ORIGINAL ARTICLE

Assessing driving-relevant attentional impairment after a multiday drinking session: A two-phase pilot study

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Abstract

Background: The possibility of residual impairment of cognitive performance after multiday drinking sessions is particularly important given the potential for the deleterious effects of fatigue and hangover. This pilot study aimed to devise a methodology to compare sober performance on driving-relevant attentional tasks at the end of a 4-day music festival with performance at varying levels of the breath–alcohol curve.

Methods: Fifty-two participants completed selective and sustained attention tasks at a breath alcohol concentration (BrAC) of 0.00%, 0.05%, and 0.08% following acute dosing in a controlled laboratory setting. A subset of participants ($n = 13$) were then tested at the conclusion of a 4-day music festival at 0.00% BrAC, with task performance compared with laboratory results.

Results: During the laboratory phase, sustained attention was poorer at the 0.05% ascending timepoint only (compared to 0.00% BrAC). During the festival phase, participants made a greater number of errors on the selective attention task predeparture than at 0.00% and 0.05% BrAC in the laboratory. Sustained attention performance was poorer while intoxicated in the laboratory.

Conclusions: Our findings suggest that the absence of blood alcohol acutely may not be indicative of unimpaired cognitive performance and that other factors related to multiday drinking may produce driving-related attentional deficits. The findings reinforce the need to measure attentional performance in real-world drinking contexts despite the methodological complexities of doing so. A larger study is warranted to replicate the findings and should include attentional measures that either are more sensitive to the effects of acute alcohol intoxication than those in our study or are based on a driving simulator.

KEYWORDS
alcohol drinking, attention, cognition, fatigue, music festival

INTRODUCTION

Each year, over 3 billion people consume alcohol worldwide (Peacock et al., 2018). Alcohol is harmful to both the drinker and others. For example, in Australia, based on the Australian National Drug Strategy Household Survey, in the previous 12 months 17% of participants aged ≥14 years indicated that they had put themselves or others at risk of harm while under the influence of alcohol. One of the key harms associated with problematic alcohol use is motor vehicle accidents (Australian Institute of Health & Welfare, 2017). Young drivers aged 21–29 are at greatest risk of being involved in automobile accidents, particularly if they have been consuming alcohol (Bates et al., 2014; Regev et al., 2018). Therefore, it is important to gain a greater understanding of how alcohol impairs driving in this group.

Multiple studies have demonstrated adverse effects of acute alcohol consumption on driving-relevant domains of cognition, including attention, and response inhibition (Abroms et al., 2003, 2006; Dougherty et al., 2000; Marczinski & Fillmore, 2005). Importantly, cognitive impairment has also been demonstrated in select domains as a result of the next-day effects (i.e., hangover) of alcohol consumption, including direct driving ability, attention, memory, and psychomotor speed (Gunn et al., 2018). This is concerning when considering the number of patrons who drive the day after a drinking episode, both on a national and global scale. However, alcohol-related impairment is not universal across all cognitive domains and its effects are typically dose-dependent at both an acute and residual level. It is thus important to assess which domains and to what degree individuals may be residually impaired by alcohol consumption.

In addition to alcohol consumption, fatigue is also a factor of concern regarding driving safety. Heavy drinking episodes often accompany a late night out, and alcohol is also known to contribute to poorer quality sleep (Park et al., 2015). Fatigue is known to attenuate select cognitive and motor abilities relevant to driving; both sleep deprivation (prolonged wakefulness) and partial sleep deprivation (chronic sleep restriction) can affect cognition, although to differing degrees (Alhola & Polo-Kantola, 2007). Specifically, total sleep deprivation can reduce attention, working memory, and the ability to make decisions, while partial sleep deprivation can reduce attention. The effects of sleep deprivation on psychomotor performance have been shown to match or surpass those seen in alcohol intoxication. Seventeen hours of continuous wakefulness can impair cognitive psychomotor performance (e.g., hand eye coordination) up to levels seen at 0.05% blood alcohol concentration (Dawson & Reid, 1997); the legal driving threshold in Australia. Twenty-four hours of continuous sleep deprivation can impair these abilities up to levels of 0.10% blood alcohol concentration (double the limit).

In line with experimental impairment-related alcohol and fatigue research, a recent cross-sectional study identified that the number of alcoholic drinks consumed, perceived breath alcohol concentration (BrAC), license type (relating in part to proscribed legal blood alcohol concentration (BAC); 0.00% g/ml for learners/provisional and 0.05% for full), and the number of hours slept were all strongly correlated with perceptions of in-the-moment driving safety among music festival patrons (Fernando et al., 2018). Music festivals are typically multiday events with late nights, with patrons typically being young adults. Importantly, half (45%) of all music festival patrons interviewed at the event intended to drive that day despite only one in five feeling completely safe to do so (Fernando et al., 2018). There is a clear overlap between individuals who do not feel safe to drive yet still intend on driving that same day. The potential for risky driving behaviors has sparked cause for driving-related safety strategies at events such as music festivals. Indeed, there are efforts at some music festivals to both increase awareness of driving risks (e.g., messaging around alcohol, drugs, fatigue, and driving) and reduce the risk of drink driving (e.g., free breath testing).

Assessing real-world driving-related performance after multiday drinking sessions is an important but underinvestigated line of research. Devising an appropriate methodology to assess driving-relevant cognition after drinking in real-world settings is an important step toward achieving this. To date, no studies have attempted to investigate the objective effect of residual alcohol intoxication or fatigue after a multiday drinking session on the impairment of driving ability, or its associated cognitive processes. Therefore, the purpose of this pilot study was to devise an appropriate methodology to assess driving-relevant cognition after a multiday naturalistic drinking session. Specifically, the pilot study compared performance on attention tasks that are related to driving ability over a range of BACs in a controlled laboratory environment in the absence of fatigue. Subsequently, a subset of the laboratory participants were studied at the conclusion of a multiday music festival, comparing last-day task performance with performance at varying levels of acute alcohol intoxication in a controlled environment (0.00%, 0.05% [ascending and descending limb], and 0.08% g/ml), including an assessment of their levels of fatigue via questions on sleepiness, hangover, and fatigue. This comparison allows for greater understanding of the differences between the effects of festival participation—a naturalistic environment—and the typical, more controlled laboratory-based alcohol dosing studies on driving-related cognition.

MATERIALS AND METHODS

Design and setting

We utilized a repeated measures quantitative design, comprised of two distinct phases: During the controlled *laboratory phase*, participants attended a single laboratory-based experimental session in which alcohol was administered, and attentional performance was assessed across the BrAC curve (up to peak of 0.08%). The purpose of the laboratory phase was to assess attentional performance under sober and acute alcohol intoxication conditions (in the absence of fatigue) in a controlled environment, which served as a comparison to attentional performance during the festival phase (a naturalistic environment). During the *festival phase*, a subset of participants from the laboratory phase attended a 4-day music festival, and at the

conclusion of the festival, objective measurements of intoxication and attentional performance were taken in situ and compared with measures taken during the laboratory phase.

Data collection occurred at two sites: the laboratory phase at the University of Tasmania Hobart campus between January and February 2018; the festival phase at an Australian music festival (patron capacity of 7000) in the first quarter of 2018. The festival attended by participants was an open-air event, set in a field, with accommodation predominantly comprising tents and vehicles brought by patrons. This study was approved by the University of Tasmania Human Research Ethics Committee (ref# H0016125) and approval to operate onsite was provided by festival organizers.

Participants

Participants were recruited online via social media advertisements. Inclusion criteria included: aged 18–34 years, encompassing those most likely to binge drink and susceptible to alcohol-related harms (Australian Bureau of Statistics, 2015; Spear, 2004); English as a first language; completed high school or equivalent; frequent alcohol consumption (≥2 standard alcoholic beverages on one occasion in the preceding month to ensure alcohol familiarity); normal or corrected-to-normal vision; normal sleep patterns; BMI between 18.50 and 29.9; and, for those in the festival substudy, able to attend the festival for all days (including camping onsite). Participants were excluded from both phases (laboratory and festival) of the study for: recent illicit drug use (preceding 6 months); regular tobacco use; a history of a significant medical/mental condition, a history of an alcohol or drug dependence disorder or use of alcohol indicative of an alcohol use disorder (evident via a score of 15 or higher on the Alcohol Use Disorders Identification Test [AUDIT]) (Saunders et al., 1993).

In total, 52 individuals were recruited for the laboratory phase, with a mean age 23.0 years (SD = 3.2, range = 18–31; 53% female). Fifty participants reported consuming alcohol in the previous fortnight, with an average of 10.1 standard drinks during this period (SD = 8.1, range = 1–30). Of the total sample, a subset of 15 attended the music festival phase (mean age 21.9 years, SD = 3.6, range = 18–29; 53% male). The festival subset reported drinking an average of 12.5 standard drinks in the previous fortnight (SD = 10.1, range = 15–29). However, one participant was removed from the festival sample postevent due to a high breath alcohol reading (0.07%) on the final day of the festival. To minimize the effect of confounds, one more participant was removed after self-reporting illicit drug use. Therefore, 13 participants were included in festival-related analyses (mean age 23.5, SD = 3.7, range = 18–29; 53% male). We found no differences between the laboratory sample and festival subsample on gender [χ^2(1, N = 52) = 1.65, p = 0.19], age [t(50) = 0.64, p = 0.52] or self-reported alcohol consumed (among those who consumed alcohol) in the previous fortnight [t(48) = 1.03, p = 0.31].

Participants attending the laboratory phase received $50 reimbursement, while participants attending the music festival received admission into the festival as reimbursement. All festival participants had attended at least one festival prior to participation. The consumption of alcohol at the festival was at the discretion of the participant; they were not encouraged or discouraged by the researchers to consume alcohol.

Measures

Cognitive assessment battery

A cognitive assessment battery was compiled to measure attentional domains related to driving, guided by the International Council on Alcohol, Drugs and Traffic Safety's experimental guidelines (Verster et al., 2009), with domains known be acutely affected by acute alcohol intoxication (Zoethout et al., 2011). Participants completed the assessments four times during the laboratory session (0.00%, 0.05% [ascending and descending limb], and 0.08% BrAC) and on the final morning of the festival (0.00% BrAC). The assessment battery included:

1. *Arrow Flankers* (AF; Eriksen & Eriksen, 1974): This task assessed selective attention. Participants react to a central stimulus—an arrow pointing left or right—by selecting the arrow key indicating the corresponding direction. The central stimuli are presented with *flankers*; two congruent or incongruent arrows (arrows pointing in the same or opposite direction to the central stimulus, respectively), neutral stimuli (squares), or no-go suppressors (crosses) to both the left and right of it. Participants were asked to not respond to no-go trials. There were 80 trials, with congruent, incongruent, and neutral flanking stimuli comprising 30% of these each. The final 10% comprised suppressor trials. Difference between incongruent and neutral flanker trial reaction time (RT) (incongruent RT), difference between congruent and neutral trial RT (congruent RT), RT of correct responses, number of incorrect responses for all trials, and percent of no-go errors (responses to the suppressor condition [response inhibition]) were recorded.[1]
2. *Rapid Visual Information Processing* (RVIP; Wesnes & Warburton, 1983): This task assessed sustained attention. Single digits appear sequentially (600 ms interstimulus interval) inside a white box center-screen. Participants attempted to respond as quickly as possible whenever there were three specific number sequences (three even or three odd numbers in a row). There was a total of 300 trials; 8% (n = 24) comprised targets, and the sequence was randomly presented. Percentage of correct responses and RT of correct responses were recorded.

Questionnaire

The same questionnaire was used upon arrival for the laboratory phase and on the final morning of the festival, using a 9.7″ tablet.

The questionnaire (presented using REDCap) included: Alcohol Hangover Severity Scale (AHSS, Penning et al., 2013), a 12-item questionnaire assessing hangover severity using an 11-point Likert scale; the number of standard drinks consumed in the previous 24 h (1 standard drink = 10g of alcohol); illicit drug use in the previous 24 h (yes/no); Karolinska Sleepiness Scale (KSS), a single-item assessment of subjective fatigue using a 1–9 Likert scale (Kaida et al., 2006), and hours of sleep in the previous 24 h (including napping). Participants at the festival also retrospectively self-reported their alcohol consumption twice daily on each of the festival days.

Breath alcohol concentration

Breath alcohol concentration (BrAC) was measured at each intoxication timepoint (in the laboratory) and on the final morning of the festival using Andatech AlcoSense Prodigy S police-grade breathalyzers. These devices have a detectable BAC range of 0.000% to 0.400%, and an accuracy of $\pm 0.005\%$ at 0.100%.

Procedure

Laboratory phase

Participants attended a 4-h laboratory session (commencing 11 am), abstaining from alcohol and caffeine for 24 h and food 4 h beforehand. Weight and height were measured. A preliminary breath assessment was conducted to rule out on-arrival intoxication. The cognitive task requirements (AF, RVIP) were explained verbally and using instruction sheets. The questionnaire was completed, and participants undertook the cognitive test battery (on a tablet) at 0.00% BrAC. They had 1-minute trials of each task prior to baseline testing.

Following the baseline cognitive assessment, an alcoholic beverage was administered comprising vodka, 400 ml of soda water, and 40 ml of low-calorie hazelnut flavored syrup. The quantity of alcohol provided was calculated according to the Widmark equation (Dry et al., 2012) allowing a target BrAC of 0.08% to be reached. The Widmark equation accounts for body weight and ensures that females receive less alcohol by volume than men due to differences in body water percentage. They were given 10 min to orally consume the beverage. As retention of mouth alcohol can influence breathalyzer sensitivity (Spector, 1971) they were instructed to avoid retaining the beverage in their mouth for longer than 5 s. They were encouraged to drink the beverage at a steady pace throughout the administration period. Participants rinsed their mouths with water after administration to further eliminate alcohol mouth retention. Except for 250 ml still water provided upon request, participants were unable to consume any other fluids for the duration of the experimental session. A postconsumption breath assessment was immediately taken, with participants undergoing the psychomotor battery once breathalyzer readings indicated that the participant was at 0.05% BrAC on the ascending limb of the alcohol curve.

Participants once again completed the battery when identified as being at 0.08% BrAC on the ascending limb (or at peak BrAC if they did not reach 0.08%) and at 0.05% BAC on the descending limb. BrAC readings were taken every ten minutes postconsumption until the participant had completed all psychomotor assessments.

Festival phase

A subset of laboratory participants ($n = 15$) then attended the festival. Participants travelled independently to the festival (up to 3 weeks postlaboratory testing), presenting to members of the research team at the ticketing tent on arrival for an orientation between 1 pm and 4 pm. They were directed to the research camp: the meeting place for subsequent data collection. Participants were required to establish a static meeting time (between 9:30 am and 11:30 am) for the assessment on the final morning of the festival to be completed. This session comprised a questionnaire, a breath alcohol assessment, and completion of the cognitive test battery (on an electronic tablet), completed under silent conditions in an onsite purpose-built private gazebo. Other than the face-to-face session with the research team, participants were asked to behave as they normally would in the festival environment. They were not asked to be at any specific breath alcohol level for testing on the final morning.

Data analysis

All statistical analyses were conducted using SPSS (version 2.7).

We first analyzed breath alcohol readings to determine the level of intoxication at each administration of the attention tasks during the controlled laboratory phase, and the festival phase. Specifically, during the laboratory phase, mean BrAC was calculated at the 0.00%, 0.05% ascending, 0.08%, and 0.05% descending timepoints. Participants' mean BrAC was also calculated before leaving the festival to ensure that all participants were not acutely affected by alcohol at the time of festival testing. Additionally, self-reported alcohol consumption during the festival phase was analyzed to determine the extent to which participants consumed alcohol over (i) the course of the festival and (ii) in the 24 h prior to departure.

Next, subjective ratings of sleepiness, hangover, and hours slept were compared between the laboratory and festival phases, using paired samples t-tests, to determine differences in these impairment-relevant factors.

Finally, performance on the attention tasks was analyzed during the laboratory phase and the festival phase. We first conducted a series of repeated measures ANOVAs to assess attentional performance in the controlled laboratory environment across the different intoxication timepoints. Paired comparisons between the baseline laboratory timepoint (0.00% BrAC) and the intoxicated laboratory timepoints (0.05% ascending, 0.08%, and 0.05% descending) were conducted to assess cognitive task sensitivity to acute alcohol

consumption (i.e., to determine the extent to which alcohol acutely impaired task performance within our sample). Then, additional repeated measures ANOVAs and follow-up pairwise comparisons were conducted to understand how attentional performance at the festival (naturalistic environment) differed to varying degrees of intoxication in the controlled laboratory environment (0.00% festival BrAC vs. 0.00% laboratory BrAC, 0.05% laboratory BrAC [ascending and descending limb], and 0.08% laboratory BrAC). For each analysis, Mauchly's test was undertaken to assess for violations of sphericity, with Greenhouse–Geisser corrections applied as necessary. To minimize concerns of inflation of Type I errors, effect sizes (Cohen's d) were computed to assess magnitude of differences between timepoints for the laboratory and festival phases. Effect sizes >0.40 were considered meaningful and interpreted. Furthermore, Bayesian paired samples t-tests were conducted to compute Bayes Factors (testing the null hypothesis) for each pairwise comparison relating to the laboratory phase and the festival phase.

RESULTS

Laboratory phase: BrAC

All participants were assessed and determined to be at 0.00% BrAC during the baseline measure of cognitive performance. Mean BrAC at the 0.05% ascending timepoint was 0.056% (SD = 0.006, range = 0.046–0.069). Mean BrAC at the 0.08% timepoint was 0.080% (SD = 0.01, range = 0.043–0.10). Mean BrAC at the 0.05% descending timepoint was 0.05% (SD = 0.003, range = 0.037–0.055). See Figure 1 for individual BrAC readings at each assessment timepoint.
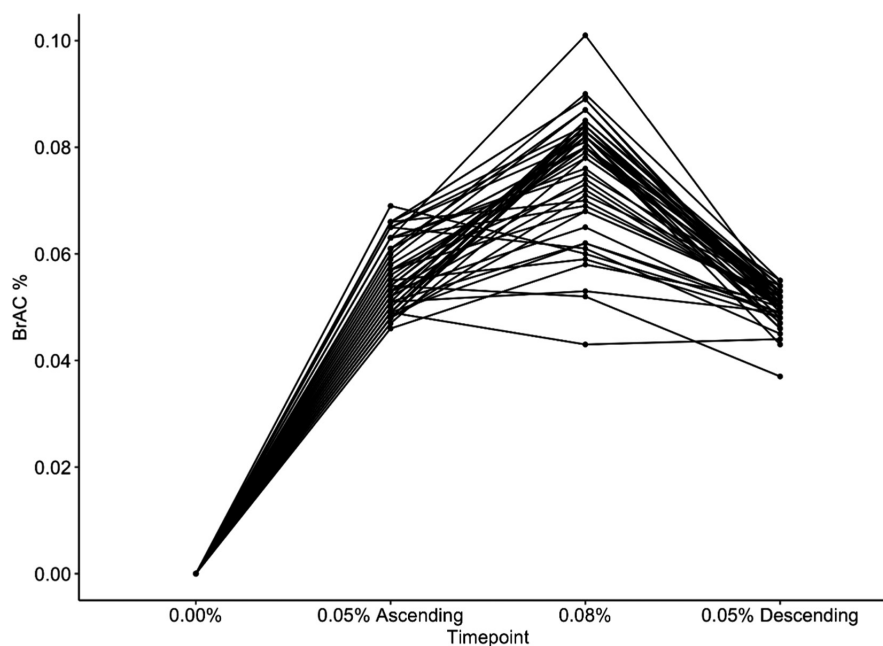
Festival phase: preassessment BrAC and festival alcohol consumption

All analyzed participants returned a breath alcohol assessment of 0.00% on arrival to the laboratory, as well as the morning before leaving the festival. Participants self-reported consuming an average of 23.5 standard drinks over the course of the 72-h event (SD = 9.1, range = 8–40) and 10.6 standard drinks in the 24 h before the festival assessment (SD = 5.5, range = 2–18). All participants consumed alcohol in the 24 h prior to conclusion of the event. See Figure 2 for individual BrAC readings at each assessment timepoint.

Subjective sleepiness, hangover, and hours slept

In the laboratory session, participants reported 8.1 h of sleep in the previous 24 hours (SD = 1.3, range = 6–10), a mean KSS score of 3 (alert; SD = 1.6, range = 1–6), and an average AHSS score of 0.8 (SD = 0.7, range = 0.2–2.5). On the last day of the festival, participants reported 6.5 h sleep in the previous 24 h (SD = 1.6, range = 3–9), a mean KSS score of 5.6 (neither alert nor sleepy; SD = 2.0, range = 2–8), and a mean AHSS score of 2.2 (SD = 1.1, range = 0.7–4.5).

Paired samples t-tests were performed to assess for differences in these measures between the festival and laboratory timepoints. At the festival, participants reported significantly greater subjective sleepiness, $t(12) = 3.770$, $p = 0.003$, 95% CI [1.10, 4.13], greater mean rating of hangover severity, $t(12) = 4.126$, $p = 0.001$, 95% CI [0.64, 2.07], and fewer hours slept in previous 24 h, $t(12) = 3.433$, $p = 0.005$, 95% CI [0.58, 2.58] than reported in the laboratory.
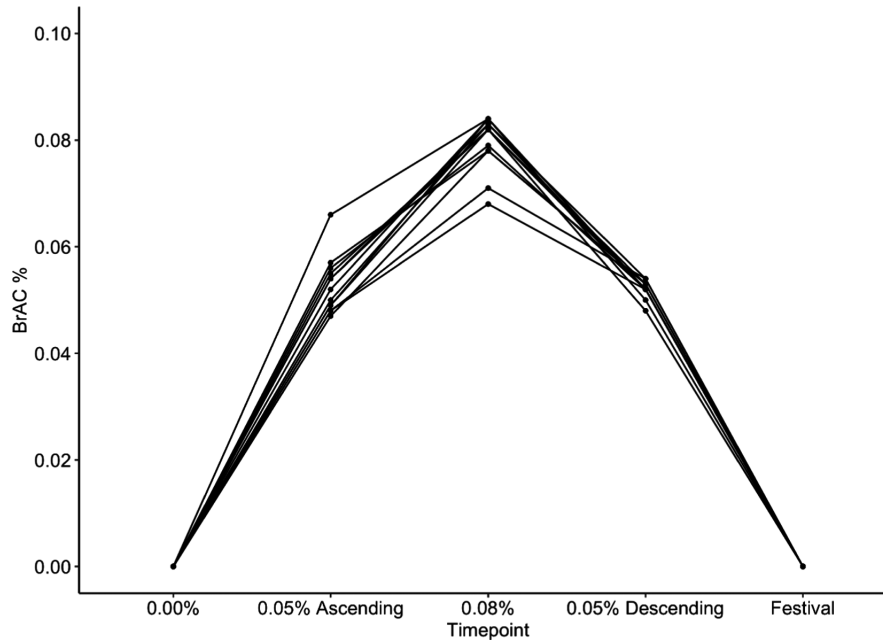

FIGURE 1 Laboratory BrAC readings at cognitive assessment timepoints ($N = 52$)

FIGURE 2 Laboratory and festival BrAC readings at cognitive assessment timepoints (*N* = 13)

Attentional performance: task sensitivity to acute alcohol consumption

See Figure 3 for task performance descriptive statistics and Table 1 for comparison of timepoints within the laboratory phase (i.e., 0.00% lab performance vs. each intoxication timepoint). When compared to 0.00% BrAC, task performance on the RVIP was significantly poorer at the ascending phase of 0.05%, with small effect size, while there were no significant differences at any other timepoint. All other effects were nonsignificant with a small magnitude.

Attentional performance: festival vs. controlled laboratory intoxication

See Figure 4 for task performance descriptive statistics and Table 2 for a summary of effects between postfestival and controlled intoxication timepoints. AF incorrect response performance at the festival was significantly poorer than at the 0.00% and 0.05% BrAC levels in the laboratory, with large and medium effect sizes, respectively. This may have been the result of a speed-accuracy trade-off, with participants also performing the task significantly faster at the festival than all timepoints in the laboratory (medium to very large effect sizes). While there were no statistically significant effects for the AF "no-go" task, there was an effect size of over 0.40 for the 0.05% ascending timepoint, indicating poorer performance while acutely intoxicated. RVIP performance at the festival was significantly better at the festival than at the 0.05% ascending and 0.08% BrAC levels in the laboratory, with large and medium effect sizes, respectively.

DISCUSSION

The purpose of this pilot study was to devise an appropriate methodology to assess driving-relevant attentional performance after a multiday naturalistic drinking session—in this case, a multiday music festival. In the controlled setting (i.e., limiting the influence of fatigue and other environmental factors), neither of the attention tasks were markedly sensitive to acute alcohol intoxication, with the exception of the sustained attention task at the 0.05% ascending timepoint. However, at the conclusion of the festival, a greater number of attentional errors (incorrect responses on the AF task) were recorded by participants than at 0.00% and 0.05% ascending BrAC in a controlled setting. Collectively, while these findings raise concerns about our chosen attentional task as appropriate references for field-based comparisons, they also indicate that the residual effects of a multiday naturalistic drinking setting may have a deleterious effect on attention.

In respect to performance in the controlled setting, our results indicated that our chosen driving-relevant attention task performance was not uniformly sensitive across the alcohol curve, up to a peak BrAC of 0.08%. This was unprecedented considering these domains have been demonstrated to be impaired by the effects of acute alcohol intoxication (Zoethout et al., 2011). While there are some possible theoretical mechanisms behind these findings, such as compensatory responding, biphasic effects, and alcohol myopia theory (i.e., that alcohol restricts the range of cues able to be attended to; see Mocaiber et al., 2011 for further discussion), it does suggest that impairment detection for these tasks did not increase linearly as intoxication increases. This makes the use of controlled baseline performance for these tasks, across the alcohol curve (at least up to 0.08% BrAC) less attractive as referent variables for later
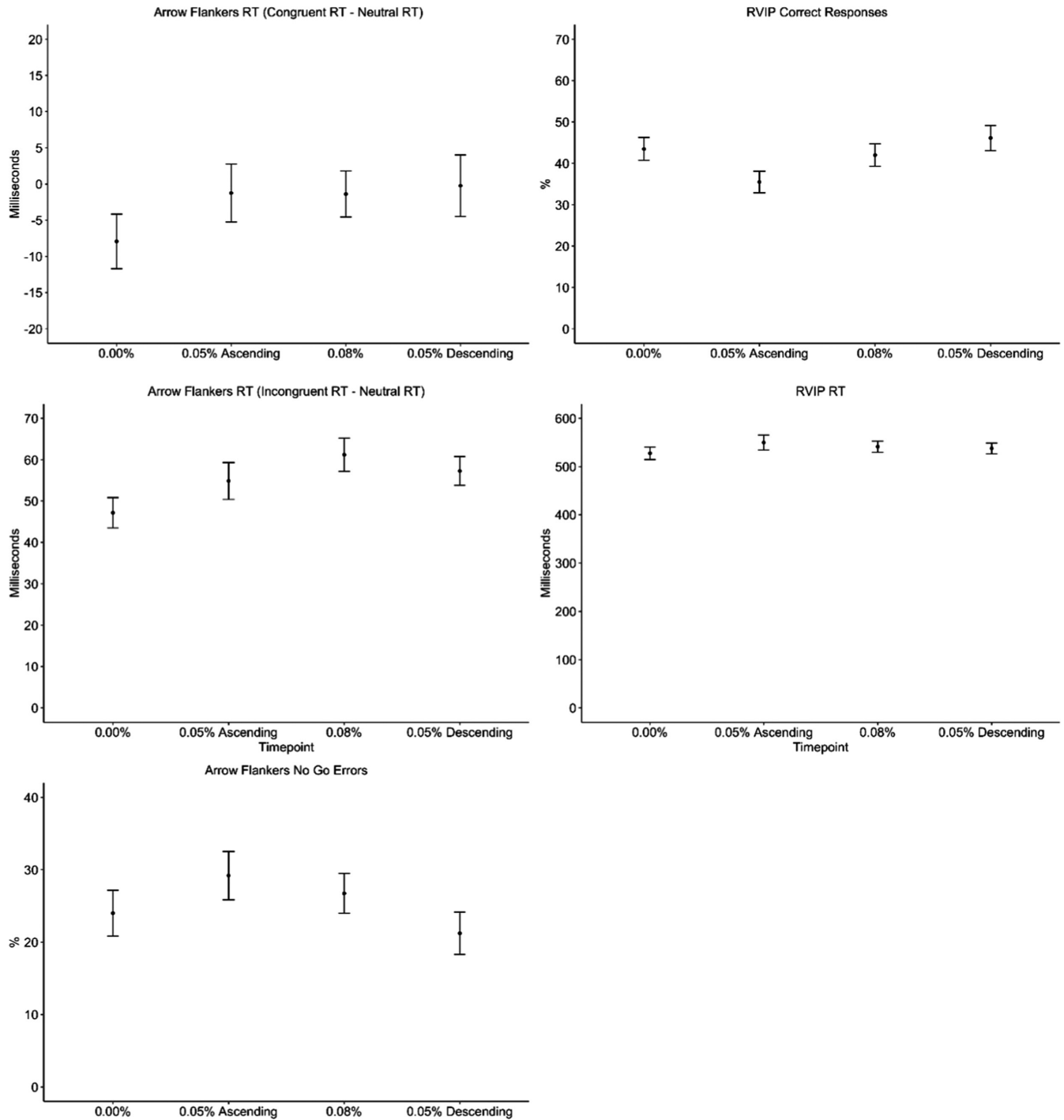
FIGURE 3 Cognitive task descriptive statistics for sensitivity analysis (*N* = 52)

field-based measurements (although not completely unusable) due to the unstable impairment detection. Ideally, in future studies of this nature, we would identify tasks that detect impairment (relative to 0.00% BrAC) across the entire intoxication curve, as they would provide a more robust referent category to the next day effects of alcohol consumption in naturalistic settings.

However, importantly, our results demonstrate the potential for individuals to be adversely affected by the experience of a multi-day drinking session compared to their baseline levels in a controlled

setting. In line with previous research (e.g., Fernando et al., 2018; Jenkinson et al., 2014), participants reported consuming alcohol in considerable quantities during the event; three times greater than recommended in a single instance by the National Health and Medical Research Council (NHMRC, 2009). They also reported sleeping significantly fewer hours on average in the previous 24 h than they had reported in the laboratory, while simultaneously reporting a greater degree of sleepiness. These differences contextualize the subjective state of individuals following a multiday

TABLE 1 Summary of effects: laboratory baseline versus controlled intoxication performance

| | Paired comparisons: laboratory baseline (0.00% BAC) versus laboratory intoxication levels | | | | | | | | |
| | 0.05%[a] | | | 0.08% | | | 0.05%[b] | | |
	p	d	BF^{01} (E%)	p	d	BF^{01} (E%)	p	d	BF^{01} (E%)
Selective attention: arrow flankers									
Incongruent RT, ms (incongruent–neutral)	0.707	0.05	6.18 (8.77)	0.113	0.22	1.98 (9.24)	0.588	0.08	5.75 (6.04)
Congruent RT, ms (congruent–neutral)	0.151	−0.20	2.46 (6.94)	0.188	−0.18	2.87 (4.90)	0.122	−0.22	2.10 (8.69)
No go errors, %	0.098	−0.24	1.73 (3.88)	0.417	−0.12	4.69 (4.79)	0.351	0.13	4.24 (4.80)
Sustained attention: RVIP									
Correct responses, %	**0.032**	0.33	0.68 (2.02)	0.842	0.03	6.01 (1.38)	0.214	−0.19	2.92 (8.27)
Reaction time, ms	0.269	−0.17	3.41 (9.33)	0.287	−0.16	3.56 (9.63)	0.607	−0.08	5.40 (1.29)

Note: Positive *d* value indicates better baseline (0.00% BrAC) performance, negative *d* indicates poorer baseline performance.

Abbreviations: BAC, blood alcohol concentration; BF^{01} (E%), Bayes Factor (Error %); RVIP, rapid visual information processing; RT, reaction time (reaction time includes correct responses only).Bold values indicate *p* = < 0.05.

[a]Ascending limb.

[b]Descending limb.

drinking session, having reported the greatest amount of subjective impairment—both in terms of fatigue and residual alcohol effects—in the naturalistic (festival) phase of testing.

With regard to our selective attention task (AF), mean RT of correct responses on the final morning of the festival was significantly faster than all laboratory timepoints (0.00%, 0.05% ascending and descending limb, and 0.08% BrAC). However, total incorrect responses on the final day of the festival saw a significant, large increase (i.e., impairment) over the 0.00% and 0.05% ascending limb timepoints, while differences between the 0.08% and 0.05% descending limbs were nonsignificant. This suggests that, compared to the sober and early (stimulatory) phase of acute alcohol intoxication in the laboratory, participants performed the task faster at the detriment of overall accuracy relative to 0.00% and 0.05% ascending BrAC. Interestingly, the number of AF errors made at the festival paralleled those seen at the peak and descending limb timepoints (0.08% and 0.05%, respectively). This is an important finding, offering preliminary evidence that aspects of postfestival attentional performance may be impaired to levels akin to the peak (0.08%) and the sedation (0.05%) limbs of intoxication (considering limitations, discussed below).

This finding may suggest that, at an attentional level, patrons respond to stimuli faster after a festival when compared to their controlled sober performance but are more prone to making errors in their responses. Indeed, such an impairment could have implications in driving contexts. Attention is widely accepted as an important cognitive component in driving safety and suboptimal attentional performance is responsible for a host of accident-causing attentional errors (Hoel et al., 2011). For example, drivers may fail to identify appropriate information from a visual image (looking but failing to see appropriate stimuli in a timely manner) or fail to appropriately respond to identified hazards (Trick et al., 2004). While the mechanism behind such a speed accuracy trade-off is unclear in this context, one possible explanation is that a hungover and/or fatigued state elicits an attentional apathy toward a given task, resulting in a faster but more careless attentional state. With this finding in mind, alongside the increase in subjective impairment compared to baseline levels in the controlled setting, it is clear that there is potential for adverse cognitive performance after engagement in such multiday naturalistic drinking settings and that this phenomenon warrants further investigation.

Predeparture festival performance on the RVIP (both RT and correct responses), our measure of sustained attention, was significantly better than all controlled laboratory timepoints except for the baseline (0.00% BrAC), and 0.05% descending timepoints, while the laboratory comparisons indicated sensitivity to acute alcohol consumption at the 0.05% ascending level only. This suggests that impairment on this task was primarily detected on the stimulatory phase of acute alcohol intoxication and was not deleteriously influenced by participant state after the festival. Given that a recent meta-analysis has shown the next-day effects of alcohol consumption to be associated with a decrement in sustained attention performance (Gunn et al., 2018) and our participants were significantly
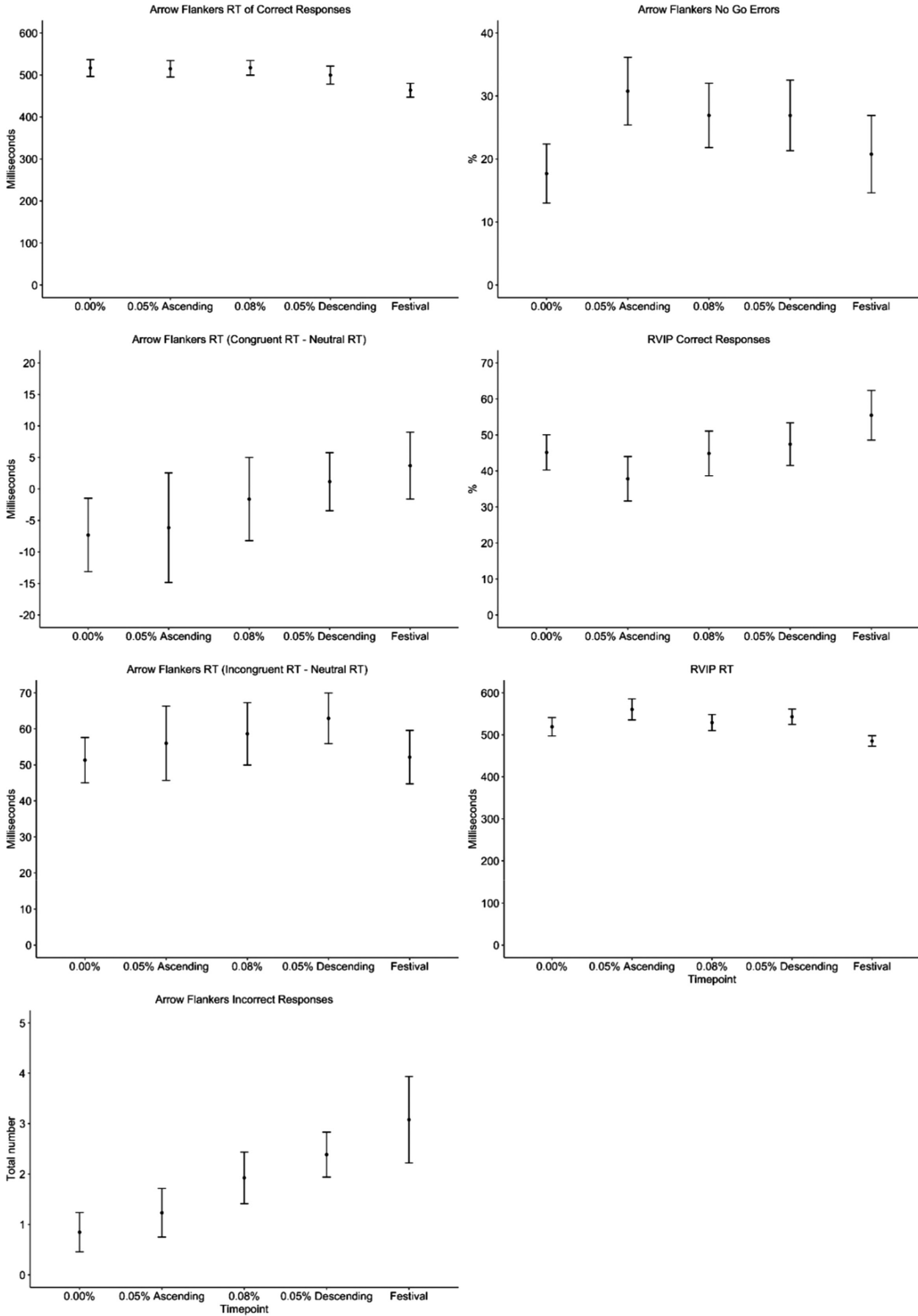
FIGURE 4 Laboratory and festival cognitive task descriptive statistics (*N* = 13)

TABLE 2 Summary of effects: festival performance versus controlled intoxication performance

| | Main effect: timepoint | | | Paired comparisons and Bayes Factors: last day (0.00% BAC) versus laboratory intoxication levels | | | | | | | | | | | |
| | | | | 0.00% | | | 0.05%[a] | | | 0.08% | | | 0.05%[b] | | |
	F	p	ηp^2	p	d	BF_{01} (E%)	p	d	BF_{01} (E%)	p	d	BF_{01} (E%)	p	d	BF_{01} (E%)
Selective attention: arrow flankers															
Incongruent RT, ms (incongruent–neutral)	0.51[c]	0.616	0.041	0.924	−0.03	3.58 (0.016)	0.796	0.07	3.49 (0.016)	0.598	0.15	3.16 (0.017)	0.288	0.31	2.14 (0.020)
Congruent RT, ms (congruent–neutral)	0.569	0.686	0.045	0.101	−0.49	1.05 (0.003)	0.372	−0.26	2.49 (0.019)	0.548	−0.17	3.05 (0.016)	0.727	−0.10	2.40 (0.016)
RT correct reponses, ms	6.561	**<.001**	0.353	**0.001**	1.140	0.03 (7.62e-6)	**<0.001**	1.277	0.02 (1.33e-5)	**<0.001**	1.517	<0.00 (7.11e06)	**0.043**	0.627	0.55 (8.01e-4)
Total incorrect responses, %	4.250	**0.005**	0.262	**0.013**	−0.81	0.21 (0.002)	**0.015**	−0.789	0.24 (7.99e-4)	0.22	−0.36	1.80 (0.022)	0.24	−0.34	1.91 (0.021)
No go errors, %	1.471	0.226	0.109	0.703	−0.12	3.36 (0.016)	0.127	0.45	1.24 (0.005)	0.219	0.36	1.80 (0.022)	0.193	0.38	1.65 (0.006)
Sustained attention: rapid visual information processing															
Correct responses, %	2.577	**0.049**	0.177	0.095	0.502	1.01 (0.003)	**0.022**	0.727	0.33 (0.001)	**0.030**	0.684	0.41 (0.001)	0.101	0.493	1.05 (0.003)
Reaction time, ms	2.971	**0.029**	0.198	0.102	0.492	1.05 (0.003)	**0.004**	0.984	0.08 (6.15e-5)	**0.040**	0.637	0.52 (9.95e-4)	**0.005**	0.955	0.10 (1.34e-5)

Note: Positive d value indicates better festival performance, negative d indicates poorer festival performance.

Abbreviations: BAC, blood alcohol concentration; BF^{01} (E%), Bayes Factor (Error %); RT, reaction time (reaction time includes correct responses only). Bold values indicate $p = < 0.05$.

[a] Ascending limb.

[b] Descending limb.

[c] Greenhouse-Geisser correction applied.

more subjectively hungover and fatigued when compared to their laboratory assessments, this finding is unprecedented. However, it is important to note that our task did not take into consideration the potential for compensatory responding by participants.

Cognitive compensatory responding, or the compensatory maintenance of cognitive performance in the face of stressors (e.g., fatigue), has been demonstrated in recent electroencephalography studies (Wang et al., 2016). Specifically, the recruitment of anterior frontal regions of the brain, regions not typically associated with performance prior to the introduction of stressors, are hypothesized to assist with cognitive load during periods of fatigue. Compensatory responses are temporary and taper off after continued assessment (Wang et al., 2016). The RVIP is a measure of the ability to sustain attention over time. However, our task only ran for 300 trials over a few minutes. It is possible that, given the brevity of our task, participants were able to effectively compensate during the festival assessment, resulting in an increase in performance over a short period of time. Such compensation may have also been associated with the selective sensitivity to intoxication seen in our controlled comparisons, with impairment in the stimulation phase of intoxication only. It may be that individuals are able to effectively compensate for intoxication once past the initial stimulatory phase of intoxication, resulting in a return (albeit temporary) to baseline performance during this assessment. However, given that festivals are often in rural settings, and often involve lengthy drives back to urban regions, it is important to consider that cognitive compensation may not last the length of time it takes to drive back home from the event, resulting in a tapering of performance over time. Consequently, it would be beneficial to investigate postfestival sustained attention over a longer period to determine if compensatory responding is a factor of consideration in this context, and if so, for how long this effect remains.

Despite identifying potential impairment after the festival, it would be beneficial for future projects aiming to upscale this line of enquiry to either (i) identify portable cognitive tasks that are more sensitive to the effects of acute alcohol intoxication and associated impairment (and thus a more appropriate referent measure for performance in naturalistic settings), or (ii) attempt to implement a more robust and direct measures of driving performance in lieu of a cognitive proxy. While portable cognitive tests are perhaps not as robust or direct as other measures of driving impairment, such as a driving simulator, they are advantageous in that they are a middle ground between feasibility of deployment in ephemeral drinking settings (i.e., bringing the test to the setting) and their association with our key outcome of interest. This is especially true when considering that the sole assessment of driving impairment postalcohol intoxication in a controlled setting is unlikely to be wholly generalizable due to a host of extraneous performance-affecting factors relating specifically to the setting of interest (e.g., amount and quality of sleep, food intake, general fatigue). In this sense, our findings are encouraging in that they demonstrate that a portable tablet-based assessment can be utilized in these naturalistic festival settings to assess attention, while remaining a relatively cost-efficient and easy to deploy solution. However, as discussed, considering the marked logistical challenges associated with recruiting very large samples for a dual-pronged laboratory/field study of this nature, investigation of more context appropriate and sensitive assessments is warranted—either in the form of different portable tasks, or using a more direct measure such as a driving simulator.

Strengths and limitations

This was the first study to attempt to assess attentional performance in both the laboratory and following a licensed multiday music event, comparing postevent and controlled intoxication performance. While preliminary findings of this pilot study indicate important directions for future work in this area, some caveats should be considered.

First, this study may have been underpowered due to the small sample sizes. As such, it is possible that the null effects for some outcomes are the result of low power rather than a true null effect. However, given that many of the significant results at festival showed marked effect sizes (e.g., total incorrect errors), further investigation into these preliminary effects with an upscaled sample is warranted. Moreover, the inclusion of Bayesian analyses helps clarify which of the effects are likely to be real null effects and which are likely to be Type II errors.

Second, while the findings indicated that subjective impairment (e.g., hangover) might account for poor postfestival attentional performance, we were not able to directly assess the association between these factors due to low sample size. As such, it would be important for future research to investigate what specific role subjective impairment plays in attentional performance in these settings. Furthermore, given our subjective impairment measures did not necessarily encapsulate all performance-relevant factors, there may be relevant influences that were not assessed during the course of the event (e.g., food consumption), which should also be further investigated.

Third, a lack of a placebo condition in the laboratory phase precluded the ability to disaggregate task performance that was (i) due to pharmacologic alcohol effects, versus (ii) expectancies about the impairing effects of alcohol. In upscaled versions of this study (i.e., with capacity to recruit a greater number of participants), the inclusion of a placebo condition will be an important consideration.

Finally, ethical and methodological considerations precluded recruitment from the highest risk subset of the population, including those who regularly consume illicit substances, drink heavily, and/or regularly consume tobacco. Indeed, the excluded subset may have included those with a higher propensity to engage in risk behaviors associated with cognitive performance attenuation. Our sample may have subsequently underestimated the level of postfestival impairment that would be experienced by these individuals. Furthermore, while individuals who used illicit substances were precluded (both in the laboratory and at the festival), this was based on self-reported use. Biometric evaluation of illicit drug use (e.g., saliva swabs) should be included in future studies to concretely rule out this confound.

CONCLUSIONS

Assessing real-world driving-related performance after multiday drinking sessions is an important but underinvestigated line of research. Devising an appropriate methodology to assess driving-relevant cognition after drinking is an important step toward achieving this. While performance in many of the cognitive tasks deployed in our assessment battery was not impaired (either uniformly or entirely across the curve) by acute alcohol intoxication, the findings of this study pave the way for the development of a more refined field-comparison cognitive assessment battery. Specifically, it would be beneficial for future field-based impairment assessments to include attention-specific tasks that are highly sensitive to the impairing effects of acute alcohol intoxication, characterized by consistent impairment detection across most or all of the alcohol curve at intoxication levels relevant to driving policy. This would increase confidence in using these measures as a referent outcome for field-based comparisons.

In the naturalistic multiday drinking setting, our findings suggest that the absence of blood alcohol acutely may not necessarily be indicative of unimpaired cognitive performance and that other factors related to multiday drinking settings (e.g., hangover, fatigue) may result in driving-related attentional deficits. However, these findings need to be upscaled and replicated in a more robust sample, and with attentional measures that are either more sensitive to the effects of acute alcohol intoxication than those selected in our study or using a driving simulator.

CONFLICT OF INTEREST

The authors report no conflict of interest.

ETHICS STATEMENT

This study received approval from the University of Tasmania Human Research Ethics Committee. All procedures were performed in compliance with relevant laws and institutional guidelines. Informed consent was obtained for all participants.

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ENDNOTE

[1] AF RT correct responses and AF incorrect responses were not recorded for Study 1 due to a technical error. Thus, data for these outcome measures are not presented in the data analyses.

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