The Influence of Small Doses of Alcohol on the Rate of Decision Making

Paul Verhaegen\textsuperscript{1,2}, Etienne van Keer and Roger Gambart

One afternoon, a few years ago, one of the authors was driving a Volkswagen minibus with 8 young children in it along a crowded three-lane single carriageway with fairly fast moving traffic. In order to enter the secondary road to his home he had to turn left. Thus he slowed down and began to leave the right-hand lane, marked by an unbroken white line, so that he could stop in the middle lane to wait for a gap in the oncoming traffic. All at once, he saw in the driving mirror, at perhaps 200 meters behind him, an ambulance swiftly leave the right lane and drive at high speed along the middle lane, left of the unbroken white line, overtaking the vehicles progressing in the right lane\textsuperscript{3}.

The driver's immediate thought was to give way to the ambulance, to pull back into his place in the right lane and eventually make his left turn at the next road junction. However, when he started to re-enter the right lane he heard the horn of a car that was already overtaking him on his right. Consequently he decided to discontinue this manoeuvre and to redirect the car to the middle lane of the carriageway and to stop there. This would either oblige the ambulance to stop and to lose some time or, as was the actual case, to slip into the right lane behind the minibus again.

This incident could easily have developed into a serious accident. The resolution made by the minibus driver was that in the future he would not let himself be influenced so easily by irregular behaviour of ambulances.

We think this critical incident is interesting. Within five seconds the driver had to change his mind at least three times; he had to make decisions and then reverse them;

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\textsuperscript{3}This is of course a clearly illegal way of driving. During the last few years there have been in Belgium some fatal accidents caused by ambulances and police cars that tried to gain a few minutes by breaking elementary traffic rules by not stopping before red traffic lights or by crossing white unbroken lines.
and he had to start and reverse his actions accordingly. Luckily, in this case he was able to make the relevant decisions or to choose the right responses at a high speed.

Thinking about such incidents in general, we wondered whether the capacity to make decisions, and to take action, would not be hampered by alcohol, even in very small amounts? This seems probable because, within our information transmission system, the decision making system is something like a bottle-neck. Broadbent calls it a 'limited capacity system' (1). We have looked into this question by using exploratory field research and a laboratory experiment.

In principle we were interested in alcohol doses that are lower than those eliciting a blood alcohol concentration (BAC) that makes driving illegal. Nevertheless, as it turned out, it was not possible to do field research concerning such small dosages.

The field research will be reported here very briefly. The laboratory study will be treated more extensively.

AN EXPLORATORY FIELD RESEARCH

One of us (R.G.) had the opportunity to interview a series of 105 drivers in 1973, who had been involved in one or more accidents while under the influence of alcohol. Their ages ranged from 19 to 54 years with a mean of 36. It was possible to interview them in a strictly confidential setting. The aim of the interviewer was to get an insight into each accident and to make a final appraisal concerning the nature of its main 'cause'. The idea was that an inability to process complex information in a critical traffic situation might have been a factor in accident causation. The conclusions of the interviews are summarized in Table I.

These conclusions make the idea that information overload may be a causal factor in accidents where alcohol is involved highly plausible. Information overload is, without doubt, also an important factor in accidents by sober subjects as shown by Fergenson (5). Because we had no control group, we cannot decide whether this factor becomes more important under the influence of alcohol.
### TABLE I  Main 'Causes' in 105 Traffic Accidents

<table>
<thead>
<tr>
<th>Main ‘cause’</th>
<th>Number of accidents in which the cause was present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow reaction</td>
<td>40</td>
</tr>
<tr>
<td>Tracking error</td>
<td>26</td>
</tr>
<tr>
<td>Information overload</td>
<td>16</td>
</tr>
<tr>
<td>Fast driving</td>
<td>16</td>
</tr>
<tr>
<td>Dangerous action of another driver</td>
<td>11</td>
</tr>
<tr>
<td>Unsafe behaviour</td>
<td>11</td>
</tr>
<tr>
<td>Insufficient intake of information</td>
<td>9</td>
</tr>
<tr>
<td>Insufficient steering movements</td>
<td>7</td>
</tr>
<tr>
<td>Sleeping</td>
<td>5</td>
</tr>
<tr>
<td>Exaggerated steering movements</td>
<td>5</td>
</tr>
<tr>
<td>Absence of reaction</td>
<td>3</td>
</tr>
<tr>
<td>Deliberate causation of an accident</td>
<td>1</td>
</tr>
<tr>
<td>Incorrect estimation of distances</td>
<td>1</td>
</tr>
</tbody>
</table>

*Main ‘causes’ were determined by interview in 105 traffic accidents in which at least one of the drivers was under the influence of a high alcohol dose.*

Further, in the group studied, the BACs were too high with respect to the general aim of our study. The mean BAC from 79 subjects was 218 mg/100 ml. The standard deviation was 58 mg.

Finally, the taxonomy we used to classify the ‘causes’ of accidents can be discussed. Most of the ‘causes’ are in some way related to information processing. It seems to us that the concept of ‘information overload’ must be limited to situations in which too much information must be processed in too short a time.

We hope in the future to find an opportunity to study a representative series of road accidents. Then we shall try to analyse the situations just before each accident in terms of their information processing demands and see if these are more important in subjects under the influence of alcohol.

### A LABORATORY EXPERIMENT

Two parallel curved lines representing a road are generated on the display of a computer configuration (see Figure 2). Between these two lines there is a small circle which can be moved laterally by the subject by means of a steering wheel. Because the road and also the curve in it are continuously moving to the lower part of the display, the subject has the impression he is steering the circle to the upper part of the display on a road that unfolds itself in an unpredictable way.

The subject’s task consists of holding the circle between two parallel lines by adapted steering movements. Every time the small circle touches or transgresses the limits of the road, it is registered by the computer. The latter also computes the time during which the circle is off the road.
The task lasts for 20 minutes. Within each minute it is relatively easy for 45 seconds, in which time there are a total of 15 to 18 curves to negotiate. The remaining 15 seconds within each minute form a 'critical period' during which the task varies from very easy (one curve per 15 seconds) to quite difficult (10 curves per 15 seconds). On the whole, there are 10 different critical periods, each of them appearing twice. The critical periods come in a random order, different for each subject. Each curve covers nearly half the height of the display. A curve appears only when the preceding one has disappeared completely. The concavity of the curve is to the left or to the right, in a random order.

It is clear that the described task has some face validity in connection with the problem of drinking and driving. Nevertheless, it must not be considered as simulating the complete driving task. The only resemblance is in the swift changes of direction after brief anticipation times that are required by the task. In other words, the resemblance consists in the episodes of information overload in which the required rate of decision making is quite high. We wanted to know whether such situations are more difficult to handle under the influence of small doses of alcohol.

Subjects and Experimental Design

We used three groups, each of 12 male university students. Their ages ranged from 18 to 28 years. The age distribution is given in Table II, which also shows the age distribution in each experimental condition.

The subjects were allocated at random to one of three experimental conditions which differed only by the quantity of alcohol given. We chose an experimental design with independent groups in order to be free of asymmetrical transfer effects described by Poulton (8).

The subjects were all tested before breakfast in order to have similar absorption curves, and at the same hour of the day, actually in the morning between 8 and 10 to control circadian influences on performance.

Before starting the experiment, the subjects were familiarized with the apparatus. They had ten minutes exercise during which no critical periods were present. Half an hour before starting the experiment they were served a drink which
TABLE II  Age Distribution of Subjects in the Three Experimental Conditions

<table>
<thead>
<tr>
<th>Conditions</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low dosage</td>
<td>2</td>
<td></td>
<td>3</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>'High' dosage</td>
<td>5</td>
<td>1</td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

they were told contained a small dose of alcohol; a dose that would not yield a blood concentration too high to allow driving\(^4\). The subjects were also told that the aim of the experiment was to study low alcohol dosages as there was still some uncertainty as to their effects.

In the first or placebo condition, a drop of alcohol was spread on the surface of the drink so that subjects could smell it and have the impression of having received some alcohol. In the second condition, the low dosage condition, we wanted to reach a BAC of 25 mg/100 ml, and in the third condition, the 'high' dosage condition, where we wanted a dosage of 60 mg/100 ml, we used the Widmark's ratio to compute the alcohol quantity to be served. Immediately after having carried out the experimental task, the BAC was determined by measuring the alcohol concentration in the breath using a Photo-Electric Intoximeter\(^5\) (6). In the placebo condition we obtained a mean value of 2 mg/100 ml; in the low dosage condition a value of 24 mg/100 ml with a standard deviation of 2.4 mg and in the high dosage condition a value of 57 mg/100 ml with a standard deviation of 5.5 milligrams.

RESULTS

We separately considered the number of errors and the duration of errors and we did so for non-critical periods and likewise for critical periods. In Figure 3 are shown the total number of errors and the total duration of errors made during the non-critical periods for each subject. Figure 4 shows the mean number of errors and their mean duration per critical period, also for each subject.

Of course, our hypothesis was that there should have been some deterioration of performance in the high dosage condition, when compared with the placebo condition. For the low dosage condition our hypothesis was rather in the direction of a higher performance in comparison to the placebo condition. We were indeed impressed by laboratory studies (4, 7, 10) which showed that small doses of alcohol sometimes enhance performance.

Statistical comparisons were carried out on the data presented in Figures 3 and 4. Analyses of variance, carried out although the F-ratios between some conditions amounted to significant values, did not show significant differences between conditions.

\(^4\)In Belgium, people are not allowed to drive with BAC of 80 mg/100 ml or more. From 150 mg/100 ml on they are punishable and may be considered guilty without further proof in cases where they are involved in an accident. Presently the Government is considering a modification of the law in order to make driving with a BAC of 80 mg or over punishable as in other European countries.

\(^5\)This apparatus is manufactured by Intoximeters Incorporated, Locust Street 1901, St. Louis, Mo. 63103.
On the other hand, inspection of Figures 3 and 4 shows clearly that there are no differences between the numbers of errors in the different conditions, but that there is at least a strong tendency towards larger error duration scores in the high dosage condition, compared to the placebo condition, especially for the critical periods. Actually, a t-test between error duration scores from the placebo condition and from the high dosage condition for the critical periods, amounts to 2.085 which is significant at the 0.025 level (one-tailed test). The Mann-Whitney U-test yields a value of 41, which is significant at the 0.05 level (one-tailed test).

Consequently, we may conclude that there is at least a strong tendency to deterioration of performance in the information processing task used, by BACs between 50 and 60 mg/100 ml. In this experiment there was no enhancement of performance in the low dosage condition.

When we analyse the deterioration of performance in the high dosage condition we see that there is no difference in the frequencies with which the subjects in the three conditions go off the road, but the time during which they remain off the road increases in the high dosage condition. This seems to fit with the general idea that within the information processing system, the decision making or response choice subsystem deteriorates under the influence of alcohol. Because the direction of the curving 'road' on the computer display cannot always be anticipated, every subject makes some errors. However, correcting these errors requires an efficient choice of responses and this seems to become more difficult under the influence of alcohol. It must be stressed that this interpretation was formulated after the experiment.
Comments and Further Analysis of the Data

We further analysed our data in different ways. It must be pointed out that the following are to be considered only as a basis for new hypotheses.

As we already remarked, the dispersion of the scores varies in the different conditions. The F-ratios between high dosage and placebo conditions are significant for error-number and error-duration scores in both critical and non-critical periods. Between low dosage and placebo conditions the F-ratio does not attain the 0.05 level of significance except for the error number scores during non-critical periods.

The effect of alcohol on performance seems to vary greatly with the individual, at least when small doses are taken. This is, of course, a well known fact. In the study of Drew et al. (3) for instance, ten subjects out of 40 made less tracking error under the influence of alcohol than when sober.

Within each condition we divided our subjects into two groups according to whether they obtained a score above or below the median value on an introversion-extraversion scale. The scale used was part of a Dutch personality questionnaire, constructed by Wilde (9) and largely inspired by the Maudsley Personality Inventory and the Two-Part Personality Measure of Heron. Analysing our data in this way, we did not find any difference in performance between extraverts and introverts under the influence of alcohol.

A similar analysis of our data was carried out after dividing our subjects into a group of younger and a group of older ones within each condition. Figures 5 and 6 shows the results. On inspection of these figures it seems clear that the performances of older subjects decrease from the placebo condition over the low dosage to the high dosage condition. On the other hand, the reactions of younger subjects do not change over the different conditions.
TOTAL NUMBER OF ERRORS
Younger Subjects=(18-20) Older Subjects=(21-28)
Placebo
Low dosage
High dosage

TOTAL DURATION OF ERRORS
Younger Subjects=(18-20) Older Subjects=(21-28)
Placebo
Low dosage
High dosage

Figure 5 Results of younger and older subjects during noncritical periods.

For the older subjects the differences between the placebo conditions and the high dosage conditions are always significant at least at the 0.05 level (two-tailed tests), using t-tests as well as using Mann-Whitney U-tests. Differences between placebo and low dosage conditions are also significant in most cases and for our most sensitive performance measure, i.e., the mean duration of errors during critical periods, even the 0.01 level is obtained (two-tailed t-test and Mann-Whitney U-test).

For the younger subjects there are no significant differences. One may wonder whether very young adults really are more difficult to influence by alcohol and also whether the low significance level we obtained in our experiment was brought about by their inclusion in our experimental groups.

CONCLUSION

The present laboratory study, corroborating by and large results obtained in previous studies, e.g. (3), seems to yield evidence that people under the influence of alcohol
MEAN NUMBER OF ERRORS PER CRITICAL PERIOD

Younger Subjects = (18-20)  
Placebo  
Low dosage  
High dosage
3 4 5 6 7 8 9

Older Subjects = (21-28)  
Placebo  
Low dosage  
High dosage
4 5 6 7 8 9 10

MEAN DURATION OF ERRORS PER CRITICAL PERIOD (IN SECONDS)

Younger Subjects = (18-20)  
Placebo  
Low dosage  
High dosage
0.2 0.4 0.6 0.8 1.0 1.2 1.4

Older Subjects = (21-28)  
Placebo  
Low dosage  
High dosage
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8

Figure 6  Results of younger and older subjects during critical periods.

doses of e.g., 60 mg/100 ml or even less, (25 mg/100 ml if we consider only the results from our older subjects), become slower in handling situations that require swift changes in their response choices. It seems further evident that some critical traffic situations require such quick decision making.

Finally, it must be remembered that perhaps even more important than decreased rate of decision making or response choice as cause of accidents, are emotional changes and the risk taking brought about by alcohol (2).

REFERENCES


