Effects of Small Doses of Alcohol on Driver Performance in Emergency Traffic Situations

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INTRODUCTION

Although considerable energy seems to have been spent on finding measures that might detect the effects of alcohol, many studies bear little resemblance to real world traffic situations in which alcohol associated accidents occur — other than the fact that a real car is used. Parking, precision manoeuvring and low speed have been predominant characteristics of these studies. A technique attempting to remedy this deficiency was employed by Huntley, Perrine and Kirk. The driving task included an emergency stopping situation and an evasive manoeuvre and was shown to be sensitive to the effects of alcohol. However, the BAC of their subjects was 90 mg%. According to Goldberg, in emergency situations the critical BAC is estimated to be 20-40 mg% whereas in a task requiring less complicated performance the critical level is estimated to be 40-50 mg%. BACs around 50 mg% are of special interest because some countries already have adopted laws that incriminate driving with higher alcohol concentration and others are considering laws to that effect.

The present study centred on subjects with BACs below 50 mg% in a demanding emergency type task — a task that any driver could have to face any day. The driving task was also designed to rule out possible effects of momentary compensation for the impairing effects of alcohol.

Such efforts can often be suspected in experiments where the subjects know the precise point or instance of measurement. This bias could be avoided by employing a technique which leaves uncertain where and when the stimuli will appear. By adding to this a situation which is a total surprise in a relaxed phase of the experiment, chances would be that motivational and related experimental bias effects could be reduced.

METHODS

The reported investigation was carried out in three stages: a pilot study with 6 subjects and a target BAC of 50 mg%, and two main experiments A and B with 10 subjects in each and target BACs of 50 mg% and 30 mg% respectively.

Procedure

The driving task consisted of a situation which required emergency braking and an evasive manoeuvre (e.g. where the roadway is suddenly blocked). In order to be able to perform correctly the driver had to: 1. brake hard; 2. release the brake pressure in order to be able to ... 3. swerve; 4. realign the car; and 5. brake hard to full stop. All subjects practised the driving task for a total of two hours. Correct behaviour and the consequences of incorrect behaviour were demonstrated by the experimenter, who also gave the subjects feed-back as to their performance and instructions for improvement. The subjects served as their own

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controls by taking part in two experimental sessions on two consecutive nights, one without alcohol and the other after having consumed alcohol. The order of conditions was rotated so that half of the subjects drove with alcohol on the first night and without alcohol on the second and vice versa with the other half.

After having made all test trials on the second night and upon returning to the starting point for an assumed tenth trial the drivers — without any prenotion — suddenly, in the light from the dipped head lights, saw an obstacle blocking the path. Either of swerving or braking actions released a camera shutter to take a picture of the obstacle at the moment of reaction.

Course

A 500 m closed section of a four-lane motorway was used as the experiment site. On this closed course an arrangement of rubber pylons was set out. It was used for training as well as for testing and consisted of three parallel lanes forming 8 emergency openings along the path as seen in Figure 1.

The subjects' task was to drive in the middle lane at 50 km/h and as soon as two red brake lights came on to brake and make an evasive manoeuvre. For this manoeuvre the driver should use the first available emergency opening into the left or into the right adjoining lane.

The obstacle for the surprise situation was matte dark-grey, 1 m high and 40 cm wide.

Subjects

The subjects were 26 men, their ages ranging from 19 to 31 with a mean age of 24.5 (st.dev. = 3.3, median = 23.5); the majority were university students. Six subjects took part in the pilot study, ten in each of the two parts of the main study (experiments A and B). Their mean distance driven during the last twelve months was approximately 12 000 km with a range from 2000 to 20 000 km. Seven of the subjects did not own a car. The drinking habits were quite similar for all subjects — consumption of alcohol a couple of times per month and at each occasion an amount equivalent to approximately 8 cc. of 100% ethanol. Their payment was made dependent upon performance in the two experimental sessions in a manner described under ‘measurement of dependent variables’.

Vehicle

The experimental vehicle was a 1966 Volvo Station Wagon. For the presentation of the emergency signal to the driver two red brake lights were placed on the fenders. The car was also equipped with a 35 mm camera inside the windshield and an electronic flash unit attached to the front bumper. This equipment was triggered by the subjects either braking or turning the wheel 60°. In order to make it easier for the driver to maintain the required speed, the accelerator pedal was equipped with an extra spring making it hard to press the pedal beyond a point corresponding to 50 km/h in third gear.

Emergency action stimulus

The two red brake lights were triggered at a distance of 7 m from the emergency opening. The lights were triggered by a photocell system placed inconspicuously among the pylons. The photocell was placed at random at one of the eight emergency openings. The subjects were told to use the very first available opening as soon as the lights came on.
Figure 1 Specifications of pylon arrangement.
Alcohol — administration and measurement

The subjects had a light meal 4-5 hours before the experimental session. Alcohol was served in the form of scotch whisky without ice or water. A dose of 1.5 ml of whisky per Kg of bodyweight\(^b\) was used in the pilot study and experiment A, whereas in experiment B a dose of 1.3 ml/kg\(^c\) was ingested. The time allowed for consumption of the alcohol was 15 min. Immediately prior to driving, three capillary samples were taken from the fingers. No attempt was made to disguise the alcohol nor was any placebo given in the control condition. The same schedule of timing, however, was maintained in both conditions.

This procedure was repeated as soon as a subject had completed his driving task. Breath samples were also taken with an Alcometer in both instances as well as before the no-alcohol driving. Driving commenced 60 min after the start of drinking and lasted for approximately 25 minutes. The capillary samples were then refrigerated and taken to the Department of Alcohol Research at Karolinska Institutet, Stockholm, where they were analysed with an automated enzymatic ADH-method.\(^8\)

Measurement of dependent variables

Emergency Situations

1. Angle of car: Both bumpers were marked into quarters. Each quarter protruding into the adjoining lane from the correct position after the car had come to a full stop rendered a 2 sw.cr (40 c USA) reduction of payment from the initial value of 22 sw.cr ($4.40 USA) per trial.
2. Stopping distance: Stopping distance was measured from the first pylon in the emergency opening to the front of the car — minus 7 m. Payment was reduced by 1 sw.cr (20 c USA) per metre.
3. Pilons hit or moved: Each pylon knocked down or moved rendered a reduction of 1 sw.cr (20 c USA).
4. Faulty decision: No evasive manoeuvre, turning in the wrong direction or at the wrong place all resulted in a reduction of 15 sw.cr ($2.00 USA).

Surprise Situations

1. Distance of reaction. Distance of obstacle from the front of the vehicle at the moment of reaction (as determined photographically).

RESULTS

The means and ranges of payment reductions on three measures in the three different parts of the study are presented below. In addition, the figures present the BAC-means of three blood samples taken immediately prior to driving and the means of three samples taken directly after the driving. They also show the total mean, taken to be the estimation of BAC during the actual driving.

\(^b\)The equivalent of 0.6 ml 100% ethanol/kg.
\(^c\)The equivalent of 0.52 ml 100% ethanol/kg.
Pilot Study

In the pilot study, performance, as far as pylons hit and stopping distance are concerned, deteriorated for all subjects between control and alcohol conditions. Tests of significance of the difference between conditions, made with the Sign test\(^2\) give \(p = 0.015\) for both measures. The same method applied on angle of car, where three subjects showed deteriorated performance and three subjects improved performance, yielded no significant difference. Figure 2 shows BAC during actual driving to have been fairly close to the intended 50 mg%, and indicates decreasing BAC from before- to after-measurement. This was the case for all six subjects.

Experiment A

In experiment A eight subjects out of ten were affected in a negative way by alcohol in measures: pylons and stopping distance. This shows a significant difference (\(p = 0.055\)), whereas angle of car again did not reveal any significant differences between conditions. Five subjects improved their performance and five had their performance impaired. As for BAC the same tendency as was shown in the pilot study is again evident. All ten subjects had lower BACs after driving — a mean reduction of 9 mg% in 25 min.
Experiment A

In experiment A, per trial-means and ranges of reduction of payment in sw. cr. (Swedish crowns).

Experiment B

In experiment B, the number of pylons that were hit increased in eight cases, decreased in one case and remained the same in one as calculated from control to alcohol conditions. The difference between conditions is significant (p = 0.02). This is also true of stopping distance (p = 0.055), where two subjects improved their performance and eight had longer stopping distances. As for angle of car, nine subjects showed impaired performance and one improved his performance with alcohol — a significant difference (p = 0.011). In this part of the study, two subjects were shown not to have reached the elimination phase of the blood alcohol curve. The other eight subjects had lower BACs after driving than before.

False Actions

The small absolute number of false actions carried out during the experimental sessions did not provide a basis for statistical testing. However, the number of false actions carried out in the control condition — all three parts taken together was 4 as compared to 10 in the alcohol condition.
Illustrated in Figure 6 is the performance on three measures of the ten subjects that reached the lowest BACs. Eight subjects hit more pylons in the alcohol condition whereas two subjects hit fewer pylons. The difference between the alcohol and no-alcohol conditions is significant ($p = 0.055$). Exactly the same relation also holds true for stopping distance. The measure angle of car however does not reveal any significant differences between conditions. Performance deteriorated for six subjects and improved for four from control to alcohol conditions.

A comparison has also been made of possible differences related to the order of presentation of the two conditions. Thus, if the results from the total number of 13 subjects driving with alcohol in their first session and no alcohol in the second are grouped together and compared with the ones of the reverse order, we find no significant differences.

The overall mean of rank order correlations between performance in control and alcohol conditions was 0.69, as calculated via Fisher's Z.$^9$

**Surprise Situation**

As for the surprise situation, a series of circumstances (strong wind gusts blowing the obstacle away) reduced the number of tests successfully carried out. These circumstances (repeated
camera failure) also made the use of the photographic distance measuring method impossible. Thus only collisions or safe stops could be registered. A total of ten subjects were tested while under influence of alcohol and another ten subjects in the control condition. The results are presented in Figure 7. Since repeated measurements could not be made, the results of the two groups of subjects in the emergency situation were tested for possible differences. However, no significant differences between the two groups were found.

When the procedure was repeated to test for a 'pull-oneself-together-effect' all subjects made safe stops.

**DISCUSSION**

The results give clear evidence of the degrading effects of alcohol upon driving performance in emergency situations. Detrimental effects are found to exist at blood alcohol concentrations below 50 mg% — the overall mean of BACs being 42 mg%. The ten subjects who happened to reach BACs in the range between 24 and 40 mg% show the same impairment of performance. The differences between conditions are significant for the two measures: pylons hit and stopping distance.

As can be seen in the figures, there were tendencies for ranges to be wider, the maximum values to be higher and also the minimum values to be higher in the alcohol condition than in the control condition. As far as the pylons hit measure is concerned, these tendencies constitute significant difference between the two conditions.

The difference in blood alcohol concentrations between parts A and B of the study were too small to justify separate conclusions. No significant difference was found between BACs as tested with the Mann–Whitney U-test.
As for the surprise situation, the loss of data and the crude observational method, stating only collision or no-collision, give little justification for safe conclusions in a statistical sense. However, a tendency for impairment of performance can be observed, much the same as in the rest of the study. Taylor and Stevens\textsuperscript{24} came to much the same results at a mean BAC of 66 mg\% in a study which also included a surprise situation.

There are reasons to believe that the results underestimate rather than overestimate the true differences between driver performance in emergency situations under the influence of alcohol and performance under sober conditions.

Thus, the drivers were subjected to stress by taking part in an experiment, by being observed and by knowing that on each experimental trial an emergency situation would occur.

This could reduce the effect of alcohol, an interpretation in accordance with the Hawthorne effect which indicates that an individual who knows that he is observed in an experiment may try extra hard and thus, in this case, try to compensate for the impairing effects of alcohol. The compensation would be especially likely at lower BACs.\textsuperscript{19} In traffic situations it is thus possible that differences between sober performance and performance under influence of alcohol would be even greater. The fact that the subjects had practised the driving task very thoroughly also indicates a possible underestimation of true differences. There are indications that well-learned skills are less vulnerable to the effects of alcohol than unfamiliar ones.\textsuperscript{17} Critical and emergency situations occur with low frequency in everyday traffic, thus providing very few chances to practise and get used to the handling of such
situations. Milner expressed it this way: 'it is likely that if a drug is shown to affect driving skills in an experimental situation, its effects are probably even more pronounced in general driving behavior'. Another reason to believe that the observed effects of alcohol by no means constitute a potential maximum is the fact that they were observed in the elimination phase of the BAC-curve in all cases but two, as indicated by the before- and after-driving means of BAC. According to Kielholz, Richter and Hobi and many others, the impairing effects of alcohol are most pronounced in the absorbing phase of the intoxication.

Comments from the subjects indicate that they considered the task relevant to safe driving and its artificiality was not felt.

Unfortunately it was not within the scope or resources of this study to demonstrate what aspect of the driving task was most affected by alcohol intoxication. Rather the purpose has been to study the effects of alcohol in a generalisable situation containing most of the ingredients that could enter a traffic situation that puts heavy demands on the driver. Thus, if one is willing to accept the semi-laboratory driving performance as representative of full-scale driving performance, then this study has shown the detrimental effects of very low BACs in situations demanding fast reactions, attention, rapid decision-making and precise and accurate action of the driver.

Figure 7 Absolute number of subjects who collided with the obstacle or stopped safely in the surprise situation.
REFERENCES