Naturalistic drinking and driving: Expectancy effects and acute protracted error with moderate alcohol consumption

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Abstract

Previous research has demonstrated biphasic effects of alcohol consumption on performance; some responses are more impaired on the ascending limb of the intoxication curve when blood alcohol concentrations (BACs) are increasing, and others are more impaired on the descending limb (when BACs are decreasing). It has also been suggested that well-practiced automatic responses are more resistant to alcohol impairment and may show improved performance on the descending limb (acute tolerance). The present research investigated these effects in the context of a naturalistic alcohol consumption protocol in which drinking occurred in social groups over a period of four hours. Forty-four participants were assigned to one of two alcohol dose conditions or a placebo control group and consumed alcohol in groups of three such that they gradually reached their target BAC (.05 or .08) and maintained it for one hour. The participants completed a series of cognitive tests (Cogstate test battery) and a simulated driving task (Driver Attention Inhibition and Reaction test) over the course of their intoxication curve. The results showed strong placebo effects on self-ratings of intoxication. No evidence of acute tolerance was found in driving performance, instead speed management showed acute protracted error, greater impairment during the descending limb. The findings provide strong evidence of expectancy effects in contributing to perceptions of intoxication but do not support the idea that well-practiced automatic behaviours may be resistant to alcohol impairment.

Introduction

Nearly 100 years of research has left little doubt that alcohol intoxication has an adverse effect on driving performance (Marshall, 1941; Martin et al., 2013). Increasing blood alcohol concentrations (BACs) are associated with increased crash risk (Blomberg et al., 2009) and a higher likelihood of involvement in a serious injury or fatal crash (Maycock, 1997; Phillips & Brewer, 2011). In spite of the wealth of research indicating that drinking and driving is dangerous, there remains much that is unknown about alcohol's effects on drivers. Some general principles have been established, such as the finding that complex constituents of driving such as divided attention are affected at lower BACs than simple elements such as reaction time and psychomotor coordination (Leung & Starmer, 2005; Liu & Fu, 2007; Moskowitz & Fiorentino, 2000). Yet, the wide variation in research findings associated with the alcohol-behaviour link has led some to conclude that "*Alcohol does not consistently affect behaviour*" (Moss & Albery, 2009, p 516).

One of the sources of variability in alcohol's effects comes from the influence of biphasic effects on behaviour across the time course of the alcohol dose-response curve (Holdstock & de Wit, 1998). Some aspects of performance appear to be more impaired during the ascending limb (i.e., acute tolerance, also known as the Mellanby effect) while performance on other aspects appears to be impaired to a greater degree during the descending limb (acute protracted error) (Cromer et al,. 2010; Schweizer & Vogel-Sprott, 2008; Weafer & Fillmore, 2012). Our own research has shown that self-ratings of intoxication and willingness to drive appear to recover faster than BAC levels (acute tolerance) while many important aspects of actual driving performance show poorer performance during the descending limb (acute protracted errors), and still others show strong symmetric effects of BAC (approximately equal impairment across both limbs of the intoxication curve) (Starkey & Charlton, 2014).

There is also an increasing amount of data showing that participants' expectancies about the effects of alcohol play an important role in the degree of impairment resulting from consumption of alcohol (Moss & Albery, 2009). This has been repeatedly demonstrated on drinkers' self-reports of degree of intoxication and impairment to the extent that participants receiving a placebo alcoholic beverage often report moderate levels of intoxication (Starkey & Charlton, 2014; Fillmore & Vogel-Sprott, 1995). Expectancies associated with the belief that one has consumed alcohol can result in disinhibition of a range of perceptual and behavioural responses (Bègue et al., 2013) and even some impairment on simple motor tasks (Fillmore & Vogel-Sprott, 1995). Alongside these findings, self-assessments of intoxication and driving impairment are inaccurate, unreliable and do not correspond to BAC levels or predict actual performance (Beirness, 1987; Cromer et al., 2010; Harrison & Fillmore, 2011; Verster & Roth, 2012; Weafer & Fillmore, 2012).

Recently, it has been proposed that much of what we have learned about alcohol's effects on performance may not apply to real-world drinking. The essence of the argument is that the alcohol consumption regime used in most experimental studies, supervised consumption of large doses in a short period of time preceded by fasting, is simply not representative of the conditions under which alcohol is typically consumed; social drinking at a pace, time, and place of one's choosing (Lyvers & Tobias-Webb, 2010; Verster et al., 2014). The rapid onset-steady decline intoxication curve associated with these experimental studies may not have the same pattern of impairment as the broader and flatter intoxication curve that results from titrated, self-administered, social drinking. Although few researchers have explicitly examined the behavioural effects and BAC plateau associated with this latter type of drinking, it has been suggested that acute tolerance and acute protracted error effects may not be present to the same degree (Lewis & Nixon, 2013; Lyvers & Tobias-Webb, 2010).

The goal of the present study was to explore alcohol-induced performance impairment in the context of a somewhat more naturalistic drinking environment in which participants consumed alcohol in social groups and maintained a BAC plateau over a longer period of time. Specifically, we were interested in determining: a) whether or not acute tolerance and acute protracted error effects would occur when the intoxication curve was extended (i.e., BACs plateaued and were maintained over longer periods), and b) how the presence of other drinkers might intensify feelings of intoxication or affect performance impairment. To address these questions we used an experimental protocol in which participants consumed alcohol in small groups and the amount of alcohol they consumed was titrated to maintain target BACs for one hour. The participants' performance on cognitive tests and a simulated driving task was measured throughout their intoxication curve.

Method

Participants

All of the methods used in this study and received ethical approval from the School of Psychology Research Ethics Committee at the University of Waikato. Volunteers were eligible to take part if they were aged between 20-50 years, held a full New Zealand driving licence, and drank occasionally. People expressing an interest in the experiment were first screened to ensure that they were in good health, had no neurological /psychological conditions (e.g., head injury, stroke), were not taking any contra-indicated medication, and for female participants no possibility of being pregnant, consumed alcohol occasionally but not excessively, with a score <8 on the Alcohol Use Disorders Identification Test (AUDIT) (Babor et al., 2001). The 44 participants (23 female) completing the experiment had an average age of 32.84 years (*SD* = 8.49, range 20-47 years). Participants had held full New Zealand driving licences for an average of 15. 93 years (*SD* = 10.59). In the previous 12 months, 9 participants had received at least one traffic infringement notice (including parking tickets).

Apparatus

Three Alcomate AccuCell AL9000 professional grade breathalysers were used to measure the participants' BAC levels. The cognitive performance tests were presented on an Acer Iconia (W510) touch screen tablet computer configured to run the Groton Maze Learning Test (GMLT) and Card Identification test from the Cogstate Research software (www.cogstate.com). The Driver Attention Inhibition and Reaction test (DAIR) was presented using the University of Waikato driving simulator consisting of a complete automobile (BMW 314i) positioned in front of three angled projection surfaces. The details of the simulator and the DAIR have been described elsewhere (Charlton & Starkey 2011, Starkey & Charlton, 2014).

Performance measures

The performance measures used in the present study were the same as those used and described in our previous study of driving and cognitive performance (Starkey & Charlton, 2014). The Timed Chase test (the first part of the GMLT) was used to assess visual motor function; the maze learning phase of the GMLT was used to assesses executive functions and spatial problem solving and the delayed GMLT recall task provided a measure of visual learning and memory; The Card Identification task (performed during the delay between GMLT learning and recall phases), was used to provide a measure of choice reaction time. These tests possessed good construct validity (Pietrzak et al., 2008) and have parallel forms which allowed repeated administration without appreciable learning across testing blocks. The DAIR is a simulated 11 km driving task with five equivalent versions and assesses steering performance (SDLP), speed maintenance, and reactions to an embedded hazard identification and avoidance task (Starkey & Charlton, 2014).

Subjective intoxication was assessed using a visual analogue scale in which participants responded to the question "How intoxicated do you feel right now?" by placing a mark on a 200mm line (Cromer et al., 2010). Response anchors ranged from "Least intoxicated I've ever felt in my life" to "Most intoxicated I've ever felt in my life". The participants' momentary willingness to drive was assessed by responding on a 100mm visual analogue scale ranging from "Not at all" to "Very much" (Beirness, 1987). The Karolinska Sleepiness Scale (Akerstedt & Gillberg, 1990) was used to rate how sleepy participants felt on a 9 point scale ranging from 1 (very alert) to 9 (very sleepy).

Procedure

Following the telephone screening, participants were invited to the laboratory individually to complete a familiarisation session during which they provided informed consent, completed a breathalyser test, practice trials of the cognitive tests, and took a practice drive in the simulator. At the end of the 40 min session, participants were scheduled to return to the laboratory in groups of three (consisting of friends who all completed the preliminary screening and familiarisation session) and received a $10 voucher to thank them for their participation thus far. Participants were asked to refrain from having a meal or caffeinated drinks for the three hours immediately prior to their full experimental session and not consume any alcohol for 24 hours prior to their experimental session.

The sessions began with confirmation that each participant had a BAC of zero. This was followed by a reminder of the test protocol, and another practice drive in the simulator. All participants were then shown to a lounge room containing a table, chairs, sofa, music system, and a variety of puzzles and games. Participants completed five test blocks; Test Block 1 recorded their baseline performance and occurred shortly after all three participants had completed their practice in the simulator (prior to any drinks being served). Test Block 2 measured performance while BAC levels were ascending. Test Blocks 3 and 4 occurred when BACs reached their peak and were maintained for 1 hour (the plateau phase). Finally, Test Block 5 measured performance as BAC levels were descending, and were at the same level as the ascending block (Block 2).

During each test block participants were taken, one at a time, to a nearby room where they completed the cognitive tests (approximately 8 min duration) followed by completion of the DAIR simulated drive in a separate room (another 8 min). Test Blocks 2-5 also included ratings of subjective intoxication, willingness to drive, and sleepiness. After completing Block 5 participants were individually asked to estimate how much alcohol they had consumed during the session, were given a debriefing sheet informing them of the actual amount of alcohol they consumed (but not their BAC levels) and recommending that they not drive for the rest of the day. Each participant was given a $50 voucher for their participation and provided with a taxi to take them home.

Alcohol administration

At the start of a full experimental session each participant was randomly assigned to one of three groups: (1) Medium - an alcohol dose of 6g/kg (women) and .75g/kg (men) intended to produce a target BAC.05; (2) High - an alcohol dose of 75g/kg (women) and 1.0g/kg (men) intended to produce a target of .08 BAC; or (3) a placebo dose of alcohol. These doses were based on our previous research (Starkey & Charlton, 2014), and the alcohol (vodka, 37.5%) was mixed with orange juice at a ratio of 30% vodka: 70% orange juice. Participants in the Placebo group received an equal drink volume as the other participants, but consisted of orange juice with 5 ml of vodka added to the top of each drink. Of the 44 participants completing the full sessions, 14 were assigned to the Placebo group, 15 were assigned to the Medium group, and 15 to the High group.

At the end of Test Block 1 participants received their first drink. Additional drinks were served every 15 mins (or longer depending on how rapidly the participants consumed them) and BACs were recorded every 15 minutes until participants reached the Block 2 (ascending BAC) target of .03 for the Medium (.05) group or the .05 target for the High (.08) group. Placebo participants were served drinks and tested at a similar time as those in the alcohol conditions. As soon as a participant reached their Block 2 BAC target they were taken from the lounge area and administered the cognitive and performance tests and completed the subjective ratings before returning to re-join the other participants in the lounge area. Completion of Block 2 was followed by additional drinks and BAC testing (every 15 min) until the participant reached a BAC of within .005 of their peak BAC goal (.05 or .08) at which point they completed the Block 3 tests and rating scales.

After Block 3 was completed each participant was served drinks half the size as previously but at the same alcohol concentration and BAC tested every 10 min such that they maintained a BAC level within .01 of their goal for one hour. A variety of snacks were available for the participants to consume ad libitum from completion of Block 3 onwards. At the end of the hour each participant completed Block 4 tests and rating scales and returned to the lounge area. No further drinks were served (other than water) and participants were BAC tested every 15 mins until they reached their descending target BACs of .03 or .05 (for the Medium and High groups respectively).

Data analysis

To assess the overall effects of alcohol doses over the course of the experimental sessions, mixed-design 3 x 5 ANOVAs (comparing the three groups across the five test blocks) were computed for each of the dependent measures. Comparisons of performance during ascending and descending BAC levels were conducted with mixed-design 3 x 2 ANOVAs looking at differences between the three groups during Test Blocks 2 and 5 and planned comparisons (*t* tests) of the two test blocks for individual groups. Group differences during the BAC plateau phase were tested with mixed-design 3 x 2 ANOVAs looking at differences between the three groups during Test Blocks 3 and 4 and comparisons (Bonferroni adjusted) between individual groups were calculated. Inclusion of a reference placebo group (see results below) was accommodated in the ANOVAs described above by adding a fourth group (4 x 5 or 2 x 4 mixed design ANOVA as appropriate) and during post-hoc analyses by calculating Dunnett's *t* statistics comparing each group to the reference placebo group.

Results

Subjective ratings

Participants' mean ratings of their subjective intoxication at Test Blocks 2-5 (none were collected during Block 1 baseline) are shown in the left panel of Figure 1. ANOVA indicated a significant difference across the test blocks [$F(3,120) = 9.34$, $p < .001$, $\eta_p^2 = .199$] but no difference between the ratings of the three social drinking groups [$F(2,40) = 1.92$, $p = .160$, $\eta_p^2 = .088$]. (One of the placebo participants failed to provide a rating of subjective intoxication during Block 5 and the analysis is based on the 13 placebo participants who did.) This rather surprising finding resulted from the Placebo group ratings that were equivalent to the Medium alcohol group, and at Blocks 3 and 4, actually higher than the Medium group. To investigate this further, we compared the ratings to those from a reference group of 20 Placebo participants that were tested individually with essentially the same experimental protocol in a previous experiment (Starkey & Charlton, 2014). As can be seen in the figure, the ratings of these solo Placebo participants are lower than all three of the social drinking groups in the current experiment. Statistical comparison of the ratings for the two groups indicated that the 14 social drinking Placebo participants rated their intoxication higher than the 20 solo Placebos at Block 3 [$F(1,33) = 9.52$, $p = .004$, $\eta_p^2 = .229$] and Block 4 [$F(1,33) = 5.49$, $p = .026$, $\eta_p^2 = .146$]. Re-running the original comparison of the four groups across the four test blocks indicated a significant group effect [$F(3,59) = 5.86$, $p = .001$, $\eta_p^2 = .229$] and significant difference across the blocks [$F(3,177) = 14.94$, $p < .001$, $\eta_p^2 = .202$] as well as verification with Dunnett's t comparisons that the High and Placebo groups' ratings were significantly higher than the solo Placebos during the plateau phase (Blocks 3 and 4) and higher than the High and Medium groups during the ascending and descending limbs (Blocks 2 and 5) (all ps< .028).

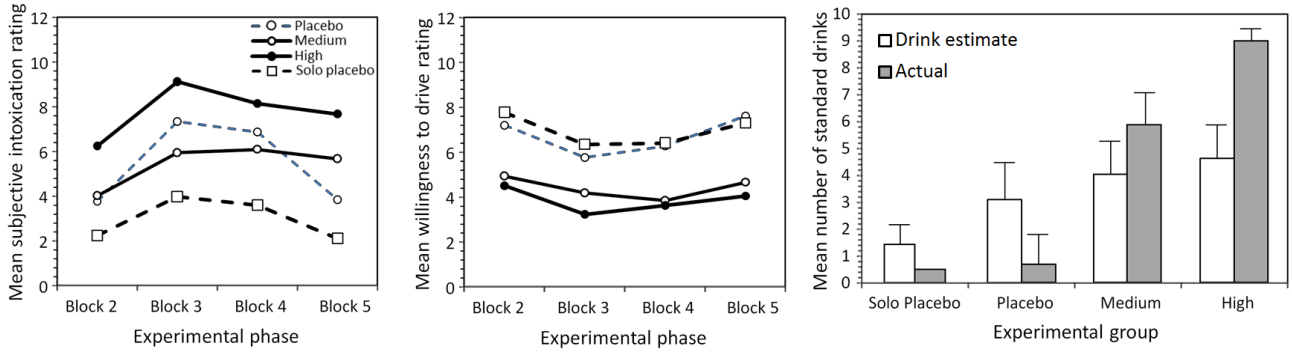

Figure 1. Mean self-ratings of intoxication (left panel) and willingness to drive (centre) across test blocks 2-5. Participants' mean estimates of how much alcohol they consumed compared to how much they actually consumed (right). Vertical lines indicate 95% confidence intervals.

The centre panel of Figure 1 shows the willingness to drive ratings for all four groups. There was a significant difference between the groups [$F(3,59) = 4.96$, $p = .004$, $\eta_p^2 = .201$] and between the test blocks [$F(3,177) = 21.31$, $p < .001$, $\eta_p^2 = .151$]. Bonferroni-adjusted post-hoc comparisons indicated that the social drinking Placebos and solo Placebos rated their willingness to drive significantly higher than the participants in the High group ($p = .042$ and $p = .018$ respectively). The ratings of subjective sleepiness (not shown) did not differ between the groups.

Finally, the right panel of Figure 1 shows the participants' estimates of how many standard drinks they consumed during the session. The three social drinking groups' drink estimates did not differ from one another [$F(2,31) = 1.35$, $p = .275$, $\eta_p^2 = .080$]. In contrast, the solo Placebo participants all received .5 of a standard drink during their session and estimated they had received a mean of 1.43 standard drinks; a Dunnett t post-hoc comparison indicated that this estimate was significantly lower than the other three groups (all ps < .036).

Driving performance

Three driving performance measures showed symmetric dose-dependent impairment: the number of centreline crossings, time spent over the centreline, and SDLP. In the case of centreline crossings (shown in the top two panels of Figure 2), mixed-design ANOVAs indicated a significant difference between the groups for both the number of crossings [$F(3,60) = 3.56$, $p = .019$, $\eta_p^2 = .151$] and total time spent over the line [$F(3,60) = 10.87$, $p < .001$, $\eta_p^2 = .352$]. In each of these analyses, significant differences between the test blocks and interactions between group and test block were also noted (all ps < .03). Post-hoc comparisons of the mean number of crossings indicated that the High group made significantly more crossings than the solo Placebo group throughout their BAC plateau (Blocks 3 and 4combined), as well as during their ascending and descending limbs (Blocks 2 and 5) (Dunnett t comparisons $p = .004$ and $p = .01$ respectively). The number of crossings made by the social drinking Placebos did not differ from the two alcohol groups. Post hoc comparisons of the time spent over the centreline revealed that both the Medium and the High groups stayed over the centreline longer than the solo Placebos. This was the case for their BAC plateau (Dunnett t comparisons; $p = .003$ for Medium and $p < .001$ for High), as well as during their ascending and descending limbs ($p = .055$ for Medium and $p = .002$ for High). The High group's time over the centre line was also higher than the social drinking Placebos and the Medium group during their BAC plateau (Bonferroni-adjusted pairwise comparisons; $p < .001$ for social Placebos and $p = .001$ for the Medium group). During the ascending and descending limbs the High group spent more time over the centreline than the social drinking Placebos (Bonferroni-adjusted $p = .048$); the social Placebo group and the Medium group were not reliably different during any of the test blocks.

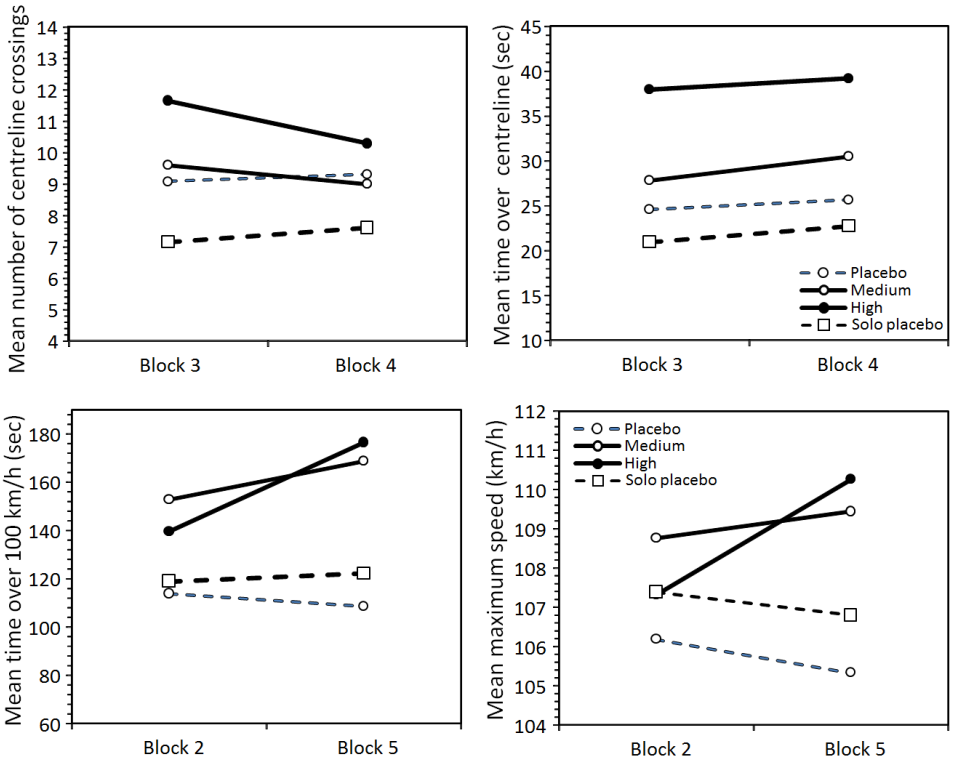

Figure 2. The top two panels show mean number of centreline crossings and time spent over the centreline during the plateau phase. The lower two panels show the mean number of sec driving faster than 100 km/h and mean maximum speeds during the ascending and descending phases.

The bottom two panels of Figure 2 show two measures of driving performance where performance appeared to be more impaired the longer the participants had been intoxicated (acute protracted error); the mean amount of time spent driving over 100 km/h (the posted speed limit for the majority of the DAIR simulated drive and the participants' mean maximum speed). Overall,

maximum speed showed a significant difference between the four groups across the five test blocks [$F(3,60) = 6.64$, $p = .001$, $\eta_p^2 = .249$], as well as a significant difference between the test blocks [$F(4,240) = 6.17$, $p < .001$, $\eta_p^2 = .093$] and a test block by group interaction [$F(12,240) = 7.92$, $p = .001$, $\eta_p^2 = .127$]. Post-hoc comparisons indicated that participants in the High group had higher peak speeds during their plateau phase than the solo Placebo participants (Dunnett *t* comparison; $p < .001$). The social drinking Placebos' speeds were also significantly lower than the High group during this phase (Bonferroni-adjusted $p < .001$). Comparing the ascending and descending limbs of the BAC curve (Blocks 2 and 5), the High group showed significantly higher speeds during Block 5 than Block 2 ($t(14) = -2.52$, $p = .024$) even though their mean BACs were nearly equivalent (.05 as compared to .057) during these blocks.

The mean amount of time spent driving over 100 km/h also showed a significant difference across the five test blocks [$F(4,240) = 17.27$, $p < .001$, $\eta_p^2 = .223$] and a significant interaction between the four groups and test blocks [$F(12,240) = 2.89$, $p = .001$, $\eta_p^2 = .126$]. Post-hoc comparisons did not reveal any reliable differences between the groups during the BAC plateau period, but comparison of ascending and descending limbs of the intoxication curve showed that the High group spent more time driving over 100 km/h during the descending limb ($t(14) = -3.07$, $p = .008$). The participants in the Medium group showed very similar trends in their performance but did not meet the criterion for statistical reliability.

Cognitive testing

Figure 3 shows the effects of alcohol on four measures from the Cogstate test battery. Analysis of the mean number of rule-break errors on the learning phase of GMLT (top left of the figure) showed a significant difference across the five test blocks [$F(4,240) = 10.21$, $p < .001$, $\eta_p^2 = .145$], an interaction between the four groups and test blocks [$F(12,240) = 2.69$, $p = .002$, $\eta_p^2 = .118$] and a marginally significant difference between the groups [$F(3,60) = 2.61$, $p = .06$, $\eta_p^2 = .115$]. The High group made more errors during their BAC plateau than the solo Placebo group (Dunnett *t* comparison; $p = .005$), as did the Medium group during the same period (Dunnett *t* comparison; $p = .053$). The social Placebos were lower than the High group (Bonferroni-adjusted $p < .01$), but did not differ from the other groups. The participants in the Medium group showed some evidence of acute protracted error, increasing their errors from the ascending limb to the descending limb ($t(13) = -2.47$, $p = .027$). (Note: Block 5 data from one participant was not available for this test.)

The mean number of total errors during the recall phase of the GMLT (top right) showed a significant difference across the five sessions [$F(4,240) = 3.41$, $p < .01$, $\eta_p^2 = .054$] and a marginally significant overall difference between the four groups [$F(3,60) = 2.59$, $p = .06$, $\eta_p^2 = .115$]. Post-hoc analyses showed that the High group made significantly more errors than the solo Placebo group during the ascending and descending limbs of their intoxication curve (Dunnett *t* comparison; $p = .007$). The social drinking Placebos also made fewer errors than the High group during this period (Bonferroni-adjusted $p < .015$), but did not differ from the other groups.

Participants' performance on the Timed Chase test (lower left) showed an overall difference between the test blocks [$F(12,240) = 2.65$, $p = .034$, $\eta_p^2 = .042$]. During the BAC plateau phase a small but significant increase in the Medium group's errors was noted ($t(14) = 2.20$, $p = .045$). Participants in the High group also tended to increase their number of errors over the five test blocks, but not enough to meet the critical *t* level in the post-hoc comparisons.

Finally, analysis of the participants' choice reaction times for correct responses from the Card Identification task indicated a small but reliable difference between the test blocks overall [$F(4,240) = 5.32$, $p < .001$, $\eta_p^2 = .081$] with reaction times increasing over the course of the session, but no significant difference between the four groups or any interaction between the four groups and the test blocks. The reaction times during the plateau phase are shown at the bottom right of Figure 3.

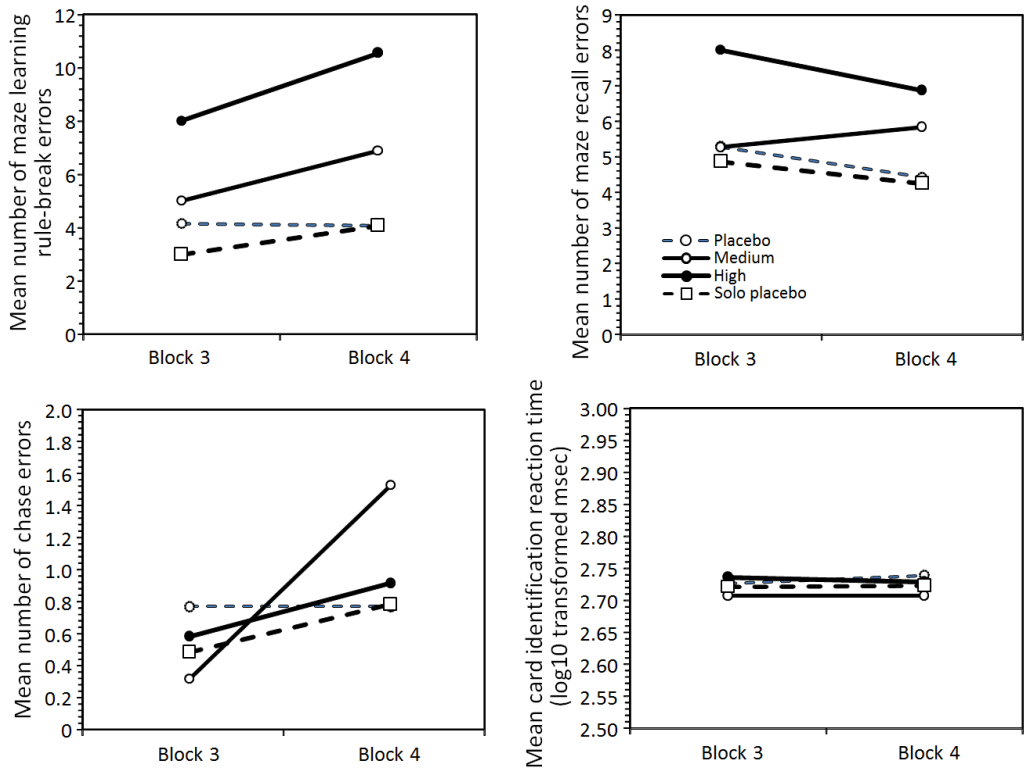

Figure 3. The top two panels show mean rule-break errors on the Groton Maze Learning task and mean number of total errors on the Groton Maze Recall task. The lower left panel shows the mean number of total errors on the Timed Chase test. The mean reaction times for correct responses from the Card Identification task are shown at lower right.

Discussion

Considering these findings as regards the goals of the research, it is apparent that prolonging the duration of the intoxication plateau did not eliminate acute protracted error effects on driving performance. In contrast, the results did not show any evidence of acute tolerance effects previously reported for subjective ratings of intoxication and willingness to drive. The second goal was to investigate whether the presence of other drinkers might intensify feelings of intoxication. It is clear that the social context of drinking in small groups had significant effects on Placebo participants' perceptions of intoxication (and to a lesser degree their performance). Placebo participants drinking in social groups rated their intoxication significantly higher, and significantly overestimated the amount of alcohol they had consumed as compared to the solo Placebo participants. This suggests an important influence of the environment and expectancies on judgements of one's own intoxication. Interestingly, although the social drinking Placebo participants rated their intoxication higher, their willingness to drive was no less than the solo Placebos.

Some researchers have argued that alcohol intoxication primarily affects intentional, controlled cognitive processes and behaviours and has little effect on prepotent or automatic cognitive processes and over-learned skills (Fillmore et al., 1999; Harrison & Fillmore, 2011; Moss & Albery, 2009). Evidence in support of this proposition has come from higher BACs required for impairment and acute tolerance effects on motor coordination and reaction time tasks but not for more complex cognitive functions (e.g., Filmore et al., 1999; Moskowitz & Fiorentino, 2000, Weafer & Fillmore, 2012). The findings of the present study did not show any evidence of acute tolerance in proceduralised behaviours such as steering or speed maintenance. Quite the contrary, these aspects of driving showed continuing impairment, or even increasing impairment on the descending limb of the intoxication curve (acute protracted error) even after a BAC plateau of an hour or more, while choice reaction times showed no evidence of alcohol impairment.

Considering these results it is tempting to suggest that expectancy effects associated with alcohol consumption act on explicit or controlled behaviours (such as judgement of one's own intoxication) whereas only the psychopharmacological effects of alcohol appear able to impair proceduralised, automatic behaviours. This of course begs the question of why some prepotent responses such as reaction time do not show alcohol impairment to the same degree as steering or speed maintenance. One possibility is that alcohol intoxication compromises the ability to monitor performance feedback on continuous tasks such as steering. Elsewhere we have proposed that driving is composed of two distinct processes working in tandem; an explicit monitoring process used for deliberate decisions and judgements and an implicit monitoring process that automatically guides performance and monitors feedback for signs of error (Charlton & Starkey, 2011, 2013a). The results of the present study and others (Berthelon & Gineyet, 2014) suggest that one of the effects of alcohol intoxication is to interfere with this monitoring process, while conscious expectancy effects may interfere with only responses governed solely by the operating process. Reaction time, a ballistic reflex that does not rely on the monitoring process to check performance feedback, may thus not be as impaired by consumption of alcohol, as was demonstrated in the choice reaction time performance of participants in the present study. While driving, the performance of well-practiced continuous tasks such as steering may be differentially impaired in comparison to discrete reaction time responses to the extent that performance feedback is continuously monitored or not. Any decrease in the sensitivity of the feedback monitoring process would result in delays in correcting deviations in performance, as reflected in the time over the centreline and time over 100 km/h measures in the present study.

Although the present study employed a fairly naturalistic drinking situation, it did not employ naturalistic driving to any degree and it remains to be seen whether the above pattern of acute protracted error would eventuate in a real-world driving situation. The performance of the social Placebo participants in the current experiment also appeared more variable than the solo Placebos. Whether this was because of an increased feeling of intoxication associated with expectancy effects, or a more general lack of effort and care in the context of the "party atmosphere", or simply due to a relatively small sample size is difficult to tell. It is worth noting, however, that at low doses alcohol effects increase variability in behaviour and may make dose-dependent effects difficult to see (Holdstock & de Witt, 1998). A similar phenomenon may occur for alcohol expectancy effects and contributed to the somewhat erratic performance of the social drinking Placebos.

From a practical standpoint, the results make it clear that drivers are extremely poor at self-evaluation of alcohol intoxication and impairment. After drinking alcohol, impairment and estimates of the amount consumed are typically underestimated. When acute tolerance effects on judgements of intoxication are present (as may be the case in some contexts, albeit not in the present experiment) drivers may be more likely to judge that they are fit to drive even though crucial aspects of their driving performance are still impaired. Social drinking may actually make explicit judgements of intoxication even more difficult and decisions about whether and when it is safe to drive should be made prior to drinking.

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