A SIMULATOR STUDY OF THE EFFECTS OF ALCOHOL AND MARIHUANA ON DRIVING BEHAVIOR

ANTHONY C. STEIN, Ph.D.

Systems Technology, Inc., 13766 S. Hawthorne Blvd., Hawthorne, CA 91352 USA

INTRODUCTION

Alcohol has repeatedly been identified as a leading cause of driving accidents (1). With increasing acceptance of marihuana (2), concurrent with the reductions of penalties for possession and use, there is legitimate concern for its possible effects (both alone and in combination with alcohol) on traffic safety.

Extensive research has been conducted on the effects of alcohol on both human behavior and driving capability; and Hurst (3) was able to establish dose response relationships between blood alcohol concentration and accident rate. The research that has been conducted with marihuana has been far less widespread. We are just beginning to understand its basic effects, and are far from establishing possible dose response relationships. While both drugs are used in combination quite often (4), even less is known about the possible combined effect.

A 1976 simulator study conducted by the author and his colleagues to determine the possible effects of these drugs on driving behavior (5) found alcohol to have a consistent and significant impairment effect, while marihuana had only an occasional effect. There was little evidence of interaction between the drugs. A more recent study (6) found no effect of either alcohol or marihuana on measures of driving performance or on a patrol officer's evaluation of driving performance. No effect was observed on driving performance when the drugs were combined, but an effect was noted on the patrol officer's evaluation variable. A Canadian study (7) found no consistent evidence that normal social levels of marihuana seriously affect driving performance; but observed some indication that the effects of marihuana and alcohol are additive when taken together.

EXPERIMENTAL METHODS

Experimental Approach

This experiment investigated the effects of 3 levels of marihuana (0, 100, and 200 mcg delta-9-THC) and 2 levels of alcohol (0, and 1.0 promil w/v), both alone and in combination, on driver behavior. Twelve subjects were tested in a driving simulator using a double-blind, full-placebo, counterbalanced design. Twice during each experimental day each subject drove a simulator scenario which presented a 15 minute sequence of driving tasks. The first drive was prior to any drug administration, and was used as a baseline for individual performance; the second drive was after alcohol ingestion and marihuana inhalation, and was timed to coincide with the peak effect of both drugs.

The driving simulator, described more fully in reference 8, consists of a cut-down car cab with interactive steering and speed control of a video projected two-lane roadway. An associated dynamic imagery slide projector introduces signs at a distance down the road and brings them closer to the driver as he progresses down the road. In addition to the roadway signs the subject was presented various driving tasks such as curves in the road; fixed obstacles requiring the driver to "thread" his way through (a double lane change task); unexpected obstacles requiring driver avoidance maneuvers; and a steering control task not unlike gusty winds.
A typical simulator drive involved a 10 to 12 mile drive during which various events were encountered. A digital computer presented these events at specified locations on the drive, so that event occurrence was proportional to car speed. The same computer gathered the task data which was used to determine the drug effects. Individual tasks are described below.

Steering Control With Divided Attention — Steering control of the vehicle is a psychomotor task involving both visual perception and motor control; both of which have been found to be sensitive to alcohol impairment (5 and 9) and marihuana impairment (5). This task was presented to the driver twice, and required the driver to compensate for random wind gusts while following a random winding road. On one of the presentations a divided attention task was added.

Isolated Curves — This event required the driver to control both speed and steering during the negotiation of a 90 degree curve. A decrease in speed was required in order to avoid loss of tire traction during the maneuver. Previous research has found this task sensitive to both alcohol (5 and 10) and marihuana impairment (5), and represents a situation which frequently leads to the single vehicle roadway departure category of accidents (11).

Obstacle Avoidance — Transient lane changes were induced by both anticipated and unexpected obstacles in the roadway. These events test the driver’s visual motor steering reaction time and his subsequent maneuver coordination.

Subjects and Methods

Twelve male volunteers were selected from a group of volunteers responding to advertisements. Subject selection was very stringent, and a complete discussion is found in reference 10. Briefly, the subjects were healthy males, age 21-65, licensed drivers, moderate-to-heavy drinkers, and current marihuana users.

Prior to the experiments all subjects were trained in the simulator. A reward-penalty structure was included to help induce “normal” driving behavior (12). Rewards were given for completing the scenario and for beating a reference time. Penalties were assessed for going slower than the reference time; for an incorrect sign response; and for getting speeding tickets or having an accident.

On experimental days a sober simulator trial was run first. Following this subjects were given 3 drinks at approximately 40 minute intervals, calibrated by body weight to achieve a maximum BAC of 1.0 promil (w/v) on drinking days, and 0.0 promil (w/v) on placebo days. Ten minutes after finishing the third drink the subject was administered a 1 g marihuana cigarette. A standard inhaling/exhaling procedure was used and was monitored by the experimenter.

Exactly one minute after the cigarette was finished venipuncture was performed and blood was drawn for delta-9-THC analysis. Following the blood draw the subject’s BAC was taken, and the subject was placed in the simulator for his peak run. After the simulator run was completed the subject’s BAC was again obtained, and exactly 1 hour after smoking a second blood sample was obtained.

RESULTS AND DISCUSSION

The results in this section are reported as a function of alcohol dose, and marihuana dose, and all results reported as statistically significant meet or exceed the p < 0.01 level. As discussed in the methods section, exacting procedures were used to draw blood samples for delta-9-THC concentration analyses. The results of these analyses were found to be 5 to 10 times greater than those observed in prior studies using similar dosages; and it was determined
that the only plausible explanation for the discrepancy lie in the Radio/Immuno Assay (RIA) kit supplied by the National Institute on Drug Abuse. Unfortunately, there was not enough plasma left to reanalyze the data base.

Overall Scenario Performance (Traffic Safety)

Accidents were recorded throughout the driving scenario. Analysis of variance procedures showed a strong alcohol/marihuana interaction on the number of accidents, as well as showing that alcohol had a negative effect on accidents. The marihuana effect was not significant.

There were no statistically significant effects of treatments on speeding tickets. The result is presented, however, because tickets are an important element in the payoff variable which is discussed later in this section.

Run completion times were significantly affected by marihuana while no statistically significant effects were observed for the alcohol or combined treatment. The results indicate a dose response relationship between run time and delta-9-THC dose; that is, as marihuana dose increases the subject drives slower. This finding is not unusual as this effect is a common anecdotal comment of marihuana smokers, as well as a frequent finding of past research. Because of the relatively small absolute speed difference (< 5 km/hr), however, these results may be of no practical significance.

The final overall performance measure is payoff. This measure combines the three previous measures in a weighted fashion providing a composite measure of traffic safety effects of alcohol, marihuana, and their combination. Both alcohol and the alcohol-marihuana combination have a statistically significant effect on this measure. Alcohol, in general, decreased driver payoff, and thus increased the traffic safety hazard. When combined with marihuana, a significant interaction effect is observed. The data indicate a partial reduction of the alcohol effects at the lower marihuana dose; however alcohol impairment is still evident. At the high marihuana dose observed impairment is CONSIDERABLY WORSE than either drug alone.

Driver Behavior During the Divided Attention Tracking Task

A strong marihuana effect was observed in the driver’s mean speed on the divided attention tracking task. A lack of statistical significance was observed for both alcohol, and the alcohol-marihuana combination. Speed variability also showed only a marihuana effect.

Driver steering behavior was adversely affected by alcohol, and a significant increase in lane position variability was seen. Lane position variability can best be described as "weaving"; since this behavior increases the likelihood of exceeding lane boundaries, the chance of accident involvement also increases.

For the divided attention task in the tracking run statistical significance was observed only for alcohol effects on mean reaction time and reaction time variability. The alcohol runs show increases in reaction time (slower response), and reaction time variability, over sober runs. No effects were observed for either marihuana or the alcohol-marihuana combination.

Isolated Curves

During the curve maneuver marihuana again caused a decrease in speed, while alcohol increased speed variability. These results were seen throughout the experiment. Lane position variability results proved inconclusive.
Obstacle Avoidance

The obstacle avoidance task involved both the double lane change task and the unexpected obstacle task. Once again, we find only marihuana having a significant effect on mean speed during the lane change task; and again marihuana causes drivers to go slower. Speed variability was fairly constant at baseline, while the typical alcohol effect (increased variability) was observed for the alcohol treatment condition. In this maneuver, however, there is also an additive effect of the drugs. That is, alcohol and marihuana in combination cause the speed variability to increase even more than either substance alone.

SUMMARY

In general we found that alcohol caused an increase in accidents, an increase in the driver's vehicle control variability, and an increase in reaction time. These results were consistent throughout the experimental tasks, and accounted for the majority of observed driver impairment. The alcohol results come as no surprise, as they are consistent with the results found in the extensive literature concerning alcohol effects on human performance.

The marihuana literature is nowhere near as complete, and thus direct comparisons are more difficult. The major result of marihuana on driving has been a decrease in speed, and this was our primary finding also. Sharma and Moskowitz (13) found that marihuana caused a decrease in a persons ability to perform divided attention tasks. Our findings provide minimal support for this. The only marihuana impairment we observed, other than the speed reduction, was during the divided attention tracking task. During this task we observed effects on both speed variability and uncorrelated steering activity.

While there is still very little research on marihuana alone, the prior research on the combined effects of alcohol and marihuana is almost non-existent. In the three prior studies referenced here (5, 6, and 7) little was found to indicate any impairment due to the combined effects. This project has come to the same basic conclusion, with one major exception. We found a combined effect that resulted in an increase in accidents. There is little to explain this finding in the intervening variables, but the fact that the major effect was found is an important result. While there is no way of knowing, it is possible that this result is due to the fact that the combined alcohol and marihuana levels used here were greater than in prior work. With the increasing potency of marihuana found on the street, this study should provide a needed "kick in the pants" for further investigation.

REFERENCES


