Overconfidence, Alcohol and the Environment: 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 numerous social ills associated with it. Our lab-in-the-field experiment assesses the extent to which intoxication leads to changes in overconfidence or cognitive ability that are often linked to problematic behaviours. Results suggest that it is the joint effect of being intoxicated *in a bar* that matters. Subjects systematically underestimated their magnitude, suggesting that they cannot be held fully accountable for their actions.

Keywords: Alcohol intoxication, overconfidence. *JEL:* C93, D91, I18

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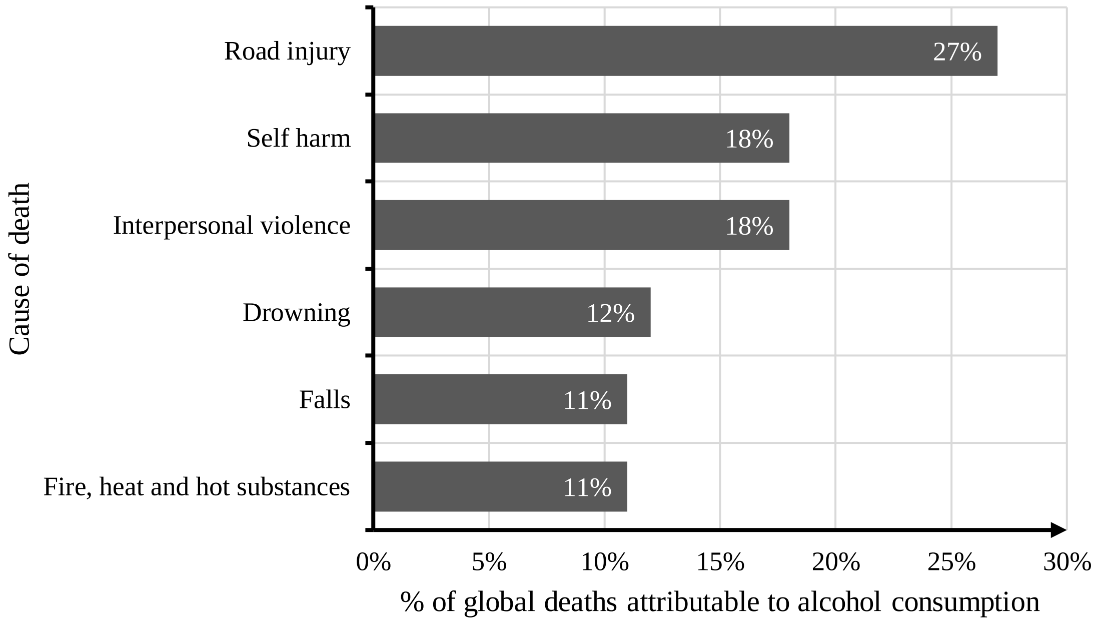
1. INTRODUCTION

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 twenty 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).

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 percent of violent crimes in the United States, and 40 percent 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 percent of the country's national defence budget (Gell et al. 2015).

Figure 1: Global percentage of selected traumatic deaths attributable to alcohol by cause



Source: World Health Organization 2018

What is it about alcohol consumption that leads to 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 the 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 **Error! Reference source not found.** 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 0 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 (Pernanen 1981; Fagan 1993) 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 (Corazzini et al. 2015; Bregu et al. 2017). 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 and Homel 1997), high temperatures (Graham 1980), inaccessible bar and toilet facilities (Tomsen 1997), noise levels (Quigley et al. 2003; Graham and Homel 1997) and competitive games (Graham and 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 and Cornell 1990). However, this can clearly lead to a self-fulfilling prophecy. Alcohol consumption adjusts the cost/benefit calculus

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

for a rational individual with, for example, a preference for driving dangerously or engaging in violence, by lowering the expected cost (Becker and Murphy 1988; Markowitz and Grossman 2000; Markowitz 2000, 2005). In effect, it can provide them with an excuse to engage in enjoyable, yet antisocial, behaviour.

Given this view, one might ask why society continues to be more forgiving of such behaviour. Once 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, it must be the case that 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 and 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 participants clearly self-selected to be at the bar and 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. Since participants were

[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.

recruited at random throughout the experimental session, their level of intoxication was implicitly randomised.[3]

After being breathalysed, they completed an off-the-shelf, timed overconfidence test. Participants were asked to answer ten 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 widely used measure of *overconfidence bias* (Moore and Healy 2008; Herz et al. 2014; Danková and Servátka 2019).[4]

Participants were invited to attend a second experimental session one 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

[3] The correlation coefficient between BAC in the treatment session and the number of units of alcohol participants reported drinking in an average session was 0.028.

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

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).

First, 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 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 ten 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 combination of ten 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. 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 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 ten new questions. These also followed Bilker et al. (2012), who identified the combination of ten 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 seconds of the correct difference would pay £10, falling to £9 for predictions within 60 seconds, to £8 for predictions within 90 seconds etc.

[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.

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 program 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 17th July 2017.

4. DATA AND ESTIMATION

4.1 *Data*

Over six weeks, we recruited 140 individuals, of whom 106 (76 percent) 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 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 percent were smokers.

The BAC score has been criticised for being more reflective of how much alcohol an individual has consumed than their intoxication. Individuals with different body shapes 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. 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.

In the treatment session, the average BAC score was 0.36 milligrams of alcohol per litre of breath expelled. For comparison, it is illegal to drive in the UK with a BAC score of 0.35 or over. Forty-five percent of our sample fell into this category. Our average participant got 6.60 questions correct out of ten. They were slightly overconfident, believing that they got 7.06 questions correct.

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

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 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. 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.

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 one 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:[8]

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

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 percent to 12.5 percent. Our measure is more restrictive, reducing the likelihood that we find any significant differences in overconfidence

[8] 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.

between sessions. We nevertheless re-ran our results employing this alternative measure as a robustness check. The overall picture was the same.

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:

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

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 ε_{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. β_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 the treatment session relative to the control session. Noting that $bar_{iT} = 1$ and $bar_{iC} = 0$, this simplifies

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

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:

$$\Delta y_i = \beta_1 BAC_{iT} + x_i'\zeta + \Delta\varepsilon_i. \qquad (3)$$

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, focusing 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 Δy_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:

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

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 focusing purely on the effect of intoxication on participants' score whilst holding the environment constant (in this case, in the SU 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.

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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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 in an attempt to control for intrinsic ability. Whilst this is significant, it is also negative, suggesting that having a degree reduces participants' average score. We interpret this as those with a degree perhaps taking the task less seriously. 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: Pooled regressions of score on BAC

	(1)	(2)	(3)	(4)	(5)	(6)
			Score			
bar × *BAC*	-3.092***	-3.055***	-3.113***	-3.150***	-3.215***	-3.167***
	(0.481)	(0.479)	(0.487)	(0.486)	(0.479)	(0.479)
BMI		0.035				0.032
		(0.030)				(0.029)
Has a degree			-0.553**	-0.641**	-0.602**	-0.536**
			(0.261)	(0.267)	(0.268)	(0.269)
Single				-0.387*	-0.399*	-0.461**
				(0.229)	(0.230)	(0.231)
ln(time taken)					0.589*	0.464
					(0.303)	(0.311)
Constant	8.141***	7.328***	8.333***	8.588***	5.401***	5.342***
	(0.134)	(0.719)	(0.139)	(0.192)	(1.683)	(1.741)
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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 starts to take the environment into account. It presents pooled OLS results, incorporating data from the control session. 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.

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 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: 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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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 second 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 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***
	(0.511)	(0.513)	(0.520)	(0.513)	(0.522)	(0.523)
BMI		-0.003				-0.001
		(0.039)				(0.038)
Has a degree			0.710***	0.865***	0.829***	0.758***
			(0.261)	(0.251)	(0.256)	(0.257)
Single				0.684***	0.695***	0.770***
				(0.224)	(0.224)	(0.227)
ln(time taken)					-0.558*	-0.464
					(0.331)	(0.338)
Constant	-0.477***	-0.387	-0.723***	-1.174***	1.847	1.369
	(0.129)	(0.911)	(0.147)	(0.182)	(1.826)	(1.993)
Observations	212	206	212	212	212	206
R^2	0.063	0.063	0.099	0.134	0.148	0.146
p-value	0.001	0.003	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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 includes data from the control session, reporting pooled OLS results across our entire sample. Again, accounting for the environment 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, GLS and fixed effects estimations are presented in the appendix, exhibiting a very similar pattern.

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 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 Δ(*bar* × *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

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

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.

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 and Cornell 1990) but not others (e.g. drink-driving). In the classical multiple-selves framework (O'Donoghue and 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 appear to 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 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 study 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. That we observe behavioural changes between sessions raises the question of how changes in, for example, risk aversion might influence our results. We hope to address these concerns in future work.

APPENDIX: FURTHER RESULTS

A.1 *Dummy variable regressions*

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

1. $BAC_{iT}^{1} = 1 \Leftrightarrow 0 < BAC_{iT} \leq 0.2$;
2. $BAC_{iT}^{2} = 1 \Leftrightarrow 0.2 < BAC_{iT} \leq 0.36$;
3. $BAC_{iT}^{3} = 1 \Leftrightarrow 0.36 < BAC_{iT} \leq 0.52$;
4. $BAC_{iT}^{4} = 1 \Leftrightarrow BAC_{iT} > 0.52$.

We omit the dummy for $BAC_{iT} = 0$. 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 A.1: 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 A.2: 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.2 *GLS regressions*

Table A.3: GLS regressions of score on BAC

	(1)	(2)	(3)	(4)	(5)	(6)
			Score			
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 A.4: GLS regressions of overconfidence on BAC

	(1)	(2)	(3)	(4)	(5)	(6)
			Overconfidence			
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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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