (14)	0.28	0.17, 0.39		
Within (4)	0.46	0.32, 0.61		

Note. [a]EGM refers to electronic gaming machines, specifically gambling tasks using slot machines, video lottery terminals, video poker machines, and computer blackjack.

Figure 1. Flow chart of study selection.

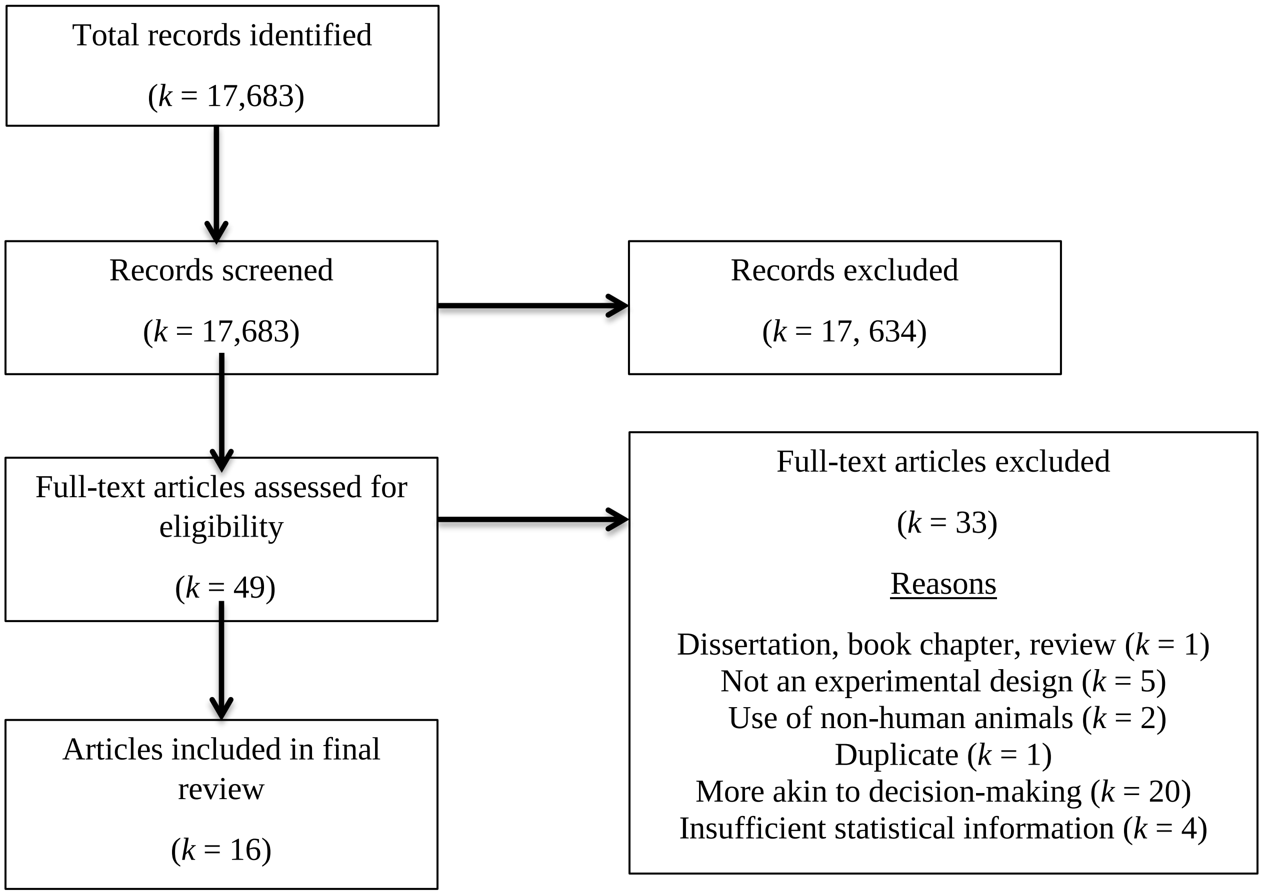


Figure 2. Forrest plot of effect sizes for alcohol consumption versus placebo or control drink consumption with all risk-taking while gambling variables combined

Study name	Subgroup within study	Hedges's g	Lower limit	Upper limit	p-Value
Balodis et al	Combined	0.000	-0.512	0.512	1.000
Caneto et al	Combined	0.153	-0.379	0.685	0.573
Corbin & Cronce	Combined	0.051	-0.166	0.268	0.646
Cronce & Corbin	Combined	0.195	-0.055	0.446	0.127
Ellery & Stewart	Combined	0.270	-0.016	0.556	0.064
Ellery, Stewart, & Loba	Combined	0.411	-0.008	0.829	0.054
Erskine-Shaw et al	Combined	0.054	-0.337	0.445	0.787
Euser et al	Combined	0.103	-0.381	0.588	0.675
Kyngdon & Dickerson	Combined	0.604	0.290	0.918	0.000
Lane et al	Combined	0.481	-0.004	0.966	0.052
Phillips&Ogeil(2007)	Combined	0.566	0.295	0.837	0.000
Phillips&Ogeil(2010)	Combined	0.433	0.148	0.719	0.003
Rose et al	Combined	0.404	0.170	0.638	0.001
Sagoe et al	Combined	0.141	-0.026	0.307	0.099
Vera et al	Combined	0.205	-0.178	0.588	0.293
Wagner et al Study 1	Combined	0.558	0.298	0.817	0.000
Wagner et al Study 2	Combined	0.439	0.180	0.697	0.001
Wagner et al Study 3	Combined	0.604	0.231	0.976	0.001
		0.324	0.227	0.421	0.000

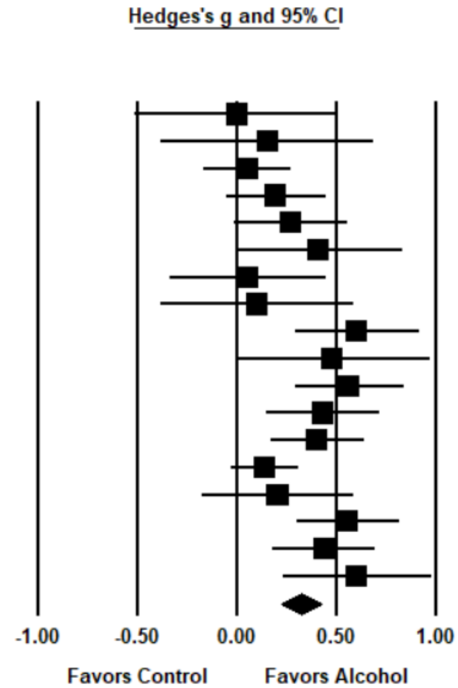


Figure 3. Scatterplot depiction of the meta-regression of Hedges' g on BAC

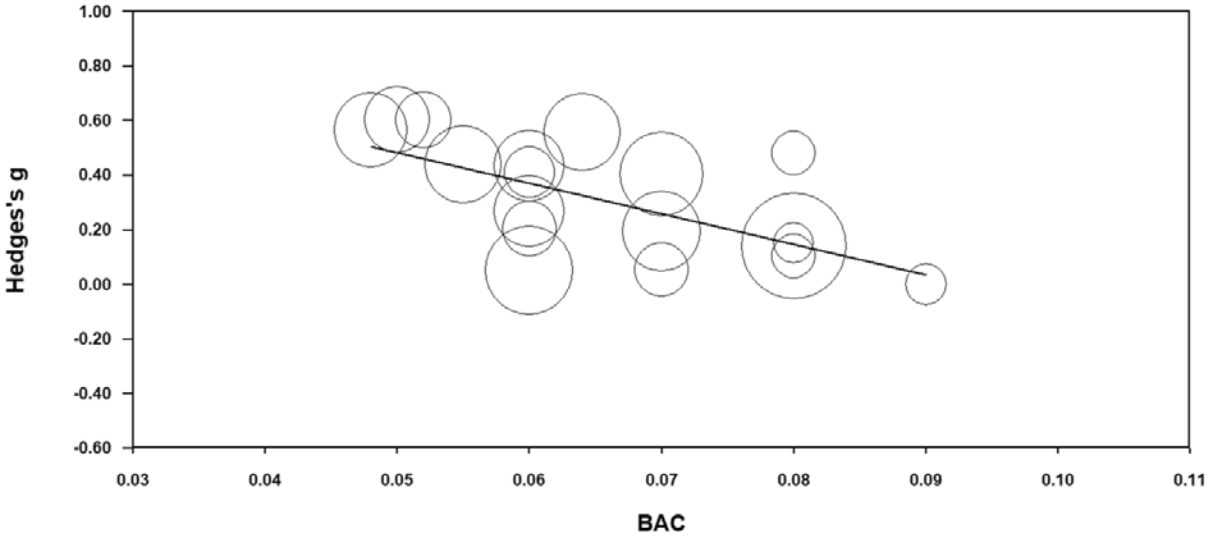
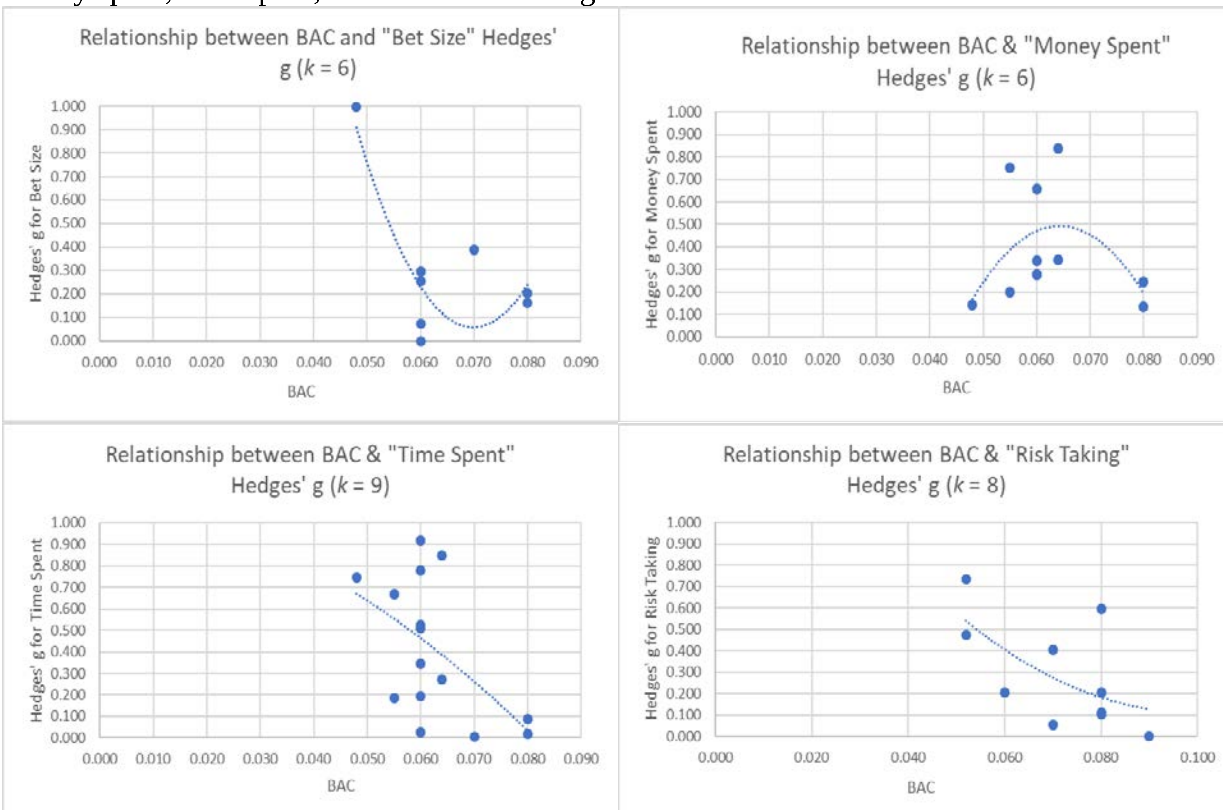


Figure 4. Scatterplots for the relationships between BAC and Hedges' *g* values for bet size, money spent, time spent, and other risk-taking behaviors



Note. k represents the number of studies included in the scatterplot. Some studies reported gambling and risk-taking variables by subgroups within the experimental and control groups yielding a greater number of data points than studies included. In the "risk-taking" plot, "risk-taking" refers to the following variables: adjusted average number of pumps on the BART task, number of risky choices in the Lane risk-taking task, and number of risky choices in a lottery task.