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THE COMBINED EFFECTS OF ALCOHOL AND COMMON PSYCHOACTIVE DRUGS

FIELD STUDIES WITH AN INSTRUMENTED AUTOMOBILE[1]

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Introduction

While the role of alcohol in traffic accidents is well known and documented (Waller, 1968) less is known about the manner in which alcohol impairs driving performance. The effect on driving of combining other drugs with alcohol is even less clear although combinations of drugs probably create even greater accident potential. Studies (Chelton and Whisnant, 1966, Finklé, 1969) have shown that 11-25% of drivers charged with impaired driving were using other drugs along with alcohol.

Most research done on the effects of alcohol on driving has been done in simulators or with tasks requiring skills related to driving. Mortimer (1974) showed, in a simulator study, that drivers under the influence of alcohol made more tracking errors and reduced their number of high frequency steering responses. In another simulator study by Drew et al (1959), decrements in tracking performance were found with blood alcohol concentration (BAC) levels as low as .03%. Also, with alcohol, the subjects not only made larger mean steering movements but the amount of tracking error associated with any given amount of movement was larger. This was thought to be due to misjudgement by the subjects as to the appropriate time to begin turning the steering wheel. A simultaneous tracking and monitoring task by Hamilton and Copeland (1971) showed that subjects under the influence of alcohol tended to concentrate on one channel in a divided attention task and neglect the others. Moskowitz (1971) also studied a tracking (primary) and monitoring (secondary) task. The monitoring task was a complex reaction time task (i.e., the subject had to give a response from a set of four possible responses). Decrements were found in response time to the monitoring task and in tracking performance for subjects under the influence of both marihuana (at doses as low as .5g) and alcohol (at doses as low as .04 BAC).

Very little work has been done on the effects on driving or on simulated driving of alcohol in combination with other drugs. Linnoila (1974) studied the effects of alcohol alone and in combination with diazepam (a sedative) on a simulated driving task. Subjects on alcohol drove faster than the placebo group, while subjects on alcohol and diazepam drove more slowly. Both groups overestimated their speeds.

The experiment to be described was a pilot study on the effects of alcohol (at .06% BAC) alone and in combinations with diphenhydramine (an antihistamine), diazepam (a sedative) and marihuana on both high and low speed driving in an instrumented car. Driving was also done under a placebo condition. Though the driving took place on an unopened highway, the use of opposing cars added to the realism of the driving task. A peripheral vision secondary task was used for the purpose of increasing the visual task load on the subject to the level of the normal search and recognition task performed while driving. The intention behind this study was to simply describe the changes in driver behavior

1 An article based on studies made by the National Research Council of Canada for the Insurance Bureau of Canada.
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under various drug conditions. No attempt will be made to establish the relation between the pharmacology of the drug and the physical effects it has on driving.

Subjects

Eight subjects, six male and two female, ranging in age from 19 - 27, participated in the experiments.

All subjects had used both alcohol and marihuana previously and reported having experienced a *"high"* on marihuana.

Site

The site used for the experiment was an 8.5 mile stretch of the new highway 417, in the Province of Ontario which was not open to the public at the time of the experiment.

Equipment

A large sedan-type, late model American car, instrumented to measure various driving parameters, was driven by the subject. The instrumentation included a potentiometer attached to the steering wheel to measure steering wheel position, a wheel counter operated by a light-interrupting mechanism in the right rear wheel to measure distance, a real time clock, a secondary task peripheral light situated on the dash of the car and extinguished by means of a foot pedal. A mini computer and tape recorder located in the trunk collected and stored the data.

Radio connections between the middle and one end of the track and the subject's car enabled an experimenter in the back seat of the car to start the opposing cars at the appropriate times.

Five hundred, eighteen inch pylons were used to set up a slalom course half a mile in length. The narrowest gap the subjects were required to drive through was eight feet in width. The pylon course occurred midway along the 8.5 mile test site (see Fig. 1).

Three traffic lights were installed, fifty feet apart, at one end of the test stretch. Cables across the lane at a distance of one hundred and fifty feet from each traffic light were connected to the lights. The weight of the car tires passing over the cables activated one of the three signals. The subjects were asked to stop at a white line adjacent to the traffic signal which was on.

Procedure: Administration of Drugs

The schedule by which the subjects were administered drugs allowed a run in the instrumented car to take place every half hour. Each subject made one run under one of the drug conditions each day.

Body weight was used to determine the amount of alcohol needed to bring the subject up to a 0.06% level. The alcohol was consumed in three drinks over a half hour period with a full hour elapsing after the consumption of the alcohol before driving began. For the placebo condition the subject consumed three drinks of orange juice only, over the same time period. A pill containing either sugar, or 50 mg of diphenhydramine or 5 mg of diazepam was administered 90 minutes before the driving test. Three 0.5g joints of marihuana (the placebo having the active ingredient THC removed) were smoked over a 30 minute period, 30 minutes before the driving test.

The design of the experiment was such that practice effects would be balanced over all the drug conditions.

Procedure: Driving Task

The subjects entered the car at the start point (see Figure 1) and adjusted the seat position and safety belt. An experimenter in the back seat then gave the subject instructions to put the reaction time light out as soon as it appeared by pushing a foot pedal to the left of the brake. The light appeared, on the average, once every twelve seconds, during the run. Subjects were then asked to drive at 60 mph for approximately three miles. Just before the cone course the subject was asked to slow down to 25 mph and keep the car as close to 25 mph as possible throughout the slalom course.[6] (The cones knocked over were

6 The combination of low speed and violent movements in the cone course caused the computer to lose power on almost half the runs. When this occurred, data for the remainder of the course was not recorded and the computer had to be restarted at the end of the course.

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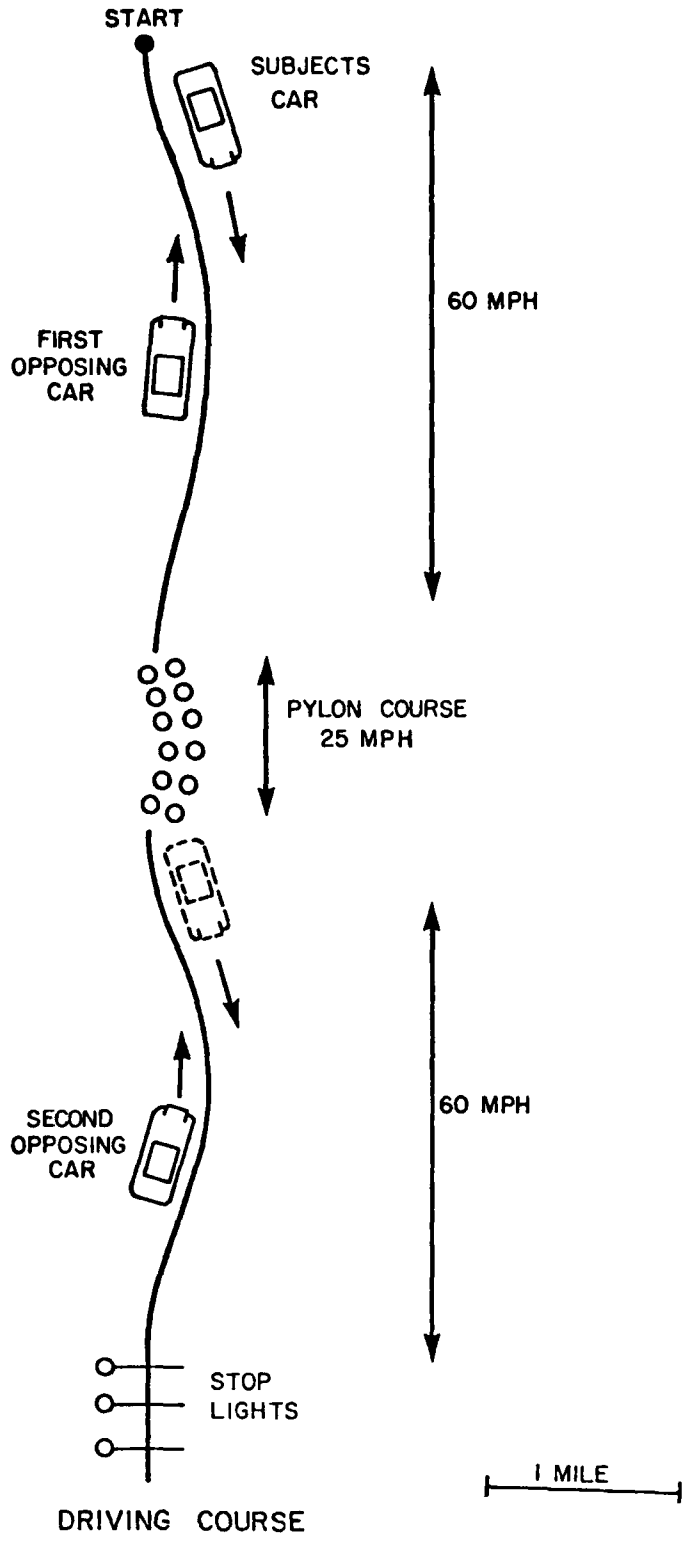

Figure 1

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counted and placed back in their original positions before the next run.) The subject then took the car up to 60 mph for another 3½ miles. At 300 yards from the traffic signals a sign instructed the driver to slow down to 30 mph. The subject was told to stop at the traffic signal which was on, with the front wheels touching the white line adjacent to the signal. The distance of the front wheels from the white line was then measured and recorded. The subject then made a U turn at a distance of several hundred yards from the stoplight. The driving task was then repeated; in the reverse order, another stop being made from a speed of 30 mph at the traffic light that was on before proceeding at 60 mph. At the start of each 60 mph section, the experimenter in the back seat of the subject's car radioed requests for an opposing car to start from the other end of the section towards the subject.

On the day preceding the experiment each subject made four trial runs through the slalom course to avoid large practice effects over the five day period of the experiment. This also allowed subjects to become familiar with driving the instrumented vehicle.

Measurements Taken

The following measures of driver performance were made: steering amplitude and frequency in the 60 mph region, steering amplitude in the 25 mph region, speed and speed variation in both the 60 and 25 mph zones, number of pylons knocked down, distance between the front tires and the white line adjacent to the traffic signal.

Results

A) Speed

Though the subjects were asked to maintain 60 mph, the average speed they did maintain was dependent on the drug condition. Subjects on the placebo drove at a higher speed than under any other condition (see Table 1 for means and levels of significance). On alcohol alone, the subjects drove at a significantly higher speed (0.05 level of significance) than on alcohol with diazepam or on alcohol with marihuana. The slowest average speeds recorded were for subjects on alcohol and marihuana. In summary, the drug conditions in order of decreasing mean speed were placebo, alcohol, alcohol with diphenhydramine, alcohol with diazepam and alcohol with marihuana. It is possible that the subjects were slowing down in response to the degree of impairment they felt. A study of the same drug combinations was carried out in conjunction with this experiment using a

TABLE 1
SUMMARY OF T-TESTS FOR SPEED DIFFERENCES BETWEEN DRUG CONDITIONS [7]

MEANS IN DECREASING ORDER

Placebo	Alcohol	Alcohol and Diphenhydramine	Alcohol and Diazepam	Alcohol and Marihuana	Level of Significance
62.93			62.31		.10
63.44				60.48	.01
	62.81		62.19		.05
	62.24			60.97	.05

7 Because of four missing data points it is necessary to show each comparison separately as the subject group differs slightly from comparison to comparison. This will, of course, be true for all other tables given.

pursuit tracking device to measure effect on performance.

In this study the subjects expressed stronger feelings of impairment on alcohol and marihuana than under any other condition which lends some support to the above interpretation.

B) Steering Movement

The measure of steering movement used in the 60 mph region was a power spectral density function of steering wheel angle. This function gives a measure of the power or amplitude in the signal (steering wheel angle over time) for each frequency level. For each subject and drug condition a power spectral density function was calculated using methods found in Bendat and Piersol (1966). The total area under the curve gives a measure of the average amplitude of steering wheel movements. One subject's results are shown in Fig. 2 with the size of the area shown under each curve. As can be seen, this subject made the largest amplitude movements under the alcohol and diphenhydramine condition and the lowest under the alcohol and diazepam condition. The drug conditions in order of decreasing mean area were alcohol and marihuana, alcohol and diphenhydramine, alcohol, placebo and alcohol and diazepam (see Table 2).

In the simulator study by Drew et al (1959), mentioned previously, it was found that the best tracking performance occurred for a moderate amount of steering movement. Tracking performance deteriorated as mean steering amplitude increased or decreased from this optimum point. Also tracking performance was significantly worse for alcohol at .06% B.A.C. than for the placebo. Assuming a carry-over of effects from a driving simulator to the road, it is possible that under the placebo condition in this experiment mean steering amplitude was at that optimum, intermediate, point and that tracking performance was better than under the drug conditions where steering amplitude was larger or smaller than under the placebo condition. However a measure of tracking performance would be needed to verify this.

Peak Frequency

Generally drivers show a peak frequency of between 0.1 and 0.3Hz and sometimes a smaller peak in the region above .4Hz in the power spectral density function of steering wheel angle. (McLean and Hoffman, 1971.) The larger, low frequency peak is related to control of the car's heading angle and the small high frequency peak to control of a higher order quantity, heading rate. McLean and Hoffman found that peak frequency shifted to higher frequencies with increasing task difficulty. Because the resolution used in the calculation of the power spectra was so coarse (.08Hz), small shifts in the peak frequency were hidden. Consequently, a shift in the peak frequency was tested for by looking at the percentage of the low frequency area (<.4Hz) lying below .2Hz, the average peak frequency. The higher the percentage of the low frequency area (<.4Hz) in the region between 0 and .2Hz, the lower the peak frequency. The peak frequency of wheel angle under the alcohol condition was indicated by this method to be significantly lower than the peak frequency under the alcohol and marihuana condition (.05 level). Though no other significant differences were found, the trends were toward a lower peak frequency occurring for alcohol and diazepam, alcohol and diphenhydramine and alcohol alone than for the placebo, and for a lower peak frequency for alcohol and marihuana than for alcohol and diphenhydramine. (See Table 3 for a summary of significant differences and trends.) The means in order of increasing peak frequency are alcohol and diazepam, alcohol, alcohol and diphenhydramine, alcohol and marihuana and placebo. This finding is supported by work done by Mortimer (1974), in a simulator study where it was also found that drivers on alcohol alone reduced their peak frequency of steering movement. This Mortimer attributed to a change in the cue structure used by the drivers from predominant use of heading angle as a cue to the use of lateral error, a lower order cue than heading angle, which is correlated with lower frequency control movements. This change in cue structure resulted in increased tracking error.

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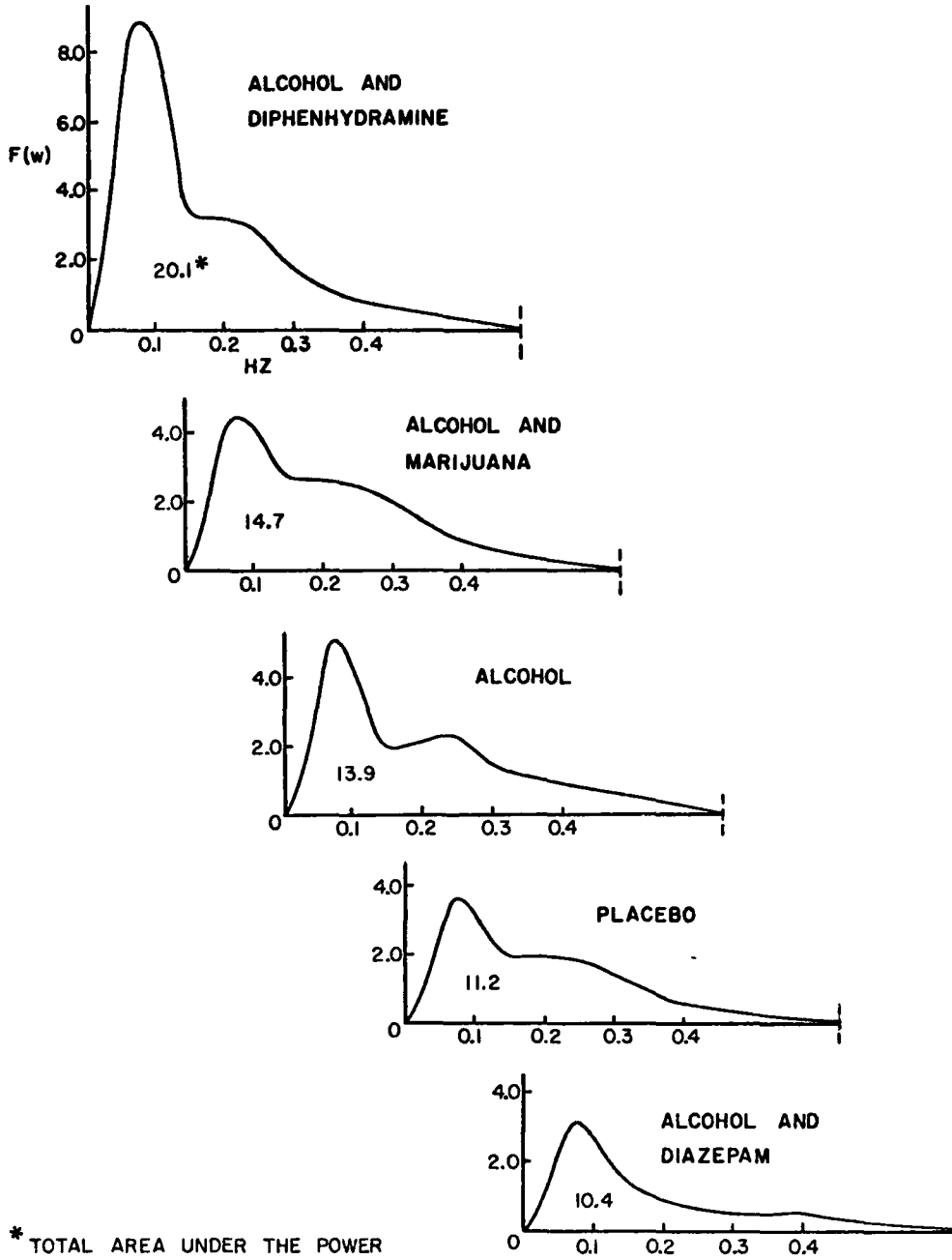

* TOTAL AREA UNDER THE POWER SPECTRAL DENSITY FUNCTION.

TYPICAL POWER SPECTRA OF STEERING WHEEL ANGLE

Figure 2

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TABLE 2

SUMMARY OF T-TESTS FOR DIFFERENCES IN TOTAL AREA UNDER THE POWER SPECTRA DENSITY FUNCTION BETWEEN DRUG CONDITIONS

MEANS IN DECREASING ORDER

Alcohol and Diphenhydramine	Alcohol and Marihuana	Alcohol	Placebo	Alcohol and Diazepam	Level of Significance
37.70			30.91		.10
	36.85			23.61	.05
		30.54		21.37	.10

TABLE 3

SUMMARY OF T-TESTS FOR DIFFERENCES IN % LOW FREQUENCY AREA BELOW .2Hz BETWEEN DRUG CONDITIONS

MEANS IN DECREASING ORDER

Alcohol and Diazepam	Alcohol	Alcohol and Diphenhydramine	Alcohol and Marihuana	Placebo	Level of Significance or number of cases in trend
54.0%	52.7%				5 out of 6
55.2%				48.7%	5 out of 6
	54.9%			47.6%	5 out of 6
		52.9%		46.0%	5 out of 7
	54.4%		48.5%		.05
		51.7%	48.0%		5 out of 7

Cone Scores

For each subject and condition a cone score was calculated in which both the speed through the cone area and the number of cones knocked over were considered. Unfortunately, half the measurements of speed through the cone area are missing due to computer failure in this region. Not enough data was available to make meaningful tests for significant differences. However, the observed trend was that the best scores occurred for the placebo condition and the worst for the alcohol and marihuana condition. Scores for the other three conditions fell between these two extremes.

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Stopping Accuracy

Stopping accuracy at the white line adjacent to the traffic signal was significantly (0.05 level) poorer under the alcohol condition than under the placebo condition. Although there were no other significant differences, definite trends existed towards improved stopping accuracy for the placebo condition as compared to the alcohol and diphenhydramine condition (6 out of 8 subjects) or for the alcohol and diazepam condition (5 out of 7 subjects). The effect that alcohol and marihuana had on stopping accuracy varied widely among the subjects. Two subjects made their best stop under this condition, another two made their worst stop under it. The conditions in order of decreasing mean stopping accuracy were: placebo, alcohol and diphenhydramine, alcohol and diazepam, alcohol and alcohol and marihuana.

Summary

The results of this experiment show that alcohol alone and in combination with other drugs affects driving performance in different ways. Measures which most clearly differentiated between drug conditions were steering movement and average velocity. Further research in this area will be needed before the manner in which driving behaviour is affected by a drug can be related to physiological action of that drug.

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