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# Environment, alcohol intoxication and overconfidence: Evidence from a lab-in-the-field experiment

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**Abstract**

Alcohol has long been known as the demon drink; an epithet owed to the numerous social ills it is associated with. Our lab-in-the-field experiment assesses the extent to which changes in intoxication and an individual's environment lead to changes in overconfidence or cognitive ability that are, in turn, often linked to problematic behaviours. Results indicate that it is the joint effect of being intoxicated *in a bar*, rather than simply being intoxicated, that matters. Subjects systematically underestimated the magnitude of their behavioural changes, suggesting that they cannot be held fully accountable for their actions.

**KEYWORDS**

alcohol intoxication, overconfidence

**JEL CLASSIFICATION**

C93, D91, I18

## 1 | INTRODUCTION

Alcohol consumption is never far from public debate, arising in discussions across a wide range of policy areas, from crime to health. It is thought that, globally, one in 20 deaths are attributable—directly or indirectly—to alcohol consumption; more than those caused by HIV/AIDS and diabetes combined (World Health Organization, 2018). These include one-in-four deaths due to road accidents and one-in-five due to interpersonal violence (see Figure 1).

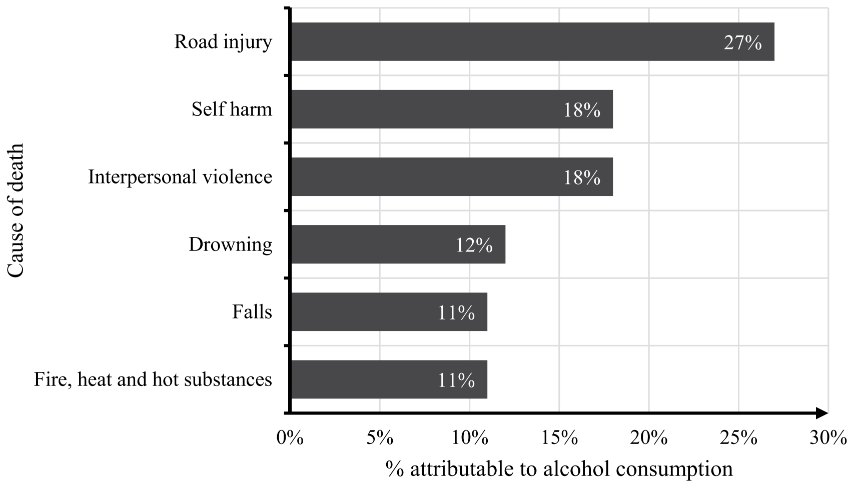


**FIGURE 1** Percentage of different types of traumatic deaths globally that are attributable to alcohol consumption. *Source*: World Health Organization, 2018.

Alcohol consumption is known to be the source of numerous negative externalities. Not only will the death of an intoxicated individual have serious repercussions for their families, but it is often the case with road traffic incidents or fires that they were not the only person killed. Intoxication is thought, for example, to be a contributing factor in around 36% of violent crimes in the United States, and 40% of those in the United Kingdom (Bureau of Justice Statistics, 2010; Office for National Statistics, 2017). These incidents alone inflict a significant cost on society. Victims suffer physical and emotional harm, resulting in lost productivity and large healthcare bills. Perpetrators must be prosecuted, incurring criminal justice expenses. Alcohol intoxication is also associated with numerous other problems, ranging from foetal alcohol exposure and child neglect to property damage and absenteeism (Karriker-Jaffe et al., 2018). In the UK, the annual social cost associated with alcohol consumption was estimated to be £15.4 billion in 2015, equivalent to more than 40% of the country's national defence budget (Gell et al., 2015). Whilst numerous channels have been proposed to explain the link between alcohol and these externalities, we focus on one: alcohol intoxication and changes in overconfidence.

Overconfidence is, itself, associated with welfare losses in a variety of settings. Whilst several definitions exist, it broadly refers to individuals having inflated beliefs about their own ability (see Swift & Moore, 2012 for a discussion). In financial markets, overconfident asset managers trade excessively, leading to higher risk and lower average returns (Daniel & Hirshleifer, 2015) or the formation of asset price bubbles (Scheinkman & Xiong, 2003). Overconfident entrepreneurs also make poor decisions, leading to excess entry into markets, high business failure rates and wasted resources (Camerer & Lovallo, 1999). Within firms, overconfidence can exacerbate moral hazard. CEOs may be slow to react to falling sales, anticipating an upturn that never arrives (Kuang et al., 2015), or may undertake value-destroying mergers (Malmendier & Tate, 2008). Workers may also exert suboptimal effort (Chen & Schildberg-Hörisch, 2019).

What is it about alcohol consumption that leads to, or exacerbates, these problematic behaviours? Three channels are thought to exist, discussed in detail in the next section. First, alcohol has a *psychopharmacological* effect, altering the brain's chemistry. Second, stimuli in the drinking environment may affect individuals' perceptions. Third, society tends to be more forgiving of actions taken under the influence of alcohol, changing individuals' cost/benefit calculus.

We present the results of a pilot lab-in-the-field experiment that adds to all three discussions. Adopting a within-subject design, we recruited participants from the Cardiff University Students' Union bar during a weekly pub quiz event. After taking a breathalyser test, participants completed a series of tasks designed to measure two behavioural traits—cognitive ability and overconfidence bias. This constituted our treatment. The same participants were then invited to a small lab one week later, set up in the same building, where they underwent a similar series of tasks for comparison.

Our contributions are three-fold. First, we confirm the findings of the previous laboratory studies that the psychopharmacological effect of alcohol alone cannot explain behavioural changes. Second, we provide evidence that it is the joint effect of being intoxicated *in a bar* that triggers behavioural change. Third, we find that our participants appear relatively unaware of the true extent of these behavioural changes, suggesting that they cannot be held fully accountable for their actions.

Section 2 places our contribution within the existing literature. Section 3 outlines the experiment in detail and highlights some important ethical constraints. Section 4 discusses our data and outlines our empirical strategy. Section 5 presents our findings. Section 6 concludes. Experimental protocols and additional empirical results are presented in the appendices.

## 2 | ALCOHOL AND BEHAVIOURAL CHANGE

Alcohol consumption is thought to lead to changes in an individual's behaviour through three main channels.[1] The first argues that alcohol has a direct, psychopharmacological effect. Its chemical properties are thought to boost courage or excitability (Fagan, 1993; Pernanen, 1981) and to impair internal inhibitory processes, yielding to aggressive impulses (Bushman, 1997). These changes lead intoxicated individuals to engage in problematic behaviour.

Contrary to this perceived wisdom, several recent laboratory experiments have yielded surprising results (Bregu et al., 2017; Corazzini et al., 2015). Across a broad range of decision-theoretic experiments, intoxication caused no significant behavioural change. We find similar results when restricting attention to our treatment session, supporting this assertion. The authors conjectured that the one thing that they could not vary in a lab—the environment—may also play a role in triggering the changes they expected to find.

There is plenty of support for this conjecture, which represents the second channel through which alcohol consumption is thought to cause behavioural change. Over-crowding, sexual competition (Graham & Homel, 1997), high temperatures (Graham, 1980), inaccessible bar and toilet facilities (Tomsen, 1997), noise levels (Graham & Homel, 1997; Quigley et al., 2003) and competitive games (Graham & Wells, 2001) are all thought to contribute. Our experiment is designed to test this directly, explicitly altering the environment. We find that the first two channels, combined, appear to cause the changes the laboratory experiments expected to observe.

The third channel notes that society tends to be more forgiving of abhorrent behaviour under the influence of alcohol (Fagan, 1990; Gelles & Cornell, 1990). However, this can clearly lead to a self-fulfilling prophecy. Alcohol consumption adjusts the cost/benefit calculus for a rational individual with, for example, a preference for driving dangerously or engaging in violence, by lowering the expected cost (Becker & Murphy, 1988; Markowitz, 2000, 2005; Markowitz & Grossman, 2000; Markowitz et al., 2012). In effect, it can provide them with an excuse to engage in enjoyable, yet anti-social, behaviour.

[1]For a survey see Lipsey et al. (2002).

Given this view, one might ask why society continues to be more forgiving of such behaviour. One response lies in the idea that individuals cannot fully be held responsible for their actions under the influence of alcohol. For this to stand up to scrutiny, a forward-looking rational agent must be either unaware of or, at least, underestimate, how alcohol changes their behaviour. Otherwise, when deciding to consume alcohol, the agent would fully understand the actions it may lead them to take. This line of reasoning has parallels with the multiple selves framework, commonly applied to hyperbolic discounting (O'Donoghue & Rabin, 1999). In settings where individuals are unaware of how their preferences change, it is possible that they inflict so-called "internalities" on their future selves. For example, a young person may choose to systematically under-save, inflicting a cost upon their elderly self. In this case, an individual's intoxicated self may take an action (e.g. drink-driving) that their future, sober self would never endorse. However, it is the future, sober self—effectively a third party—that bears the cost of these actions. We find some merit in this argument. Our participants underestimated the true decline in cognitive ability they experienced in the treatment session and were completely unaware of any increase in overconfidence.

# 3 | EXPERIMENTAL DESIGN

## 3.1 | Overview

Our lab-in-the-field experiment takes a first step towards understanding the roles of intoxication and the environment in triggering behavioural changes. Whilst the design can be applied to a range of individual traits, we focus on two: cognitive ability and overconfidence.

We recruited participants from the Cardiff University Students' Union bar.[2] Whilst this clearly introduces selection bias into our study—our sample only consists of students who chose to visit the bar—two factors may mitigate the associated problems. First, although the results may not extend to the broader population, young adults constitute a group of particular interest to policymakers working in this area. Second, an element of randomness was introduced regarding how intoxicated participants were when they undertook the study. Each experimental session was conducted over several hours, with potential participants approached throughout the evening. Whilst participants were clearly able to determine how much alcohol they consumed over the course of the evening, their level of intoxication in the study reflected how much alcohol they had consumed up to the time that they undertook the experiment. In part, this reflected the time that they were approached. Since all participants were in the bar to take part in the pub quiz, they had all been present at least since the quiz started.[3] Nevertheless, the fact that BAC scores were not truly randomised represents a drawback of our approach relative to laboratory work, and care must thus be taken when comparing our results with those of previous studies.

After being breathalysed, they completed an off-the-shelf, timed overconfidence test. Participants were asked to answer 10 questions from a culture-free IQ test (Raven et al., 2003) without feedback. They were then asked to guess how many questions they answered correctly. Their score in the IQ test provided us with a proxy for their cognitive ability. Comparing their guess to their score provides a

[2]On Thursday evenings in February and March 2018. Thursdays coincided with a regular pub quiz at the Union, which consistently saw around 200 contestants, providing a large pool of subjects from which to draw our sample.

[3]The correlation coefficient between blood-alcohol content score from the breathalyser test in the treatment session and the number of units of alcohol participants reported drinking in an average session was 0.028.

widely used measure of *overconfidence bias* (Danková & Servákta, 2019; Herz et al., 2014; Moore & Healy, 2008).[4]

Participants were invited to attend a second experimental session 1 week later, conducted in a meeting room, mid-afternoon. They were breathalysed again, and took a second, timed overconfidence test. We also elicited their sober beliefs about their intoxicated behaviour, administered a short control survey, and paid them. This second session enabled us to exploit a within design to control for participant heterogeneity.

## 3.2 | Treatment session

Potential participants were approached at random in the Students' Union bar. They were provided with an information leaflet outlining the structure of the study and the payments they would receive, which was discussed with the researcher. Although both sessions involved the same kind of test, we were careful to only refer to 'quiz tasks' and 'prediction tasks' in the leaflet without providing any more details as to their nature. Each participant received £10 for taking part in the study, and up to another £10 based upon their performance in one randomly chosen task in the experiment. The six tasks were explained, and that the payment task would be chosen by the roll of a die at the end of session two. Recent evidence suggests that paying participants for one randomly selected stage of an experiment has a similar effect on their incentives as paying for every stage (Charness et al., 2016) and is more likely to be incentive compatible (Yaron et al., 2018). Breakdowns of potential payments were also provided immediately before each task.

Discussing the information leaflet served two purposes. First, it gave participants a chance to ask questions about the study. Second, it allowed the researcher to determine whether the participant was able to give informed consent (an approach commonly taken in medicine where doubts exist about how much a patient understands). If both parties were satisfied, the researcher talked them through a consent form, which the participant then completed and signed. Anyone considered by the researcher to be unable to provide informed consent (for example, due to severe intoxication) was excluded from the study. The consent form also asked for an email address—the only personal information participants provided while intoxicated. They were then led to the Students' Union foyer, just outside the bar, where several laptop computers had been set up. All stages of the experiment were conducted using z-Tree (Fischbacher, 2007).

After their completed consent forms were double-checked by the researcher, participants undertook an alcohol breath test. This provided a blood alcohol content (hereafter BAC) score, defined as the milligrams of alcohol per litre of breath expelled. So as not to bias their responses, participants were not told their score.

The research design relied upon our ability to link the results for the same participant across two separate sessions, whilst maintaining their anonymity. We devised a system to achieve both aims that was simple, visual, and did not rely on remembering any information. Participants drew a raffle ticket from an urn, providing a unique identification number. Without showing the researcher, they entered this into the computer. They then sealed the ticket in an envelope with their name on it, which was retained by the researcher.

Participants then undertook an off-the-shelf overconfidence test, based on Raven's Standard Progressive Matrices (hereafter SPM, Raven et al., 2003). Each screen presented a pattern, one piece

[4]The term *overconfidence* has also been used to refer to a variety of other cognitive biases (see Fellner & Krügel, 2012 for a review). The sense in which we use it has also been referred to as over-optimism, overestimation or self-enhancement.

of which had been removed. Immediately underneath, several candidates for the missing piece were shown, and the participant was asked to identify which option completed the pattern. The test's relatively simple structure and visual nature reduced the probability that intoxicated participants would become confused by the instructions. The SPMs are designed not to become easier with practice, minimising gains from learning across sessions. Responses were timed.

We first presented two practice questions. After selecting an option, the correct answer was immediately displayed. Participants were then prompted to ask questions if they did not understand any aspect of the test. They were then told that they would have to answer 10 questions and that, if this task was chosen for payment, each correct answer was worth £1. No feedback was given on their performance, and questions became increasingly difficult. Questions were selected from the full 40-question test based upon Bilker et al. (2012), who identified the combinations of questions that best predicted a participant's score in the full test.[5]

Upon completing the test, participants were asked to predict how many questions they answered correctly. If this stage was chosen for payment, a correct prediction would pay £10, and would fall in £1 intervals as their prediction became less accurate. No feedback was provided. We considered introducing a binary lottery procedure but felt that it would likely be too complicated for our intoxicated participants to fully appreciated (certainly relative to the control session). This raised additional concerns about informed consent, which we sought to avoid, and potentially introduced a bias into our results due to participants having a different understanding of the incentive structure between sessions.

This concluded the first session, and participants were told that they would be contacted shortly to organise a second session.

## 3.3 | Control session

The control session was held in a meeting room at the Students' Union on the Thursday afternoon a week after the treatment session. Participants received another information sheet and signed a second consent form. They then underwent a second breath test.

Their sealed envelope was returned, and the participant entered their ticket number into a computer without showing the researcher. This action automatically recalled their responses from the first session.[6] Participants then worked through the experiment. Initially, they reflected upon session one. They were asked to recall their previous prediction regarding the number of correct answers they gave. This provided us with their sober beliefs about their intoxicated *beliefs*. They were asked to provide a new prediction of their session one performance. This provided us with their sober beliefs about their intoxicated *performance*. If this task was chosen for payment, a correct answer to each question would pay £5, falling in 50p intervals as their response became less accurate.

Participants then completed a second, timed overconfidence test under an identical payment structure. They were given two practice SPMs and were then presented with 10 new questions. These also followed Bilker et al. (2012), who identified the combination of questions, excluding those from session one, that best predicted a participant's score in the full test.[7] Participants were then asked to guess their number of correct responses.

Finally, participants were asked to predict the difference in the amount of time they had spent on the SPM questions during each session. If this stage was chosen for payment, a response within 30 s

[5]Questions A11, B5, B12, C4, C12, D7, D12, E1, E5 and E7 were used in the treatment session.

[6]They kept the ticket, so that it would be impossible to identify their responses. Envelopes for those who did not return were destroyed, unopened.

[7]Question A10, B4, B9, C6, C10, D5, D8, E2, E4 and E9 were used in the control session.

of the correct difference would pay £10, falling to £9 for predictions within 60 s, to £8 for predictions within 90 s etc.

After answering a series of control questions, participants were shown their results and how they translated into payments. They were then prompted to inform the researcher that they were finished. They had completed six tasks: (i) session one test; (ii) session one prediction; (iii) reflection at the start of session two; (iv) session two test; (v) session two prediction; and (vi) prediction about the amount of time taken. The researcher provided a die, which they rolled to determine which task they would be paid for. Payments were made immediately in cash.

### 3.4 | Ethical considerations

The nature of our study required that we take several steps to ensure we maintained the highest ethical standards. First, it was felt that it would be unethical to explicitly encourage participants to go to a bar to consume alcohol for the sake of our treatment session. This dictated that we recruit individuals who were already drinking in the bar. Not only did this have introduce potential selection bias into our sample, but it also precluded a full factorial design.

Protocols for acquiring and maintaining informed consent were also influenced by the fact that our participants were initially intoxicated. In addition to excluding individuals who the researchers were not convinced were able to provide consent in the treatment session, our experimental programme asked participants to reaffirm their consent at the start of each task. If they did not do so, the experiment ended immediately, without the experimenter knowing why. Participants who returned for the control session were provided with a second information leaflet, and asked to complete a second consent form, so we could be sure that all those who formed our sample gave consent whilst not under the influence of alcohol. We were careful to request the minimum amount of information during the treatment session needed to arrange attendance at the control session—a name and email address—to again ensure the consent was truly informed.

Finally, it was considered unethical to pay individuals at the end of the treatment session when they were about to return to the bar. In previous laboratory experiments, participants were asked to wait after the conclusion of the experiment so that the effects of alcohol could leave their systems before receiving payment. This was infeasible in the field, as it would have made recruiting participants all but impossible. Instead, all payments were made at the end of the control session. This obviously introduced a delay into the incentive structure of the treatment session, and also meant that those who withdrew consent between sessions did not receive any payment. Participants were made aware of this in the information leaflet.

Our study received approval from the Cardiff Business School Research Ethics Committee on 17$^{th}$ July 2017.

## 4 | DATA AND ESTIMATION

### 4.1 | Data

Over six weeks, we recruited 140 individuals, of whom 106 (76%) returned for the control session. This latter group forms our sample. As we did not ask control questions at the end of the treatment session due to concerns about consent, it is difficult to say whether our study suffers from attrition bias. We checked for difference in participant scores (overall and by question), BAC score and time

**TABLE 1** Descriptive statistics.

| | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|
| Personal characteristics | | | | |
| Age (years) | 20.67 | 2.54 | 18 | 31 |
| Is female | 0.34 | 0.48 | 0 | 1 |
| Body Mass index (BMI) | 23.41 | 3.74 | 10.01 | 38.62 |
| Is white | 0.87 | 0.34 | 0 | 1 |
| Holds a degree | 0.34 | 0.48 | 0 | 1 |
| Lifestyle | | | | |
| Is single | 0.57 | 0.50 | 0 | 1 |
| Drinks frequently (three or more times per week) | 0.42 | 0.50 | 0 | 1 |
| Average units of alcohol per session | 8.88 | 5.76 | 2 | 35 |
| Smokes | 0.25 | 0.44 | 0 | 1 |
| Experimental results | | | | |
| Treatment session | | | | |
| Blood alcohol content (BAC) | 0.36 | 0.24 | 0 | 1.42 |
| Score in Raven's SPM task (out of 10) | 6.60 | 1.69 | 1 | 10 |
| Prediction of treatment session score | 7.06 | 1.55 | 2 | 10 |
| Time taken (seconds) | 251.25 | 100.13 | 85.88 | 721.28 |
| Control session | | | | |
| Blood alcohol content (BAC) | 0.00 | 0.00 | 0.00 | 0.19 |
| Score in Raven's SPM task (out of 10) | 8.56 | 1.37 | 4 | 10 |
| Prediction of control session score | 7.80 | 1.38 | 4 | 10 |
| Time taken (seconds) | 236.02 | 86.76 | 100.31 | 500.23 |
| Prediction of treatment session score | 6.45 | 1.91 | 2 | 10 |
| Prediction of treatment session prediction | 6.49 | 1.84 | 2 | 10 |

taken (overall and by question) in the treatment session between those who continued and those who dropped out. The only significant difference related to responses to question nine. As such, we have no clear evidence to suggest that attrition bias is a concern.

Sample descriptive statistics are presented in Table 1. Most of the participants were white, male, and single. Most drink frequently (defined as at least three times per week), and report consuming an average of 8.88 units of alcohol on each occasion. This is equivalent to one bottle of wine. Around 25% were smokers.

The BAC score has been criticised for being more reflective of how much alcohol an individual has recently consumed than their true level of intoxication. Individuals with different body shapes, for example, could consume the same amount of alcohol and suffer different levels of intoxication. To control for this, we calculated participants' body mass index (BMI) from control questions about their height and weight.[8] Those with a higher BMI tend to be more heavily built and are less affected by alcohol on average than those with a lower BMI. Similarly, individuals who had recently consumed

[8]Three participants did not provide answers to these control questions that enabled us to calculate their BMI. Where BMI is included as an explanatory variable in the upcoming regressions, the smaller sample size reflects this.

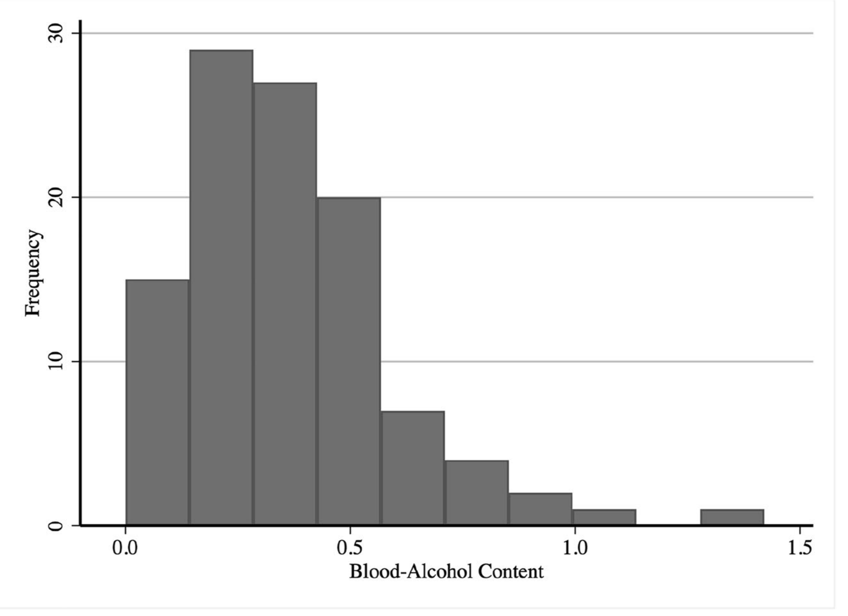


**FIGURE 2** Histogram of blood-alcohol content in the treatment session.

a strong spirit may present a higher BAC score due to residual alcohol in their mouth.[9] The delay between leaving their table, arriving at the laptops, having their consent form double-checked by the researcher, having the breathalyser test explained and then providing a reading will have gone some way to alleviating this possibility.

In the treatment session, the average BAC score was 0.36 mg of alcohol per litre of breath expelled. Further details are provided in Figure 2, which presents a histogram of BAC scores in the treatment session. This illustrates the substantial variation in BAC scores between participants. Seven percent of the sample had BAC scores of zero, indicating that they had not consumed alcohol at the time they undertook the tests. Forty-five percent had scores above the UK drink-driving limit of 0.35. More generally, the coefficient of variation of BAC scores during the treatment session is 67%.

Our average participant got 6.60 questions correct out of 10. They were slightly overconfident, believing that they got 7.06 questions correct.

In the control session, only two participants recorded positive BAC scores. Participants got an average of two more questions correct. They also predicted a higher average score than session one, suggesting that they understood that intoxication was likely to lower their ability. However, in contrast to session one, participants tended to be pessimistic about their performance. Participants also reflected on their session one performance. They believed that their average score was 6.45 and that their average prediction at the time was 6.49 (it was 7.06).

## 4.2 | Estimation of behavioural changes

The aim of the experiment is to assess the determinants of changes in two behavioural variables. We proxy for the first, ability, with the participant's score in each session. Whilst this variable's

[9]This was kindly pointed out by an anonymous referee, for which we are very grateful.

interpretation requires care, the experiment is designed to control for alternatives. It could reflect differences in the difficulty of the two tests. Raven's SPMs are divided into five banks, labelled A to E, of increasing difficulty. Within each bank, question difficulty is designed to be broadly comparable. Both tests drew one question from bank A, two each from banks B, C and D, and three from bank E, reducing the variation in difficulty between them.[10]

Differences in score could reflect learning. Whilst impossible to remove entirely, we take several steps to reduce opportunities for learning. Firstly, our information leaflet made no reference to Raven's SPMs. This limited their ability to practice between sessions. Secondly, participants receive no feedback until the end of session two. Thirdly, we impose an interval of 1 week between sessions. Fourthly, we provide participants with practice questions at the start of each session, so they are familiar with the test format before they start. Fifthly, Raven's SPMs have a very simple structure and are designed not to become easier with practice.

For the second behavioural variable, we make use of a standard measure of overconfidence bias[11]:

$$Over_{is} = E_{is}\left(Score_{is}\right) - Score_{is},$$

where $i = 1, \ldots, 106$ and $s = C, T$ denote the individual and session respectively, and $E_{is}$ is defined as participant $i$'s expectation operator in session $s$. $E_{is}$ $(Score_{is})$ is thus participant $i$'s prediction in session $s$ about their score in that session. If $Over_{is} > 0$, participant $i$ is *overconfident*. Their prediction exceeds their actual performance; they think they are more capable than they are. Conversely, if $Over_{is} < 0$, they are *underconfident*. Comparing across individuals, if $Over_{is} > Over_{js}$ then $i$ is more overconfident than $j$. Similarly, if $Over_{iT} > Over_{iC}$ then $i$ was more overconfident in the treatment session than the control session.

There are alternative measures of overconfidence bias that we could have employed. For example, we could have measured overconfidence as a percentage of score. We did not adopt this because participants tended to perform worse in session one than session two. Suppose that a participant predicted six correct answers in session one, but only got five. In session two, they predicted nine correct answers, but only got eight. According to our measure, they are equally overconfident in both sessions. However, using a percentage measure, their percentage overconfidence declines from 20% to 12.5%. Our measure is more restrictive, reducing the likelihood that we find any significant differences in overconfidence between sessions. We nevertheless re-ran our results employing this alternative measure as a robustness check. The overall picture was the same.

Figure 3 displays kernel density plots for both behavioural variables in treatment (dashed line) and control (solid line) sessions. Panel (a) focuses on score. Participants did not perform as well during the treatment session as during the control session, with the density estimates skewed to the right. The density estimate is also much more spread out during the treatment session. In part, this could reflect the variations in BAC shown in Figure 2.

Panel (b) focuses on overconfidence bias, as defined by $Over_{is}$. A similar pattern emerges. Whilst participants were more overconfident during the treatment session, there was also a greater spread in the difference between their perceived and actual performance.

[10]As noted by one of the anonymous referees, question banks were not randomised. This may lead to some residual difference in difficulty between sessions. Nevertheless, we are confident that that the control session questions were so much easier that it could explain the average of two additional correct responses out of 10 we observed in that session. We thank the referee for pointing this out.

[11]See, for example, Hameresh (1985) or Clark and Friesen (2009) for other uses of the difference between predicted and actual values as a measure of overconfidence.

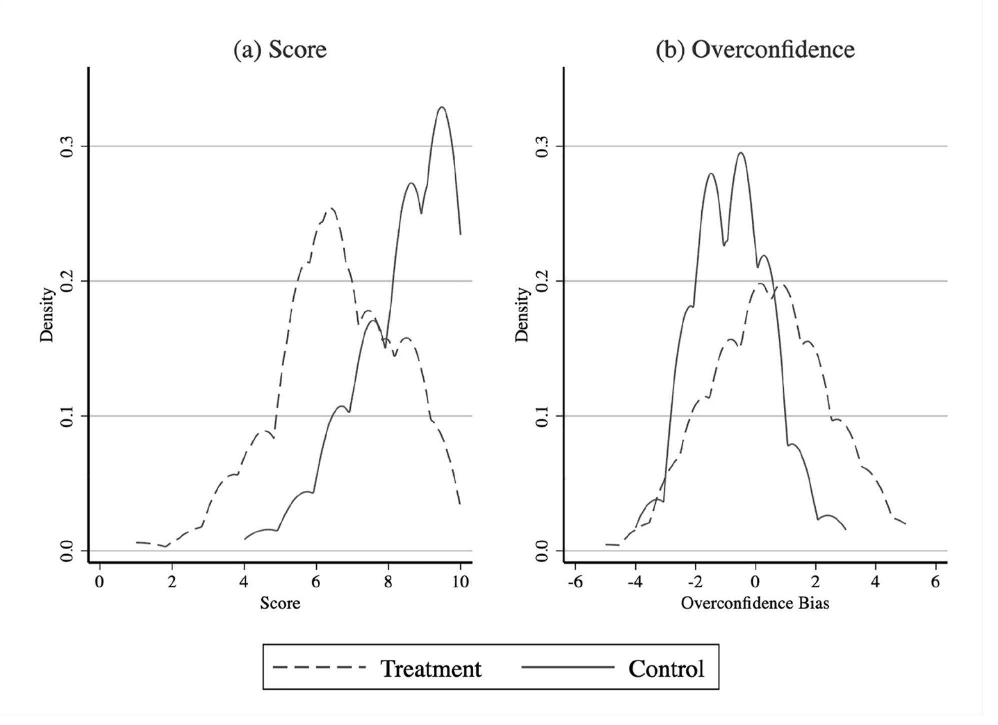


**FIGURE 3** Kernel density plots for participant score and overconfidence bias.

We aim to understand how the combination of alcohol consumption and being in a drinking environment affect our two variables of interest: $y_{is} \in \{Score_{is}, Over_{is}\}$. Suppose that the data generating process has the following form:

$$y_{is} = \beta_0 + \beta_1 (bar \times BAC)_{is} + x_i'\gamma + \varepsilon_{is}, \quad (1)$$

where $bar_{is}$ is an indicator variable which takes value 1 when the participant is in the treatment environment, $BAC_{is}$ is the participant's blood alcohol content score, $x_i$ is a vector of individual controls and $\varepsilon_{is}$ is an i.i.d. error. This is a similar structure to that employed by previous studies but incorporates the conjecture that the drinking environment also alters behaviour. $\beta_1$ represents the marginal effect of intoxication, conditional on being in the treatment environment.

We attempt to identify the effect of being intoxicated in the drinking environment on our behavioural variables of interest by employing two separate strategies. First, we undertake pooled OLS regressions to estimate (1). Second, we take advantage of our within-subject design, employing a difference estimator to control for individual heterogeneity:

$$\Delta y_i = \beta_1 \Delta(bar \times BAC)_i + \Delta\varepsilon_i,$$

where $\Delta z_i = z_{iT} - z_{iC}$ is the increase in the variable in the treatment session relative to the control session. Noting that $bar_{iT} = 1$ and $bar_{iC} = 0$, this simplifies to:

$$\Delta y_i = \beta_1 \, BAC_{iT} + \Delta\varepsilon_i. \quad (2)$$

The effect of the drinking environment is thus the expected change in our behavioural variables, conditional on intoxication. We also include controls to rule out alternative explanations for the change in behaviour:

$$\Delta y_i = \beta_1 \; BAC_{iT} + x_i\text{'}\zeta + \Delta\varepsilon_i. \tag{3}$$

Whilst our experiment has the potential to exploit the random variation in levels of intoxication across participants in the treatment session to identify both the effects of intoxication and the environment, we are mindful that our two explanatory variables of interest are covariates. Although we randomised the time at which each participant took the test, thereby implicitly randomising their level of intoxication, BAC was higher in the treatment session than the control session. Ethical and budgetary considerations made a full factorial design infeasible, and so we err on the side of caution when interpretating the experimental results, focussing on their joint effect.

We previously noted that whether individuals understood the behavioural changes while sober had potentially important policy implications. A fully aware individual would be deterred from going out drinking by, for example, a more severe sanction for drink-driving. An unaware individual would reason that, since they their sober self would never consider drink-driving, the introduction of a more severe sanction should not influence their drinking behaviour.

We exploit the participant beliefs elicited in the control session about their treatment session performance to decompose their behavioural changes into expected and unexpected (denoted by $U$) components. For each $y_{is} \in \{Score_{is}, Over_{is}\}$, we split $\Delta y_i$ into:

$$\Delta y_i = E_{iC}(\Delta y_i) + \Delta y_i^U, \tag{4}$$

where, again, we define $E_{is}$ to be participant $i$'s expectation operator in session $s$. An individual who is fully aware of the combined effect that intoxication and the environment has on their behaviour correctly anticipates their behavioural change: $\Delta y_i = E_{iC}$ $(\Delta y_i)$. Conversely, an individual who is completely unaware of the effects of being intoxicated in a bar does not anticipate any behavioural changes: $E_{iC}$ $(\Delta y_i) = 0$ and so $\Delta y_i = \Delta y_i^U$

We construct the expected components of the two behavioural changes in the following way. In the control session ($s = C$) we asked participants how many questions they believe that they got correct in both sessions. These predictions are $E_{iC}$ $(Score_{iT})$ and $E_{iC}$ $(Score_{iC})$ for treatment and control sessions respectively. Comparing their treatment session self to their control session self, they thus expect a change in score of:

$$E_{iC}(\Delta Score_i) = E_{iC}(Score_{iT}) - E_{iC}(Score_{iC}). \tag{5}$$

Deriving a participant's expected change in overconfidence is slightly more complicated. It requires that we know not only participant $i$'s control session beliefs about $Score_{iT}$, but also their beliefs about what the prediction they made in the treatment session, $E_{iT}$ $(Score_{iT})$. If, in the control session, they believe that $E_{iT}$ $(Score_{iT}) > Score_{iT}$, this indicates that they believe that they were overconfident in the treatment session. The larger the difference, the larger the expected overconfidence. Since, by definition, participants do not believe that they are currently overconfident this difference is also the expected change in overconfidence.

In the control session, we elicited what participants believed they had predicted in the treatment session; call it $E_{iC}$ $[E_{iT}$ $(Score_{iT})]$. This is an expectation of an expectation; the number of questions control session participant $i$ now believes that their treatment session self expected they had got correct. We then more formally define:

$$\begin{aligned} E_{iC}(\Delta Over_i) &= E_{iC}(Over_{iT}) - E_{iC}(\text{Over}_{iC}) \\ &= \{E_{iC}[E_{iT}(Score_{iT}) - Score_{iT}]\} - \{E_{iC}[E_{iC}(Score_{iC}) - Score_{iC}]\} \\ &= \{E_{iC}[E_{iT}(Score_{iT})] - E_{iC}(Score_{iT})\} - \{[E_{iC}(Score_{iC}) - E_{iC}(Score_{iC})]\} \\ &= E_{iC}[E_{iT}(Score_{iT})] - E_{iC}(Score_{iT}). \end{aligned} \tag{6}$$

Unexpected components are then calculated as the difference between the true and the expected changes: $\Delta y_i^U = \Delta y_i — E_{iC}(\Delta y_i)$.

# 5 | RESULTS

## 5.1 | Ability

Table 2 presents evidence in support of the results from previous laboratory experiments, by focussing purely on the effect of intoxication on participants' score whilst holding the environment constant (in this case, in the students' union bar). As with previous studies, whilst the coefficient on BAC is negative across all specifications, intoxication has no significant effect on score at the margin.

We control for possible differences in intoxication between participants with the same BAC due to body shape by including their BMI. Having a degree is included to control for intrinsic ability.

**TABLE 2** Treatment session regressions of score on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Score | | | | | | |
| BAC | −0.439 | −0.362 | −0.514 | −0.572 | −0.624 | −0.548 |
| | (0.659) | (0.655) | (0.621) | (0.627) | (0.606) | (0.607) |
| BMI | | 0.025 | | | | 0.024 |
| | | (0.044) | | | | (0.042) |
| Has a degree | | | −0.925** | −0.989*** | −0.926** | −0.858** |
| | | | (0.357) | (0.370) | (0.368) | (0.371) |
| Single | | | | −0.277 | −0.277 | −0.330 |
| | | | | (0.333) | (0.336) | (0.340) |
| ln(time taken) | | | | | 0.779* | 0.732* |
| | | | | | (0.393) | (0.400) |
| Constant | 6.763*** | 6.187*** | 7.104*** | 7.304*** | 3.052 | 2.751 |
| | (0.295) | (1.126) | (0.283) | (0.359) | (2.224) | (2.503) |
| Observations | 106 | 103 | 106 | 106 | 106 | 103 |
| $R^2$ | 0.004 | 0.005 | 0.072 | 0.078 | 0.110 | 0.101 |
| $p$-value | 0.507 | 0.668 | 0.022 | 0.042 | 0.019 | 0.062 |
| Log-likelihood | −205.226 | −198.468 | −201.489 | −201.130 | −199.261 | −193.263 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 3 Pooled regressions of score on *bar* × *BAC*.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Score | | | | | | |
| *bar* × *BAC* | −3.092*** | −3.055*** | −3.113*** | −3.150*** | −3.215*** | −3.167*** |
| | (0.448) | (0.456) | (0.456) | (0.456) | (0.449) | (0.456) |
| BMI | | 0.035 | | | | 0.032 |
| | | (0.035) | | | | (0.034) |
| Has a degree | | | −0.553* | −0.641** | −0.602* | −0.536* |
| | | | (0.299) | (0.312) | (0.313) | (0.312) |
| Single | | | | −0.387 | −0.399 | −0.461* |
| | | | | (0.268) | (0.268) | (0.266) |
| ln (time taken) | | | | | 0.589* | 0.464 |
| | | | | | (0.322) | (0.328) |
| Constant | 8.141*** | 7.328*** | 8.333*** | 8.588*** | 5.401*** | 5.342*** |
| | (0.147) | (0.855) | (0.152) | (0.217) | (1.807) | (1.864) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| $R^2$ | 0.178 | 0.180 | 0.199 | 0.210 | 0.224 | 0.220 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −406.281 | −392.292 | −403.559 | −402.143 | −400.185 | −387.180 |

Standard errors in parentheses $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Whilst this is significant, it is also negative, suggesting that having a degree reduces participants' average score. Having a degree did not significantly affect the amount of time participants spent on the tasks, suggesting that the payment structure was equally salient. Indeed, there was no significant difference between the scores of those with/without a degree in the control session. Similarly, there was no significant difference in BAC scores during the treatment session. However, those without a degree reported consuming alcohol significantly more frequently and consuming significantly more units each time they did. As such, we interpret this result as those with a degree being more affected by a given BAC than those without, due to a lower tolerance for alcohol. We also control for participants' relationship status, and the amount of time they spent on the Raven's SPM task.

We finally examined whether intoxication could have a nonlinear effect on score, by including interactions between BAC and BMI, higher-order polynomial terms for BAC and by replacing BAC with dummy variables. The results were unchanged. Regressions with dummy variables are presented in the appendix.

Table 3 starts to take the environment into account. It presents pooled OLS results, incorporating data from the control session and clustering standard errors at the participant level. The coefficient on BAC now has a slightly different interpretation. Our coefficient of interest now has a different interpretation. Since BAC and the treatment session were covariates, we instead consider their interaction, *bar* × *BAC*. It thus provides the combined effect of intoxication and being in a bar on participants' score in the Raven's SPM task. Since the vast majority of participants registered a BAC score of zero in the control session, the results would be almost identical if we instead continued to use BAC.[12]

In contrast to Table 2, our results now appear highly significant and robust. Relative to being sober in the control environment, the average participant (whose BAC is 0.36) gets one fewer question

[12]Results using *BAC* instead of *bar* × *BAC* are presented in Tables A1 and A2 in the appendix as a robustness check.

TABLE 4 Within-participant regressions of score on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ΔScore | | | | | | |
| Δ(*bar* × *BAC*) | −3.984*** | −4.022*** | | −3.150*** | −2.978*** | −2.151*** |
| | (0.509) | (0.518) | | (0.542) | (0.555) | (0.683) |
| Δln(time taken) | | 0.416 | 0.353 | 0.438 | 0.625 | 0.629 |
| | | (0.515) | (0.551) | (0.445) | (0.452) | (0.446) |
| Δ(*BAC* × *BMI*) | | | −0.165*** | | | |
| | | | (0.022) | | | |
| Has a degree | | | | −1.389*** | −1.310*** | −1.274*** |
| | | | | (0.320) | (0.324) | (0.313) |
| Smoke | | | | | −0.658* | −0.349 |
| | | | | | (0.375) | (0.391) |
| Drinks frequently | | | | | | 0.273 |
| | | | | | | (0.335) |
| Average units | | | | | | −0.068*** |
| | | | | | | (0.022) |
| Observations | 106 | 106 | 103 | 106 | 106 | 106 |
| $R^2$ | 0.464 | 0.467 | 0.442 | 0.547 | 0.561 | 0.591 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −216.093 | −215.751 | −212.430 | −207.198 | −205.474 | −201.759 |

Standard errors in parentheses $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

correct when they have been drinking in the bar. This provides the first evidence in support of the conjecture put forward by the authors of previous lab studies, namely that changes in the environment are important in explaining observed behavioural changes when individuals consume alcohol.

Table 4 takes advantage of our experimental design to present within-participant estimates of the joint effect of alcohol consumption and the bar environment on participants' score. GLS regressions yielded very similar results and are presented in the appendix. The joint effect of being intoxicated in a drinking environment is, once again, always significant. Column 2 controls for differing opportunity costs of time by including the difference in the log of the time participants took to complete the test. Column 3 replaces $\Delta(bar \times BAC)_i$ with $\Delta(BAC \times BMI)_i$, allowing for the possibility that the same BAC can lead to different levels of intoxication for participants with different body shapes. All our results were robust to this alternative measure of intoxication. We did not include both measures simultaneously as they were highly collinear (with a correlation coefficient of 0.949).

Table 4 also sheds light on the surprising result that having a degree is associated with lower ability. It appears that those with a degree did significantly worse in the bar relative to their baseline (column 4). Whilst their score during the control session was slightly higher than those without a degree, their poorer performance in the treatment session resulted in an overall negative coefficient in Table 2.

Tables Table 3 and Table 4 present a relatively consistent picture. It is the joint impact of alcohol consumption and the environment, rather than intoxication per se, that is correlated with declines in cognitive ability. Depending upon the specification, our average participant answered between 0.77 and 1.45 fewer SPMs correctly during the treatment session. Whilst there is variation in the magnitude of the coefficient on $(bar \times BAC)_{is}$, perhaps due to constraints resulting from the pilot nature of the study, our results nevertheless present early evidence in favour of the hypothesis put forward by lab experiments that suggest that intoxication alone cannot explain the changes in behaviour that are commonly observed when people consume alcohol.

## 5.2 | Overconfidence

We now turn attention to our principal potential behavioural change: overconfidence bias. This is represented by the difference between the number of Raven's SPMs each participant believes they got correct and their actual number of correct answers:

$$Over_{is} = E_{is}(Score_{is}) - Score_{is},$$

where a larger number represents a greater bias.

Table 5 replicates Table 2, showing the marginal impact of an increase in blood-alcohol content on participants' biases. Controlling for the environment by only considering responses in the treatment session, intoxication appears to have no significant effect on how overconfident individuals are. Whilst the coefficient on BAC is always positive, it equates to at most a 0.12 increase in the difference between the average participant's expected and actual number of correct responses. As with cognitive ability, this is in line with results from laboratory experiments. Having a degree or being single are both significant predictors of overconfidence.

Table 6 includes data from the control session, reporting pooled OLS results across our entire sample. Standard errors are clustered at the participant level. Again, accounting for the environment

**TABLE 5** Treatment session regression of overconfidence on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Overconfidence | | | | | | |
| BAC | 0.021 | 0.050 | 0.106 | 0.273 | 0.323 | 0.359 |
| | (0.674) | (0.684) | (0.685) | (0.677) | (0.694) | (0.708) |
| BMI | | −0.012 | | | | −0.014 |
| | | (0.072) | | | | (0.071) |
| Has a degree | | | 1.041** | 1.225*** | 1.165*** | 1.095*** |
| | | | (0.415) | (0.387) | (0.400) | (0.400) |
| Single | | | | 0.796** | 0.796** | 0.876** |
| | | | | (0.351) | (0.356) | (0.363) |
| ln(time taken) | | | | | −0.743 | −0.661 |
| | | | | | (0.503) | (0.509) |
| Constant | 0.445 | 0.722 | 0.061 | −0.513 | 3.542 | 3.388 |
| | (0.305) | (1.672) | (0.304) | (0.350) | (2.825) | (3.279) |
| Observations | 106 | 103 | 106 | 106 | 106 | 103 |
| $R^2$ | 0.000 | 0.001 | 0.065 | 0.104 | 0.126 | 0.122 |
| *p*-value | 0.975 | 0.984 | 0.042 | 0.000 | 0.000 | 0.002 |
| Log-likelihood | −220.295 | −213.831 | −216.738 | −214.463 | −213.148 | −207.147 |

Standard errors in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

TABLE 6 Pooled regressions of overconfidence on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Overconfidence | | | | | | |
| *bar × BAC* | 1.796*** | 1.781*** | 1.823*** | 1.889*** | 1.951*** | 1.931*** |
| | (0.479) | (0.492) | (0.490) | (0.485) | (0.491) | (0.503) |
| BMI | | −0.003 | | | | −0.001 |
| | | (0.043) | | | | (0.041) |
| Has a degree | | | 0.710** | 0.865*** | 0.829*** | 0.758*** |
| | | | (0.287) | (0.272) | (0.275) | (0.274) |
| Single | | | | 0.684*** | 0.695*** | 0.770*** |
| | | | | (0.249) | (0.249) | (0.250) |
| ln(time taken) | | | | | −0.558* | −0.464 |
| | | | | | (0.319) | (0.325) |
| Constant | −0.477*** | −0.387 | −0.723*** | −1.174*** | 1.847 | 1.369 |
| | (0.142) | (1.002) | (0.164) | (0.201) | (1.772) | (1.954) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| $R^2$ | 0.063 | 0.063 | 0.099 | 0.134 | 0.148 | 0.146 |
| *p*-value | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −414.780 | −401.231 | −410.611 | −406.422 | −404.735 | −391.655 |

Standard errors in parentheses $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

has a substantial impact upon the results. Across all specifications, the coefficient on $(bar \times BAC)_{is}$ is positive and highly significant suggesting that the combination of alcohol consumption and being in a bar causes individuals' behaviour to change. Again, pooled OLS estimations that use *BAC* instead of *bar* × *BAC* and GLS estimations are presented in the appendix, exhibiting a very similar pattern.

Table 7 fully exploits the experimental design, presenting within-participant estimates of the joint effect of alcohol consumption and being in a drinking environment on overconfidence. The results are consistent with Table 6. The coefficient on $\Delta(bar \times BAC)$ is highly significant across all specifications, suggesting that the average participant's overconfidence bias was between 0.52 and 0.92 higher because of consuming alcohol in the bar. The result is robust when controlling for body shape (column (3)), education (columns (4)-(6)) or lifestyle characteristics (columns (5) and (6)).

## 5.3 | Awareness of behavioural changes

The results of the previous two subsections are indicative of alcohol consumption and being in a bar combining to cause behavioural changes. Of keen interest to policymakers is whether these changes are anticipated. If they are, then introducing policies that adjust the costs and benefits of the various negative behaviours commonly associated with intoxication will likely prove effective. Individuals will factor them when deciding whether to visit a bar. If they are unanticipated, then reducing problematic behaviour may prove more challenging. In the extreme, any attempt to impose, for example, additional penalties on being drunk and disorderly will not be incorporated into individuals' thinking when deciding whether to visit a bar. Unaware of their behavioural changes, they will not expect their intoxicated self to engage in the type of activities that would lead to them incurring a penalty.

TABLE 7 Within-participant regressions of overconfidence on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ΔOverconfidence | | | | | | |
| Δ(*bar* × *BAC*) | 2.515*** | 2.557*** | | 1.920*** | 1.828*** | 1.444*** |
| | (0.432) | (0.438) | | (0.439) | (0.452) | (0.523) |
| Δln(time taken) | | −0.449 | −0.419 | −0.465 | −0.565 | −0.567 |
| | | (0.574) | (0.606) | (0.546) | (0.544) | (0.544) |
| Δ(*BAC* × *BMI*) | | | 0.104*** | | | |
| | | | (0.019) | | | |
| Has a degree | | | | 1.014** | 0.972** | 0.942** |
| | | | | (0.403) | (0.407) | (0.401) |
| Smoke | | | | | 0.354 | 0.270 |
| | | | | | (0.372) | (0.444) |
| Drinks frequently | | | | | | −0.448 |
| | | | | | | (0.370) |
| Average units | | | | | | 0.046** |
| | | | | | | (0.022) |
| Observations | 106 | 106 | 103 | 106 | 106 | 106 |
| $R^2$ | 0.229 | 0.234 | 0.218 | 0.286 | 0.291 | 0.311 |
| $p$-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −224.089 | −223.747 | −219.114 | −219.997 | −219.611 | −218.134 |

Standard errors in parentheses $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

TABLE 8 Awareness of behavioural changes $t$-tests.

| Null hypothesis | $N$ | $t$-Statistic | $p$-Value |
|---|---|---|---|
| $E_{iC}\,(\Delta Score_i) = 0$ | 106 | −7.6504 | 0.0000 |
| $\Delta Score_i^U = 0$ | 106 | −2.7326 | 0.0037 |
| $E_{iC}\,(\Delta Over_i) = 0$ | 105 | 0.3577 | 0.3606 |
| $\Delta Over_i^U = 0$ | 105 | 5.6950 | 0.0000 |

The appropriate magnitude of any penalties arguably also depends upon how aware individuals are of likely changes in behaviour. This is reflected in current legal practice, where intoxication is viewed as a mitigating factor in some criminal cases (e.g. violent behaviour; Fagan, 1990; Gelles & Cornell, 1990) but not others (e.g. drink-driving). In the classical multiple-selves framework (O'Donoghue & Rabin, 1999), an individual who does not appreciate that their preferences can change can inflict an externality upon themselves (a so-called "internality"), by failing to take into account how their future self will evaluate costs and benefits when making a decision.

Table 8 presents the results of several preliminary $t$-tests. The first two provide evidence of partial awareness of changes in ability. First, we check whether participants expect any change in ability using (5). Participants expected a significant decline in score during the treatment session relative to the control session, to 6.45 from 7.80 (a perceived fall of 1.35 marks). Second, we see whether any expected change is an accurate reflection of the true change in ability using (4) to calculate the residual, unanticipated change. Whilst participants were correct in anticipating a fall in score, they systematically underestimated its size. In truth, participants' average scores in treatment and control sessions were 6.60 and 8.56 respectively (an actual fall of 1.95 marks). We therefore conclude that they were partially aware of this first channel.

The next two rows perform identical tests for overconfidence. The average of the expected increase in overconfidence given by (6) is not significantly different from zero. Participants did not anticipate any additional overconfidence as a result of consuming alcohol in the bar. Of course, our regression results indicate that overconfidence did, in fact, increase. This suggests that participants are unaware of this change in their behaviour and are thus unlikely to take it into account when making decisions ex ante.

## 6 | CONCLUSIONS

The channels through which alcohol consumption cause changes to individuals' behaviour have important implications for policy. We present new evidence from a pilot experimental study. We find that, in line with previous laboratory studies, psychopharmacological effects of alcohol appear insufficient to explain changes in cognitive ability or overconfidence. However, when combined with a change of environment from a lab setting to a bar, intoxication does have a significant effect. Being in a bar and having a higher blood alcohol content score was correlated with lower cognitive ability and greater overconfidence.

The within-subject design of our experiment also enabled us to begin to unpick the extent to which individuals were aware of the behavioural changes they undergo. Early results suggest that, whilst participants expected a decline in cognitive ability, they underestimated its extent. They anticipated no increase in overconfidence. This is consistent with the legal viewpoint of intoxication as a mitigating factor. When deciding to consume alcohol, individuals are not fully cognisant of the implications. They are therefore unable to weigh up the costs and benefits optimally, resulting in so-called negative internalities.

Although preliminary, our results hint at several avenues to consider when designing policy to reduce the social cost of alcohol consumption. First, a flat rate of tax on all drinks with a given alcoholic content may not be optimal. Instead, one should also consider the venue in which the drinks are consumed. Second, a punitive approach to deterring problem behaviour associated with alcohol may be less effective than a more proactive approach. If individuals systematically underestimate alcohol's effect, then they will also underestimate the likelihood of being sanctioned. To be effective, relatively large sanctions are required. Third, any sanctions should be balanced against an appreciation of how much a sober individual can be held accountable for their intoxicated self's actions. Since a sober individual may be incapable of anticipating the actions of their intoxicated self, it is possible for negative internalities to arise.

Our analysis suffers several shortcomings. The sample size reflects the pilot nature of our study and places clear constraints on our results. We were also unable to implement a full factorial design due to ethical concerns. Although we could have set up a daytime treatment session in a bar, this would have substantially reduced the external validity of our results. Whilst we identify that the bar environment is important, we cannot say which features of that environment drive behavioural changes. As noted in the literature review, many easily measurable aspects have been suggested, from noise levels to temperature.

Our small sample size also necessarily limited the range of behavioural tests we could feasibly perform. Ideally, we would have sought to randomly allocate participants to tests of different behavioural parameters, such as risk aversion. Unfortunately, it was felt that participants would be unwilling to leave their quiz teams for long enough to conduct multiple tests, and so we chose to focus on Raven's SPMs as it enabled us to capture two behavioural parameters whilst ensuring a large enough sample for our analysis.

That we observe behavioural changes between sessions raises the question of how changes in, for example, risk aversion might influence our results. If intoxication was to reduce risk aversion, we may see a similar pattern of predictions to those we observe. Becoming less risk averse would encourage participants to make bolder predictions during the treatment session. In turn, this would lead to higher apparent overconfidence. Whilst we could have adopted a binary lottery procedure to control for this, it was felt that it may be too complex for our intoxicated participants to understand during the treatment session, introducing a different bias into the results. Nevertheless, changes in risk aversion would still represent a behavioural change, linked to the interaction of alcohol intoxication and the environment.

Future work will incorporate measurement of various environmental factors, along with a broader battery of behavioural tests (risk aversion, aggression, altruism, discounting etc.) enabling us to control explicitly for these potentially confounding factors.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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## APPENDIX A: FURTHER RESULTS

### A.1 | Pooled OLS regressions with BAC instead of bar × BAC

TABLE A1 Pooled regressions of score on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Score | | | | | | |
| *BAC* | −3.102*** | −3.029*** | −3.121*** | −3.159*** | −3.214*** | −3.135*** |
| | (0.455) | (0.453) | (0.462) | (0.463) | (0.456) | (0.453) |
| BMI | | 0.036 | | | | 0.033 |
| | | (0.035) | | | | (0.034) |
| Has a degree | | | −0.551* | −0.639** | −0.601* | −0.540* |
| | | | (0.298) | (0.311) | (0.312) | (0.312) |
| Single | | | | −0.387 | −0.399 | −0.456* |
| | | | | (0.267) | (0.267) | (0.266) |
| ln(time taken) | | | | | 0.567* | 0.449 |
| | | | | | (0.323) | (0.331) |
| Constant | 8.148*** | 7.308*** | 8.338*** | 8.594*** | 5.519*** | 5.397*** |
| | (0.147) | (0.854) | (0.153) | (0.216) | (1.814) | (1.870) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| $R^2$ | 0.178 | 0.176 | 0.199 | 0.210 | 0.223 | 0.216 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −406.248 | −392.726 | −403.547 | −402.132 | −400.310 | −387.720 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

## A.2 | Dummy variable regressions

The following regressions replace participant BAC scores in the treatment session with a sequence of dummy variables, defined in Table A3:

**TABLE A2** Pooled regressions of overconfidence on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Overconfidence | | | | | | |
| *BAC* | 1.821*** | 1.788*** | 1.845*** | 1.912*** | 1.965*** | 1.932*** |
| | (0.484) | (0.494) | (0.495) | (0.490) | (0.495) | (0.504) |
| BMI | | −0.004 | | | | −0.002 |
| | | (0.042) | | | | (0.041) |
| Has a degree | | | 0.709** | 0.864*** | 0.828*** | 0.760*** |
| | | | (0.287) | (0.271) | (0.274) | (0.274) |
| Single | | | | 0.684*** | 0.695*** | 0.767*** |
| | | | | (0.248) | (0.249) | (0.250) |
| ln(time taken) | | | | | −0.546* | −0.456 |
| | | | | | (0.318) | (0.324) |
| Constant | −0.484*** | −0.378 | −0.729*** | −1.181*** | 1.775 | 1.336 |
| | (0.142) | (1.000) | (0.165) | (0.201) | (1.766) | (1.951) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| $R^2$ | 0.065 | 0.063 | 0.101 | 0.136 | 0.149 | 0.146 |
| *p*-value | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | −414.619 | −401.195 | −410.457 | −406.257 | −404.639 | −391.660 |

Standard errors in parentheses * $p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

**TABLE A3** Definition of dummy variables and distribution of sample.

| Dummy variable | BAC range | No. of participants | Proportion of sample (%) |
|---|---|---|---|
| $BAC_{iT}^1$ | $0 < BAC_{iT} \leq 0.2$ | 20 | 18.9 |
| $BAC_{iT}^2$ | $0.2 < BAC_{iT} \leq 0.36$ | 31 | 29.2 |
| $BAC_{iT}^3$ | $0.36 < BAC_{iT} \leq 0.52$ | 27 | 25.5 |
| $BAC_{iT}^4$ | $BAC_{iT} > 0.52$ | 21 | 19.8 |

We omit the dummy for $BAC_{iT} = 0$. The first column defines the variable. The second gives the range of BAC scores for which the dummy variable equals one. The third and fourth columns show that there is a relatively even distribution of participants across the ranges.

Tables A4 and A5 report results for treatment session score and overconfidence respectively. No evidence of a nonlinear relationship between either behavioural variable and BAC was found. The results are robust to how we define the dummy variables.

**TABLE A4** Treatment session regressions of score on BAC dummies.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Score | | | | | | |
| $BAC_{iT}{}^1$ | −0.128 | | | | −0.127 | −0.500 |
| | (0.456) | | | | (0.475) | (0.753) |
| $BAC_{iT}{}^2$ | | 0.195 | | | | −0.258 |
| | | (0.365) | | | | (0.696) |
| $BAC_{iT}{}^3$ | | | 0.035 | | 0.003 | −0.370 |
| | | | (0.365) | | (0.380) | (0.696) |
| $BAC_{iT}{}^4$ | | | | −0.337 | | −0.667 |
| | | | | (0.390) | | (0.711) |
| Constant | 6.628*** | 6.547*** | 6.595*** | 6.671*** | 6.627*** | 7.000*** |
| | (0.178) | (0.194) | (0.194) | (0.187) | (0.219) | (0.621) |
| Observations | 106 | 106 | 106 | 106 | 106 | 106 |
| $R^2$ | 0.001 | 0.003 | 0.000 | 0.006 | 0.001 | 0.012 |
| $p$-value | 0.779 | 0.594 | 0.924 | 0.389 | 0.962 | 0.865 |
| Log-likelihood | −205.385 | −205.284 | −205.428 | −205.092 | −205.385 | −204.816 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**TABLE A5** Treatment session regressions of overconfidence on BAC dummies.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Overconfidence | | | | | | |
| $BAC_{iT}{}^1$ | −0.188 | | | | −0.192 | −0.129 |
| | (0.430) | | | | (0.468) | (0.806) |
| $BAC_{iT}{}^2$ | | 0.044 | | | | 0.055 |
| | | (0.455) | | | | (0.822) |
| $BAC_{iT}{}^3$ | | | 0.038 | | −0.010 | 0.053 |
| | | | (0.393) | | (0.427) | (0.783) |
| $BAC_{iT}{}^4$ | | | | 0.089 | | 0.095 |
| | | | | (0.504) | | (0.852) |
| Constant | 0.488** | 0.440** | 0.443* | 0.435** | 0.492* | 0.429 |
| | (0.217) | (0.210) | (0.230) | (0.207) | (0.282) | (0.713) |
| Observations | 106 | 106 | 106 | 106 | 106 | 106 |
| $R^2$ | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |
| $p$-value | 0.662 | 0.923 | 0.922 | 0.861 | 0.909 | 0.995 |
| Log-likelihood | −220.218 | −220.290 | −220.292 | −220.278 | −220.218 | −220.211 |

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

### A.3 | GLS regressions

The below tables report the results of GLS estimates of the regression equations presented in the main paper that employ pooled OLS or within-participant approaches (Tables 3, 4, 6, and 7). In each case, the results are broadly similar, both in the magnitude and significance of the effect of *bar* × *BAC* on score (Table A6) or overconfidence (Table A7).

TABLE A6 GLS regressions of score on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Score | | | | | | |
| *bar* × *BAC* | −3.471*** | −3.409*** | −3.471*** | −3.492*** | −3.542*** | −3.477*** |
| | (0.456) | (0.468) | (0.463) | (0.464) | (0.461) | (0.471) |
| BMI | | 0.036 | | | | 0.033 |
| | | (0.035) | | | | (0.034) |
| Has a degree | | | −0.557* | −0.646** | −0.610* | −0.542* |
| | | | (0.302) | (0.314) | (0.314) | (0.314) |
| Single | | | | −0.396 | −0.407 | −0.469* |
| | | | | (0.270) | (0.270) | (0.269) |
| ln(time taken) | | | | | 0.562* | 0.461 |
| | | | | | (0.310) | (0.318) |
| Constant | 8.210*** | 7.373*** | 8.399*** | 8.657*** | 5.613*** | 5.402*** |
| | (0.144) | (0.857) | (0.151) | (0.219) | (1.728) | (1.821) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A7 GLS regressions of overconfidence on BAC.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Overconfidence | | | | | | |
| *bar* × *BAC* | 2.092*** | 2.037*** | 2.089*** | 2.117*** | 2.162*** | 2.107*** |
| | (0.451) | (0.465) | (0.460) | (0.459) | (0.463) | (0.476) |
| BMI | | −0.004 | | | | −0.002 |
| | | (0.042) | | | | (0.041) |
| Has a degree | | | 0.711** | 0.867*** | 0.832*** | 0.764*** |
| | | | (0.288) | (0.272) | (0.275) | (0.275) |
| Single | | | | 0.689*** | 0.700*** | 0.771*** |
| | | | | (0.249) | (0.250) | (0.251) |
| ln(time taken) | | | | | −0.532* | −0.458 |
| | | | | | (0.322) | (0.330) |
| Constant | −0.534*** | −0.408 | −0.775*** | −1.223*** | 1.663 | 1.320 |
| | (0.134) | (1.000) | (0.160) | (0.198) | (1.784) | (1.969) |
| Observations | 212 | 206 | 212 | 212 | 212 | 206 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.