HANGOVER EFFECTS OF ALCOHOL ON DRIVER PERFORMANCE

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SYNOPSIS

Our aim was to study hangover effects of alcohol on driver performance when all alcohol has been metabolized. The driving task was an avoidance maneuver putting high demands on attention, reaction time, precision, and coordination. Each of the 22 subjects participated in an arranged drinking party. The day after when their BAC's were down to zero the first hangover driving tests were carried out. Three hours later the same tests were repeated. We found that driving performance was impaired in both hangover conditions when compared to the subject's normal performance. (The subjects acted as their own controls in rotated order of conditions). We found no relationship between impairment and subjective well-being in the hangover condition.

INTRODUCTION

Studies of laboratory tasks as well as of car driving have shown that alcohol can impair performance even after doses, resulting in blood alcohol concentrations (BAC's) of less than 50 mg%. Thus, in an investigation of alcohol related performance decrement in critical driving situations, significant impairment was recorded at BAC's averaging 42 mg% (Laurell, 1977). Also, everyday experience indicates that after-effects of drinking may remain long after all alcohol has been metabolized. However, the after- or post-toxic or hangover effects have not been subjected to wide-ranging study. This holds true even more when considering hangover effects on driver performance.

Laboratory studies have demonstrated decreased performance in certain intellectual functions. This is also true of perceptual abilities, hand steadiness, and coordination (Gold et al., 1973; Goldberg, 1966; Kelly et al., 1970; Myrsten et al., 1970; Myrsten et al., 1980; Seppälä et al., 1976; Takala et al., 1958; Tichauer et al., 1971). Driving simulator studies have also indicated that the after effects of alcohol exert a certain detrimental influence on driving performance (Stening & Dureman, 1974). However, we have been unable to find any investigations into...
possible effects of hangover on driver performance in traffic or in closed-course driving.

The duration of the alcoholic hangover effects has only been studied in connection with laboratory tasks. Decreased performance has been noted by Gold et al. (1973) up to 18 hours beyond the alcoholic peak. They also observed that the higher the peak, the more pronounced the impairment in the post-toxic state. Seppälä et al. (1976) have suggested that the most detrimental effects could occur as late as 24 hours after drinking. We explored further the time course of the hangover effects this study.

METHODS

Subjects

Six women and 16 men, aged 19-38 years, acted as paid volunteer subjects. Not until our subjects had actually volunteered for "a car driving experiment" were they informed about the fact that the investigation also included alcohol and were again asked if they wanted to participate. All subjects acted as their own controls. They were all healthy and used no medication or drugs.

A member of studies have reported difficulties in inducing hangover under the usual laboratory circumstances (e.g. Bonte & Volck, 1978). Therefore in this study, special emphasis was placed on the attempt to reproduce the circumstances under which hangover in non-alcoholics appears in our culture. To enhance that aim we chose the subjects so that the 5 of them, taking part each Friday, already knew each other.

Driving Task

The driving task was essentially the same as was used in earlier studies of effects of alcohol on driving performance (Laurell, 1977). Upon a signal, the driver has to carry out an avoidance maneuver and, in doing this, try to avoid knocking over pylon cones which were placed along the avoidance path. (The tolerance on either side of the car was approximately 15 cm.) The number of cones knocked over was employed as a measure of driver performance.

The signal could be presented at either 1 of 4 positions in the cone setting (see Figure 1) and if presented above the left headlight position, simulated an obstacle in front of and to the left of the car, and thus required an avoidance maneuver to the right -- and vice versa.
The order of presentation of positions was randomized for each subject and each treatment condition. In each session, the course was negotiated 10 times by each subject: once per signal alternative plus twice randomized. In addition, "blind" trials, in which no avoidance stimulus was presented, were inserted at random among the others. Two warm-up trials preceded each session.

Vehicle and Presentation of Stimulus Signal

The experimental vehicle was a 1967 Volvo station wagon. For presentation of the avoidance signal, the car had been equipped with a photocell-system the light of which was reflected via a mirror placed inconspicuously among the cones. The photocell controlled a relay, cutting the power of one of 2 electromagnets and, thus, releasing a spring-loaded arm which served as the stimulus. In this way the experimenter could not influence the timing of the signal. The photocell relay also triggered a counter which was stopped by the contact for the brake lights, thus providing a measure of the driver's brake reaction time. Vehicle speed was controlled via a hand throttle device held by the experimenter.

Motivation

In order to keep motivation at a high level throughout the investigation, payment was made dependent upon performance. For each trial the driver had at his disposal a sum of 25 SEK. This sum of money was reduced for each cone knocked over. A cone in one of the outer rows rendered a 2 SEK reduction and in the inner rows a 3 SEK reduction. Cones hit prior to the stimulus signal cost 1 SEK. Reductions were maximized to 20 SEK. This sum also represented the punishment for having swerved into the wrong lane or performing no evasive maneuver at all when an avoidance maneuver was called for.

Procedure

A couple of days prior to the experimental sessions all subjects practiced the driving task until they reached a stable level of performance. Reaching this level required some 2.5 hours of driving.

Half of the subjects returned for 2 experimental sessions in the normal condition (N), a couple of days prior to the "night of the party." The other half took their corresponding tests a couple of days after the hangover. In the normal condition, the first measurements (N1) were carried out at around 9 hours and the second ones (N2) 3 hours later.
Five subjects participated in each drinking party, during which a free and ample supply of food and alcoholic beverages (beer, wine, and distilled liquors) was provided. The parties lasted from 18 to 24 hours. We placed no restrictions or any requirements as to eating and drinking; all subjects ate and drank at their own discretion. All subjects stayed overnight at the research institute supervised by the experimenters.

Eight hours after going to sleep, the subjects were awakened and breath alcohol tests were taken and the BAC's determined. The BAC's were then monitored by frequent measurements, with the frequency of measurements increasing to every 5-10 minutes as zero BAC was neared. At the point when no alcohol could be detected by breath analysis, the first performance measurements in the hangover state (H1) were carried out.

Immediately prior to all driving tests, the subjects gave subjective ratings on 5 point scale as to the severity of their hangover and on each of 12 variables related to recognized hangover effects (see Table 3). Three hours later, the second hangover measurements (H2) were obtained.

BAC Measurements

The BAC's were measured during the 6 hours of alcohol consumption as well as in the following morning. The intention was to obtain BAC measures on each subject at 1-hour intervals. However, due to difficulties in preventing subjects from drinking during the 15-minute period necessary for reliable BAC measurement, this schedule could not be maintained. The measurements were carried out by breath sampling with 2 Alcolmeters (Lion Laboratories, Ltd). These instruments were calibrated against calibration air ampoules containing 50 mg% alcohol. Calibrations were made prior to each sampling.

RESULTS

Performance Measurements

The performance scores in the 2 hangover sessions, when combined (H1 + H2) were lower than the performance in the normal sessions for all 22 subjects (Table 1). None of the subjects reached the normal performance level (i.e. 100%). In comparison with the normal performance, the overall mean as well as the median indicate a 19% impairment (Figure 2).
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P_{25}: 123, 117, 90, 93
P_{75}: 149, 160, 120, 129
s: 24, 30, 23, 26

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The difference in performance between normal and hangover conditions is statistically significant ($p$ less than 0.005, Wilcoxon).

The 2 normal sessions were not significantly different ($p$ greater than 0.05, Wilcoxon), implying that learning effects were unlikely to have influenced the results. A comparison between the first sessions in normal and hangover conditions ($N_1$, $H_1$) reveals that 19 out of 22 drivers scored worse in the first hangover than in the first of the normal conditions. The average performance decrement was 20\% and the median 19\% (see Figure 3). The difference between conditions is significant ($p$ less than 0.005, Wilcoxon).

The comparison between $N_2$ and $H_2$, 3 hours later, produced almost the same picture (see Figure 4). The difference between conditions was significant ($p$ less than 0.005, Wilcoxon). Although the performance decrement at $H_2$ tended to be smaller, no significant difference existed $N_1$ and $N_2$, or between $H_1$ and $H_2$ ($p$ greater than 0.05, Wilcoxon).

If the concept of "negative score" is omitted, leaving any changes in performance to be expressed as number of cones knocked over, all comparisons still show significant differences ($N$ vs $H$, $p$ less than 0.005; $N_1$ vs $H_1$, $p$ less than 0.005; $N_2$ vs $H_2$, $p$ less than 0.005; Wilcoxon). We recorded a total of 5 false actions; one occurred in $H_1$ and 4 in $H_2$. No false action was recorded in the normal conditions.

**BAC's**

The average for all subject's highest recorded BAC readings between 18 and 24 hours was 147 mg\% and at 8 hours the next day, 46 mg\%.

**Hangover**

An analysis of the overall ratings by the 22 subjects of the severity of their hangover at $H_1$ (when their BAC first reached zero) and at $H_2$ (3 hours after zero BAC's showed hangover severity not to be significantly related to driving performance. Nor was the subjective hangover correlated with BAC's at wake-up ($r_{Spearman}$ rank = 0.16; $t = 0.72$; df = 20; $p$ greater than 0.10).

As for background variables, neither gender ($p$ greater than 0.05, Mann-Whitney U-test) nor age was related to the differences in performance decrement ($r_{Spearman}$ rank = .33; $t = 1.56$; df = 20; $p$ greater than 0.05). The lack of statistical significance also holds true for the correlation.
between the subject's normal alcohol consumption and performance decrement ($r_{Spearman} = 0.17; t = 0.77; df = 20; p \text{ greater than } 0.10$).

**DISCUSSION**

The results give clear evidence of the performance degrading effects of alcoholic hangover although all alcohol has been metabolized, following alcohol consumption to the approximate level of 150 mg%. Further, they indicate that the degrading effects prevail for at least 3 hours after all alcohol has been metabolized. Earlier results, primarily derived from psychomotor testing, support the existing data from actual car driving. When these results are compared with the earlier ones, they are strikingly clear and unambiguous.

The fact that behavioral effects were observed 3 hours after all alcohol had been metabolized (corresponding to 15 hours after peak BAC's) does not mean that 3 hours constitutes a farther limit for performance degradations. Other studies have found effects even after more than 15 hours (Gold et al., 1973; Seppälä et al., 1976; Tichauer et al., 1971). Seppälä et al. (1976) carried out psychomotor testing from 12 to 16 hours after drinking, the point at which they considered the hangover to be at its worst, and found performance impairment. Tichauer et al. (1971) found effects at even greater time distances. When BAC's had exceeded 120 mg%, after-effects could be observed at 18 to 20 hours after peak BAC's. Thus, there are reasons for further studies of after-effect duration.

The present results do not demonstrate any significant correlations between performance degradation and subjective hangover symptoms. However, greater impairment of performance tended to be associated with higher degrees of hangover. These results are in accordance with Seppälä et al. (1976) who also found that performance did not correlate with subjective hangover.

No hangover symptoms at all or just slight were reported by 12 subjects at the point when all alcohol had been metabolized (H1). Thus, the fact that no significant correlations could be found may be attributed to the reduced variation in the subjective rating of hangover. Another possible explanation could be that the driving skills that were affected are less vulnerable to such physiological changes as are manifested in subjective discomfort than to changes among other underlying factors not producing discomfort. (Seppälä et al., 1976, also pointed out that
the basic mechanisms involved in the actions of alcohol on the central nervous system are largely unknown. They also indicated that the changes in psychomotor performance are not necessarily related to the abnormal physiological conditions prevailing during hangover.)

In spite of the fact that so few hangover symptoms were reported, everyone of the 22 drivers scored worse in the driving task the day after alcohol consumption than they did in their normal performance. This indicates that, irrespective of subjective well-being, it is difficult to assess one's own fitness to drive. The conclusion is based on the presumption of an alcohol consumption corresponding to peak BAC's of 115-180 mg%. However, it is not improbable that lower BAC's could also cause performance impairment the next day, although no subjective symptoms of hangover are absent.

According to their own assertions, all subjects had slept their normal hours before the N-measurements. In the hangover condition they were awakened after 8 - 9 hours in bed. A few of those who were still above 30 mg% chose to go on sleeping for another hour. Thus, the observed impairment of performance could hardly be ascribed to lack of sleep.

The quality of sleep rather than the amount of sleep might have contributed to the observed changes in performance. Reduced proportions of REM-sleep have been found after alcohol consumption (Knowles et al., 1968) and this would indicate a change in quality of sleep. However, at this point, we cannot draw the conclusion that the degradation of performance was caused by the change.

The majority of the subjects were students, aged 20-30 years, and fairly experienced drinkers. Whether this category is somehow different from the general population with regard to susceptibility to the effects of alcohol is hard to tell since the problem has not been systematically studied. We suspect however, that the hangover effects for inexperienced drinkers could be more pronounced and appear after consumption of less alcohol. Swedish traffic laws do not permit any driving even for testing purposes if the driver is under influence of alcohol to the degree that his performance is affected. Therefore, we cannot make direct comparisons between acute and hangover effects of alcohol.

Comparisons with earlier results (e.g., the study of small doses of alcohol on driving performance in emergency situations [Laurell, 1977]) are not readily made because the driving conditions, driving task, and performance measurements were different in the different studies. The 1977 study involved 3 part-tasks which were compensatory to a certain extent and did not present a composite measure.
In order to be able to make correct judgements as to the seriousness of the observed impairment of driving performance which accompanies hangover it is also very important to try to compare these results with possible adverse effects of other factors, such as various amounts of sleep deprivation, physical strain, menstruation, and cold or fever. Among the factors which we did not evaluate in this study are drinking experience and drinking patterns during the drinking bout (e.g., the pace at which the alcohol is consumed, the dilutions). All of these are problems which are brought to the fore by the present results.

REFERENCES


Figure 1. The driving task.
Figure 2. Driving performance during hang-over (at zero BAC + 3 hours later); performance expressed as percent of normal performance.

Figure 3. Driving performance during hang-over (at zero BAC); performance expressed as percent of normal performance.
Figure 4. Driving performance during hang-over (at 3 hours after reaching zero BAC); performance expressed as percent of normal.

Figure 5. Numbers of subjects who self-estimated their hang-overs at each of the 5 levels of severity (N = 22).