Effects of Cannabis and Amphetamines on Driving Simulator Performance of Recreational Drug Users in the Natural Field

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Abstract

In 1998, a field study funded by the Federal Highway Research Institute (BAST) of Germany was conducted with drivers at discotheques. Subjects were contacted by researchers from the Center of Traffic Sciences, Wuerzburg (IZVW) and asked to participate in a short interview concerning drugs and driving. Subjects who had consumed drugs and had either been driving, were going to drive or indicated that they had been driving under the influence of drugs at other occasions were asked for an extended interview, a driving-simulator test and for blood, urine and saliva samples (N = 241). Additionally, sober control subjects (N = 59) and subjects under the influence of alcohol (N = 45) were included.

The study examines the effect of cannabis (two groups: acute and previous consumption) and amphetamines and ecstasy (two groups: low and high concentration) alone and in combination with alcohol on driving performance. Driving performance was analyzed be means of a driving-simulator which evaluates the ability to maintain lateral position and speed, tests peripheral and central attention and risk-taking behavior. The analyses show that consumption of cannabis and amphetamines / ecstasy, only, does not adversely affect driving behavior. However, the combination of the two substances with one another and or alcohol leads to a substantial impairment of driving and performance in secondary tasks.

Introduction

Evaluating the influence of drug use on driving behavior and traffic safety is still a difficult issue in spite of extensive research conducted in laboratories, because this research is restricted in several ways: (1) Most subjects are young healthy males, who are not regular drug users. (2) Drug concentrations used are low to moderate. (3) Sample size is usually small. (4) The validity of the tests used with regard to traffic safety is not clear. (5) The test situation in the laboratory results in an increased effort by the subjects to compensate for drug effects. Due to these restrictions, drug effects may not be detected. Moreover, the validity of any result is questionable. The present study aims to avoid some of these shortcomings: Recreational drug users were selected and tested in front of discotheques while being under the influence of drugs and, at the same time, were either driving a vehicle or indicated that they had been driving under similar circumstances. For the testing, a driving simulator was adapted to include sub-tasks which reflect different aspects of drug-related disturbances of performance. The testing was conducted in a social situation which is quite similar to driving with a passenger.

By means of this procedure, the drug concentrations examined in this study represent typical concentrations used. The subjects are typical recreational drug user. The testing is done at times and places where driving under the influence of drugs takes place. Therefore, this approach may give a more valid picture of the effect of drugs on traffic safety.

Method

Procedure and Subjects

The study was conducted in three larger cities in Bavaria, Germany (Munich, Nuremberg and Wuerzburg). In and around these towns, 29 discotheques were selected where a large part of the visitors attended by car and where experts rated drug use as highly probable. Between July and November of 1998, 66 events were visited. 54.5% of those were so-called Techno-Parties where amphetamines and ecstasy were supposed to be the dominant drugs. The other 45.5% consisted of Heavy Metal, Independent and various events with cannabis as the dominant drug. 62 of the events took place on Friday or Saturday night. Depending on the time schedule of the discotheques, the investigation times were either between midnight and 6 a.m. or between 10 p.m. and 4 a.m.

For the investigation, a camper van was used where a driving simulator was installed. Additionally, two tents were erected for an extended interview and a medical examination. A research team consisted of 6 researchers. Two of these conducted short interviews with potential subjects in order to select participants for the intensive investigation. One researcher performed an extended interview, another attended the driving simulator. A fifth researcher provided coordination between the different researchers. A medical doctor took blood, urine and saliva samples and conducted a short medical examination.

In order to find the subjects of interest, different selection criteria were defined: First of all, when researchers contacted a group of incoming or leaving people, they asked who the driver was and selected him or her for the short interview. If no driver was present, people were asked if anybody was driving regularly at comparable events (but just not today). Thus, either a driver or a potential driver were selected for the short interview.

In the short interview, subjects were asked about drug use and driving under the influence of drugs. The answers provided the basis for the second step of the selection process. First of all, subjects under the influence of drugs were selected. Additionally, five groups of control subjects were searched for: a performance control group (no drug use during the last year), an alcohol control group (BAC between 0.03% and below 1.1%), a group of drug users currently not under the influence of drugs (long-term effects of drug use), drugs users and drivers who do not, however, drive under the influence of drugs, and subjects admitting driving under the influence of alcohol. The latter two groups were not examined in the driving simulator but just questioned extensively (for the results, see (1) in this volume). Subjects meeting those criteria were asked to participate in the intensive investigation including driving simulator, extensive interview and medical examination. For the extensive investigation subjects were rewarded with DM 60 (about $30 US).

Overall, 3081 subjects were selected for the short interview and 2779 participated (90.2% responder rate). From these, 832 were asked to participate in the extensive investigation and 503 took part in at least some parts of the investigation. From 414 subjects who were asked to drive the simulator, valid data from 342 subjects were sampled (the majority of the rest refused, most due to lack of time).

For the present paper, only those subjects were selected who had consumed either cannabis or amphetamines / ecstasy (a distinction between these two drugs was not possible due to sample size) and where a blood sample could be used to analyze drug concentration. For cannabis, two groups were distinguished with regard to the time of drug consumption: When THC was found, consumption was quite recent (THC group). When THC-COOH, only, was found, consumption had occurred some time ago (COOH group). For amphetamines / ecstasy, two

groups were defined with regard to drug concentration. In the low concentration group, the sum of active substances was less than 0.05 mg/l. In the high concentration group, concentrations were larger than 0.05 mg/l.
Table 1 gives the numbers of subjects for the different groups resulting from this distinction. With regard to these number, the effect of cannabis and amphetamines / ecstasy alone and in combination with alcohol can be analyzed. However, the analysis of the combination of the two drugs and alcohol is hindered because some combinations were found too seldom. Thus, the effect of cannabis (THC and THC-COOH) combined with high concentrations of amphetamines / ecstasy may be analyzed as well as the combination of THC with high concentrations of amphetamines / ecstasy and alcohol. All other comparisons are not feasible. Thus, an overall of N = 191 subjects are included in the following analyses.

Table 1: Number of subjects in the different groups used in the analyses below. Numbers in brackets indicate that the subjects were not included in the analyses because the sample was too small.

		Amphetamines / Ecstasy		
		No Amphetamines / Ecstasy	Low Concentration	High Concentration
Sober	No Cannabis	37	6	7
	THC	9	(3)	9
	COOH	14	(1)	7
Alcohol	No Cannabis	34	4	9
	THC	16	(2)	5
	COOH	34	(0)	(3)

The driving simulation

In order to gain an accurate view of the performance decrement due to drug effects, a driving simulator developed by Krueger & Reiss (2,3) was adapted by Vollrath taking into account the results of meta-analyses of the effects of alcohol, cannabis, amphetamines and ecstasy (4,5, 6,7). The simulator consists of a Pentium type PC with a 15'' monitor and a commercial joystick steering wheel. The main task of the subjects consists of holding a car in the middle of a lane while driving a curved road with a speed limit of 80 km/h. At random time points, four additional tasks are presented: When an acoustic signal is presented (resembling an ambulance horn) the subject has to break as fast as possible (simple reaction). At certain points of the simulation, two traffic lights (one at each upper corner of the screen) begin to switch colors. When both signals are red, a bar appears directly in front of the car. Only by reducing speed in advance, an accident can be prohibited. In order to do this, peripheral attention is needed to watch the traffic lights. When a stop signal appears, the driver has to stop directly in front of the sign (controlled reduction of speed). Afterwards, a crossroad is presented with cars crossing. The subject has to wait until the gap between two cars seems large enough to allow crossing and has then to actually cross the street (risk-taking behavior).
For the aims of presenting the results, the parameters measured in these situations are combined. In order to find a valid combination, 34 student subjects performed the simulator test in the laboratory. By means of factor analyses three factors were extracted representing performance. These three factors were cross-validated in the sober control subjects in the field where

a nearly identical solution could be found. The three factors are 'speed' (mainly average speed), 'lateral position' (mean and standard deviation of the deviation from the lane) and 'reaction in secondary tasks' (the percentages of accidents at crossroads, with peripheral warning and at stop signs and the simple reaction time). The effects of the drugs examined are described in terms of these factors. For computing the factor scores, the mean and standard deviation of the sober control group was computed for every parameter. Afterwards, the parameter values were z-standardized using these means and standard deviations. The factor scores were computed by averaging the appropriate z-values.

Results

In a first step, the effect of each drug on the three factors was analyzed by means of t-tests comparing subjects under the influence of the drug to sober control subjects (e.g., N = 9 subjects with THC to N = 37 control subjects, see Table 1 above). For THC-COOH, speed ($p = 0.002$) and lateral position ($p = 0.004$) are changed while there is no effect on reaction. Figure 1 shows the appropriate means. Subjects under the influence of THC-COOH drive more slowly and are better able to keep the lane. For THC, a comparable effect is found for lateral position ($p = 0.023$) and no changes in speed or reaction.

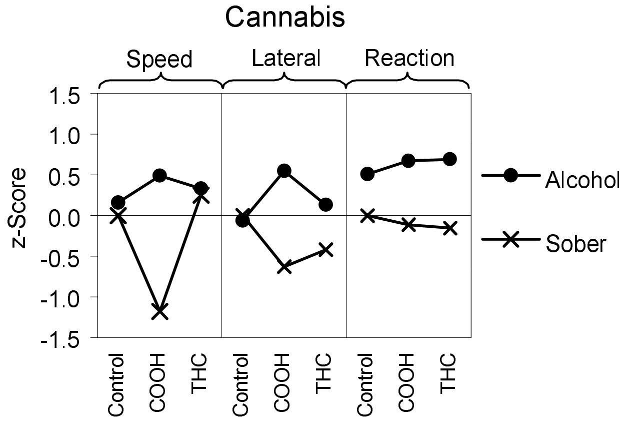

Figure 1: Effect of cannabis with and without alcohol on speed, lateral position and reaction.

The effect of introducing alcohol was tested by means of two-way ANOVAs for each factor and drug. For the COOH group, significant interactions between alcohol and drug result for speed ($p = 0.001$) and lateral position ($p = 0.026$) indicating that alcohol reverses the positive effects of THC-COOH. Subjects under the influence of alcohol and THC-COOH drive faster and deviate more from the lane than sober subjects and subjects under the influence of alcohol. For reaction, a main effect of alcohol is found ($p = 0.001$) indicating a decay of performance in secondary tasks due to alcohol. Again, a similar picture is seen in the THC group. When THC is combined with alcohol, lateral position is negatively affected (interaction: $p = 0.085$). However, the effect is not as strong as for THC-COOH. No change is found for speed. Reaction in secondary tasks is affected by alcohol (main effect : $p = 0.000$).

For amphetamines and ecstasy, speed is somewhat increased by the high concentration (see Figure 2; $p = 0.093$). The lateral deviations are decreased by low concentrations ($p = 0.018$). When low concentrations and alcohol are combined, lateral deviations increase (interaction: $p = 0.022$). A trend is found for an interaction between alcohol and high concentrations in the reactions: While alcohol and

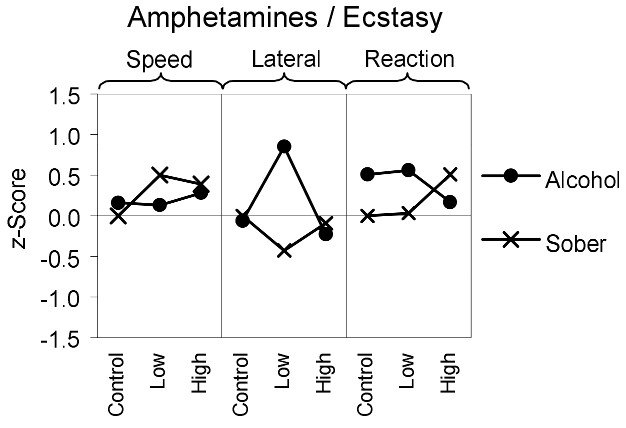

Figure 2: Effect of amphetamines and ecstasy with and without alcohol on speed, lateral position and reaction.

amphetamines / ecstasy in high concentrations each impair performance in secondary tasks, the performance level is quite comparable to sober when alcohol and amphetamines / ecstasy are combined (interaction: $p = 0.065$).

The combination of amphetamines / ecstasy and cannabis can only be analyzed for high concentrations of amphetamines / ecstasy (two-way ANOVAs including both drugs as factors). In the THC-COOH group, a main effect of cannabis is found for speed ($p = 0.011$) indicating a general reduction in speed by this drug (with and without amphetamines, see Figure 3). Amphetamines / ecstasy increase speed (with and without cannabis; $p = 0.005$). For lateral position, a main effect of amphetamines / ecstasy ($p = 0.034$) as well as an interaction ($p = 0.015$) is found. THC-COOH decreases deviations while amphetamines / ecstasy do not change lane position. When combined, a large increase in deviation results. Finally, performance in secondary tasks is impaired by amphetamines / ecstasy ($p = 0.030$). For the THC group, only the impairing main effect of amphetamines / ecstasy on reaction in secondary tasks is significant ($p = 0.007$).

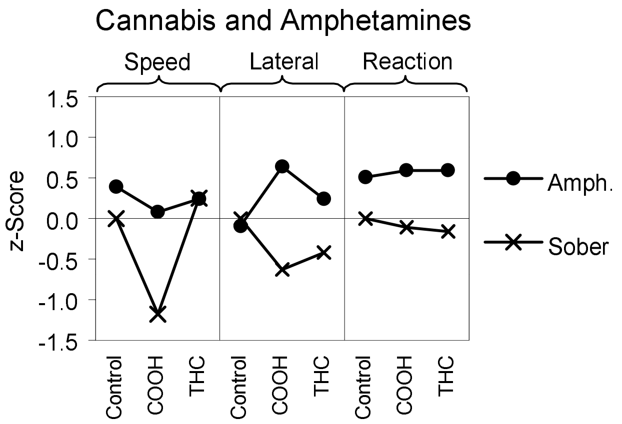

Figure 3: Effect of high concentrations of amphetamines and ecstasy with and without cannabis on speed, lateral position and reaction.

The analysis of the combination of cannabis (THC group, only), amphetamines / ecstasy in high concentrations and alcohol was done by means of a three-way ANOVA for each factor. A significant main effect of alcohol on reaction was found ($p = 0.041$) and a trend for a main effect of amphetamines / ecstasy on reaction ($p = 0.075$). The results are depicted in Figure 4. Performance in secondary tasks deteriorates when alcohol or amphetamines / ecstasy are present. When both substances are combined, the effect is not as strong as when taken single. Adding THC does not alter these effects for sober subjects. However, when THC and alcohol and amphetamines are combined, the largest performance decrements result.

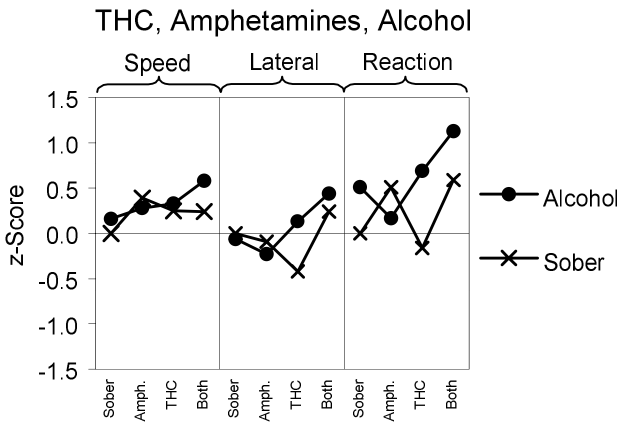

Figure 4: Effect of high concentrations of amphetamines and ecstasy in combination with THC and with and without alcohol on speed, lateral position and reaction.

Discussion

When cannabis was consumed very recently (as indicated by the presence of THC in blood) lane keeping performance improves and neither speed nor performance in secondary tasks is affected. When cannabis consumption lies some time back (as indicated by the presence of THC-COOH), the improvement of lane keeping gets even stronger. Moreover, speed is reduced. When alcohol is consumed additionally, these positive changes are reversed and reaction in secondary performance deteriorates. These effects are especially strong for the THC-

COOH group. A similar change results from combining cannabis with amphetamines and ecstasy in high concentrations. Lane keeping performance is worse than in sober subjects when both substances are combined. The deteriorating effect of amphetamines / ecstasy remains also when combined with cannabis. Thus, while for cannabis use alone no impairment of driving performance was found (and even an improvement for THC-COOH), the combination of cannabis with alcohol and / or amphetamines / ecstasy is detrimental.
Amphetamines / ecstasy in high concentrations lead to an increase in speed without affecting lane keeping and impair performance in secondary tasks. When high concentrations are combined with alcohol, this impairment is reduced. When high combinations are combined with cannabis, lane keeping performance deteriorates. Low concentrations alone do not substantially alter driving behavior. When low concentrations are combined with alcohol, lane keeping performance deteriorates and performance in secondary tasks is impaired, however, in a similar manner as with alcohol, only.
Thus, the main problem of driving under the influence of drugs is not the consumption of a single drug but the combination of illegal drugs with one another or with alcohol. These combinations leads to performance changes which are not expected from the use of a single drug.

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