EFFECTS OF CAFFEINE OR DIAZEPAM ON SUBSIDIARY REACTION TIME IN A LONG-TERM DRIVING TASK

Hans-Olof Lisper, Jan Törnros and Jim van Loon
Department of Psychology, University of Uppsala
Box 227, S-751 04 Uppsala, Sweden

The effect of drugs in combination with long-term driving is very little investigated. In a review of fatigue and driving by Lisper (1977) five such studies were presented. Four of these were concerned with stimulating drugs such as caffeine (Laurer & Suhr, 1958, 1959; Regina, Smith, Keiper & McKelvey, 1974) and amphetamine (Safford & Rockwell, 1967). The only study (Bodén & Dureman, 1970) dealing with the potentially negative interaction between long-term driving and drugs was done in a rather unsophisticated simulator. Furthermore, the effects of the drug (diazepam) was not isolated from the effects of sleep deprivation.

The lack of research on this combination is very unfortunate, since the validity of the existing research on drugs in laboratory tasks can really be questioned and studies on short-time driving tasks could be questioned on other grounds (see Lisper & Stening, 1980). In fact the extension over time might give results completely other than short-time driving studies. A short test with maximal effort put into the task by the subject is quite another thing than the monotony of normal highway driving. The main purpose with the present study is to extend our studies on fatigue in realistic driving tasks (e.g. Lisper, Dureman, Ericsson & Karlsson, 1971; Lisper & Ericsson, 1980) to the interaction between a stimulating drug (caffeine) or a tranquilizing drug (diazepam) and long-term driving.

Also the important problem of predicting drug effects from laboratory test-data will be investigated. Since it is impossible to test all drugs in realistic driving, the assessment of the effects
on driving ability must today and in the future rest on findings from laboratory tasks, clinical evidence and physiological or neurological effects of drugs. However, these predictors are very, very seldom validated. The predictor used in the present study is a reaction (RT) task of 10 min duration developed by Lisper and Kjellberg (1972). This task has been used by Gamberale (e.g. Gamberale, Lisper & Anshelm-Olson, 1976) to test the effects of solvents, by Wilkinson (e.g. Hart, Hill, Bye, Wilkinson & Peck, 1976) to test the effects of drugs and by Taub (e.g. Taub, Tanguay & Rosa, 1977) to test the effects of different sleep schedules. The task has two important features; it is sensitive effects on the level of RT and although short, it has much in common with the considerably longer vigilance tasks.

Another source of information used to assess the effects of drugs is subjective reports by the patient. This information is not only important when assessing if a specific drug in general has negative effects on driving performance, but it is also in the interest of the individual patient to assess the effects of the specific drug on his immediate performance: "How do I feel, is it safe to drive?" This matter is taken into consideration by having the subjects assess the phenomenological aspects of the drug on an inventory of self-reported arousal developed by Bohlin and Kjellberg (1973).

Finally a physiological measure, heart-rate is evaluated in the present study. Heart-rate is frequently used as a physiological indicator of arousal and is as such used as an indirect measure of driving performance (e.g. Harris & Mackie, 1972). However, in our own studies (Lisper, Laurell & Stening, 1973; Laurell & Lisper, 1976; Fagerström & Lisper, 1977) heart-rate has been unequivocally invalidated. The present study is a new test of heart-rate as an indirect measure of driving performance.

**Method**

**Subjects:** Six female university students, between 22 and 26 years of age, participated as paid subjects. Their driving experience during the prior six month period ranged between 1,000 and 3,500 km.

**Apparatus:** The experimental vehicle was a 1970 manual transmission Volvo 145 Express estate car. The RT to the tone inside the car was recorded as follows: A starting impulse was initiated by bistabile
timer with 22 different interstimulus intervals. The average interval was 50 s, the longest being approximately 2 min and the shortest approximately 10 s. This impulse started simultaneously a 90 dB/1000 Hz signal generated by an AC-oscillator, and amplifier, and a loudspeaker 20 cm behind the back of the driver’s head. The tone started an electronic timer with a resolution time of 1/1000 of a s. The subject responded to the tone by pressing a foot switch as fast as possible with the left foot. This switch was constructed in such a way that the subject could rest the left foot on it continuously. The pressing of the switch stopped the timer, which was scanned by a search unit, and finally the RT was printed by an Addo-X printer. The driver’s heart-rate was sensed by microelectrodes, two placed on the chest and the third on the back. The electrodes were connected to an EKG device and heart-rate was recorded from a digital display with an integration time of 60 s.

The 10-min RT-task was done in a 1.5 X 2.0 X 2.0 m semisoundproof chamber, which was dimly lit during the experiment. The subject were comfortably seated in a half-reclining position in an armchair and were instructed to press a microswitch, held in the preferred hand, as rapidly as possible when they heard an auditory signal. This response terminated the signal, which came from a loudspeaker, placed in front of an above the subjects. The signal was a 1,000 Hz tone produced by an Oltronix RC-oscillator Type RC0-6K and having the intensity 70 dB re .0002 dyn/cm² measured at the place of the subject’s head. The mean interstimulus interval was 3.75 s with a variation of ± 1.25 s. Eleven interval were used all with the same probability, and the order between them was randomized over the 10-min watch. The subject’s RTs were recorded in 1-ms units by an electronic timer, and were then printed on an ADDO-X printer.

The phenomenological aspects of the drug treatment was measured by an inventory of self-reported arousal developed by Bohlin and Kjellberg (1973), yielding six different factors. The inventory is an elaboration of Thayer’s Activation-Deactivation Check List.

Procedure: The experiment was double blind with three conditions: placebo, 100 mg caffeine, and 10 mg diazepam, administered at weekly intervals. The subjects participated in all conditions, the order of which was varied so that all possible orders were included. The
sessions started between 0815 and 1130. The difference in starting time was due to subjects' other activities. Every session started with the subjects filling in the inventory of self-reported arousal. Two capsules were then swallowed with a glass of water. After that there was a training period of 40 min with driving on the motorway with the RT-task. When returning to the laboratory the self-reported inventory was filled in for the second time, and then they had the 10-min RT-task. The next point on the programme (about 90 min after taking the drug) was driving for three hours on the motorway between Uppsala and Stockholm, two trips of about 130 km giving a total distance of 260 km. RT was measured continuously, the maximum speed was 90 km/h, and the distance was driven without a pause. Conversation with the experimenter in the car was avoided. After returning to the laboratory the inventory of self-reported arousal was filled in for the third time, and last the 10-min RT-task was repeated. In the instructions to the subjects we stressed that traffic safety had highest priority and that driving should be interrupted if the subjects felt any risk whatsoever.

Result

From Figures 1 and 2 it is evident that the drugs used affected RT-performance while driving and in the 10-min RT-tasks before and after driving. While driving the effect of diazepam was evident from from the first to the last time-period and caffeine gave shorter RTs during the first half of the trip. In the 10-min tasks there was no difference between conditions for the first min. The effects of diazepam was found in the subsequent mins. No effects of caffeine was found in the 10-min tasks. Table 1 shows that these effects were

Insert Figure 1 and 2 about here

Insert Table 1 about here

significant. The difference between diazepam and placebo was valid for all subjects (see Figure 3) and was tested separately [while driving: $t(5) = 2.11, p < .05$, one-tailed test; RT-task before driving: $t(5) = 2.06, p < .05$, one-tailed test]. Furthermore, in the diazepam
condition subjects A and D had to interrupt driving half-way, due to sleepiness. Also the difference between placebo and caffeine during the first four time periods was tested \( t(5) = 1.76, \ p<.10, \) one-tailed test.\]

Figure 4 shows that heart-rate decreased in the placebo and caffeine conditions, and increased in the diazepam condition. The difference between conditions was due to a rather large increase in heart-rate found in the diazepam-condition in subject B (from 66 to 108) and was consequently not significant.

Figure 5 shows the changes in self-reported arousal. There were significant effects over the three instances of for energy and wakefulness \[ \text{less energy: } F(2,10) = 4.65, \ p<.05; \text{lowered wakefulness: } F(2,10) = 6.77, \ p<.05 \text{ at the end of the experiment}. \] Only the estimation of stress showed a significant effect of drugs, an interaction drug X time \( F(4,20) = 5.89, \ p<.01. \)

**Discussion**

From the result it is evident that the drugs used affect RT during driving. Diazepam gives longer RTs already from the beginning of the three hour trip, and caffeine gives shorter RTs during the first half of the trip. It is worth noting that the effects of diazepam was valid for all six subjects and not difficult to detect in the individual data. The effect of diazepam is on the level of RT and not on the rate of decrement as a function of time of driving, as we have found in our previous studies on fatigue and driving (e.g. Fagerström & Lisper, 1977; Lisper & Eriksson, 1980). However, considering the fact that during the first minute on the 10-min RT-task before and after driving there was no difference between conditions and that driving 30 km (our 20-min period) sometimes might be tiring, it is possible
to retain the hypothesis that the effect of 10 mg of diazepam is an interaction with time of driving. This is a theoretical question too complicated to be discussed in the present applied setting. However, we believe that the effect of diazepam found in the present study is not necessarily incompatible with "normal" fatigue.

What does the increase in subsidiary RT mean? Are the statistically significant longer RTs also of practical significance? That subsidiary RT is related to at least some aspects of driving performance was shown by Laurell and Lisper (1976). They demonstrated that RT was correlated \( r = -0.78 \) with detection distance to obstacles in night driving. It is also possible to find a discussion of how great an increase in RT one can accept. In a report by Lisper and Eriksson (1977) an increase of 100 msec was chosen as a critical limit, when to decide how many of 48 truck-drivers had difficulties driving what the Swedish law permits, i.e. 6 + 5 hours. An increase of 100 msec corresponds to a 50% decrement in detection distance (from 30 to 15 m) in the study by Laruell and Lisper mentioned above. They furthermore used data from a study by Lisper, Laurell and van Loon (1974). In this study the subjects drove on a closed track until they dropped off to sleep. Down to this point RT increased with about 200 msec. Thus an increase of 100 msec is half-way to sleep. The subjects in the present study give results that approach a difference between placebo and diazepam of this size. For three of our subjects the difference between placebo and diazepam was greater than 100 msec. A prerequisite for limits of non-acceptable decrements in drug studies, is that these studies are included in a series of studies using identical measures, such as our studies with subsidiary RT. An important component in such a series are the validation-studies. It is quite evident that substantially more research is needed to find measures of driving performance, to validate subsidiary measures of driving performance, and finally to establish limits for decrements that cannot be accepted. The documentation of critical limits is very important for road-traffic legislation and for the documentation when applying for registration of new drugs.

It is also important to intensify research on the validity of the laboratory measures used to predict effects on driving performance. Laboratory tests are needed to test new drugs, since it is quite
impossible to do fullscale traffic tests of all new drugs. However, it is relevant to demand data on the validity of the tests used to evaluate the potential traffic risk of a new drug. Such data are very seldom presented. The 10-min RT-task used in the present study seems to work quite well. The effect was on level of performance, and in similarity with the driving task all subjects were affected. Could the effect of 10 mg diazepam be predicted from other laboratory studies? From a review by Kleinknecht and Donaldson (1975) the present effects on driving performance could not be predicted. They summarize: "In all it appears that diazepam, and its metabolites, have little or no effect on simple reaction time measures". To find effects on laboratory tasks at all the dosage must be above 10 mg. On the other hand Hill, Bye, Wilkinson and Peck (1976) have with a modified version of the 10-min RT-task found effects of 5 mg diazepam and using a 60 min auditory vigilance task they found effects of as little as 2.5 mg of diazepam. If we have effects on fullscale driving with these comparably small doses remains to be seen. In the present study we found positive effects of caffeine while driving, but comparable results were not found on the 10-min RT-task. Consequently we are only able to say that further validation studies are needed to determine if the 10-min RT-task is a valid predictor of drug effects on driving performance.

Without any further research it is possible to declare one of the measures used in the present study as invalid. That is heart-rate. As in our earlier studies (Lisper, Laruell & Stening, 1973; Laurell & Lisper, 1976; Fagerström & Lisper, 1977) heart-rate decreases as a function of time driving. However, there are no meaningful relations between heart-rate and our performance measure and the possible effects of the drugs used.

The subjective estimation of drug effects gave somewhat astonishing results. Only the stress-factor showed significant effects of drugs. However, this is to be expected knowing the intention with the drugs used. Apart from the lack of significant effects on the other five factors the difference as it can be seen in actual numbers were quite small. In fact none of the subjects would have from their assessment of their condition hesitated to drive. None of the subjects did show an inclination to refrain from driving in spite of the fact that they
were cautioned about the risks involved and that the experiment came second to traffic safety. The small effects are especially astonishing considering the fact that they before filling in the inventory had gone through 40 min of driving with RT, a possible feedback of performance. In spite of this they could not foretell that their performance would be deteriorated. It can thus be concluded that prediction of performance capacity from subjective feelings might be quite difficult. This is a very important finding, since from a legal point of view the decision to drive or not when taking prescribed drugs rests on the individual driver. If our findings are correct the situation for the drug consumer is very difficult. He can feel quite all-right when he starts, but might find great difficulties staying awake after only 10 to 20 minutes of driving. It is also possible to reverse the problem; does an evident change in feelings predict lowered performance capacity? This is not documented. Obviously more research is urgently needed on the relation between drugs, performance, physiology and subjective assessment of performance capacity.

References


Table 1. Analysis of variance of reaction time and heart-rate while driving and RT in 10-min task before and after driving.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F-value</th>
<th>df</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time blocks (T)</td>
<td>7,35</td>
<td>1.33</td>
<td>9,45</td>
<td>4.73 xxx</td>
</tr>
<tr>
<td>T linear trend</td>
<td>1,35</td>
<td>8.37 xx</td>
<td>1,45</td>
<td>34.41 xxx</td>
</tr>
<tr>
<td>Drug (D)</td>
<td>2,10</td>
<td>5.07 x</td>
<td>2,10</td>
<td>6.19 x</td>
</tr>
<tr>
<td>TXD</td>
<td>14,70</td>
<td>&lt;1</td>
<td>18,90</td>
<td>&lt;1</td>
</tr>
<tr>
<td>TXD linear trend</td>
<td>1,70</td>
<td>1.57</td>
<td>2,90</td>
<td>2.21</td>
</tr>
</tbody>
</table>

* p<.05; ** p<.01; *** p<.001
Figure 1. Changes in arithmetic means of reaction time over successive 20-min periods of driving (upper figure) and over successive 1-min periods in the 10-min RT-task before driving (lower figure).
Figure 2. Changes in arithmetic means of reaction time over successive 1-min periods in the 10-min RT-task after driving.
Figure 3. Changes in individual subjects' reaction times in driving and in the 10-min RT-task before driving. Figures at the right side of driving task lines show changes in the subjective estimation of wakefulness (average of the group before taking the drug 12.5).
Figure 4. Changes in heart-rate over successive 20-min periods of driving. T-values represent training period.
Figure 5. Changes in self-reported arousal. First point before taking the drug, second point before starting driving, and third point after driving.
MENTAL TASK TEST AND HEART RATE LEVEL IN ALCOHOL INTOXICATION PROCESS

Hiroshi TAKAHASHI, M.D.
National Institute of Mental Health.
1-7-3 Konodai, Ichikawa, Chiba, Japan.

Drinking experiment were carried out on male payed volunteers, recording polygraphy (EKG, cardiotachogramme, pneumogramme, etc.) continuously during all the experimental course, and setting various mental tasks intermittently and repeatedly.

Experiments lasted for 5 to 6 hours. Subjects at first took lunch at about 11:30, then finished a set of mental tasks, before alcohol, then they were given 120 ml of whisky, with a cup of water. After alcohol was drunk, an other series of mental task were given repeatedly, and blood letting for blood alcohol level evaluation also repeated.

One of these adopted mental tasks ia Random Number Generation Test (RN Test) which is originally developped by one of our colleague. This test has the characteristics of simple procedure and repeatability without learning effect.

Subjects were divided into two groups by changes of heart rate level after alcohol intake. In one group, Group A, the change for rise in heart rate level was considerably great, and in the other, Group B, the change was slightly or rather negative than before alcohol.

As to the results of RN test, in Group A the result was remarkable poor after alcohol, and in the other side, in Group B, the results was unchanged or rather improved than that of before alcohol.

The curve of change in heart rate level corresponds generously to that of blood alcohol level. Therefore, the heart rate level and the result of RN test are regarded as some of the indicators of alcohol