1. Cannabis and Driving Risk

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Evidence accumulates to suggest that the use of cannabis and other hallucinogens is increasing in North America. For the most part these drugs are not replacing the older, socially acceptable drugs such as alcohol and tranquillizers. Naturally, drug use of all types leads to an interest in the driving risks they might represent. Research in this area has been of several types: 1) laboratory, simulator and closed course studies of the impairing effects of various drugs and combinations: 2) surveys of the prevalence of drug use in driving populations: 3) studies of drug use among various persons involved in accidents: and 4) studies of accident rates among drug using or drug abusing populations. In general, research in these areas is far less adequately developed for cannabis than for alcohol. Some of the reasons involve the recency of interest in cannabis, the lack of easy methods for cannabis detection in body fluids, and the generally held view that drugs in total represent a less important factor in accidents than alcohol. The aims of this paper are: (1) To review research on cannabis each of the areas listed above; (2) To suggest what research remains to be done in assigning driving risk- and (3) To discuss the need for countermeasures related to cannabis use and driving. Previous reviews of drugs and driving problems (eg. Kibrick and Smart, 1970; Nichols, 1971) have tended to emphasize psychoactive drugs rather than hallucinogenic drugs but the present review attempts to consider only cannabis. Before examining the relevant laboratory and epidemiological work certain methodological problems need also be considered.

METHODOLOGICAL DIFFICULTIES IN ASSESSING CANNABIS EFFECTS ON DRIVING

There are several complicating factors in assessing the effects of drugs such as cannabis on driving. One is the question of drug interaction. A bewildering number of drugs interact with one another or with alcohol, consequently, assessing the effects of each possible combination is a difficult task. Research on some of these combinations has begun, but not all combinations have been tested. It is known that cannabis users are more often drinkers of alcohol than are non-users (Smart and Fejer, 1973) and that cannabis and alcohol are often used on the same occasion.

The interaction between alcohol and drug impairments may not be easily discovered. In some studies impairment appears greatest for naive cannabis users and least or even nonexistent for experienced users. Additive detrimental effects of alcohol and cannabis have been found for some complex tracking behaviours but not for simple ones where low doses of alcohol are used

(B.A.C. = 0.03 per cent). These additive effects could be important when it is realized that marijuana is often taken with alcohol. Low blood alcohol levels in drivers who have taken cannabis may suggest less behavioural or driving impairment than actually exists.
The combination of experience, multi-drug use and task complexity make clear generalization difficult.

Soehring and Wolters (1968) have reviewed the literature on relationships between blood (or urine) levels of drugs and driving performance. They state (in translation) that '(1) The ideal conditions prevailing in ethanol decomposition to carbon dioxide and water, distribution in an organ corresponding to water content in the tissues, etc., cannot be transferred to drugs- (2) In general, it appears that the 'blood level' cannot be regarded as a reliable criterion for the effect of different drugs...; (3) Many active drugs can only be separated with difficulty from their inactivated decomposed forms...; (4) Some drugs in therapeutic doses can be found in the urine many days after ingestion...; (5) Retrogressive calculation that can be done with ethanol cannot be done with most drugs, as their decomposition rates are affected with chronic use of certain drugs and by other factors.' Most of this applies to cannabis and in addition, there are also problems of achieving rapid body fluid analyses which will allow even a positive-negative judgment.

Certain facts about the metabolism and effects of cannabis make it difficult to study in relation to driving and accidents. Cannabis and its metabolites become widely distributed in many body tissues and fluids soon after ingestion. However, they do not appear in the lungs for long after smoking and hence breath tests on the alcohol model are impossible. It is also important to note that cannabis users may be able to 'come down' or decrease their behavioural impairment voluntarily; experimental demonstrations of this have been made (Cappell and Pliner, 1973). Cannabis may sometimes be detected in breath samples immediately after use. However, no easy breath or blood or urine testing method has been developed which would rival the alcohol testing methods in assessing accident drivers or victims. Methods for measuring metabolites (eg. King and Forney, 1967) will assess the remains of doses taken days or weeks prior when the major impairing effects have long disappeared. Sometimes skin swabs with alcohol or chloroform washings have been used (eg. Robinson, 1971), to retrieve cannabis samples from saliva. Fortunately, Stones and Stevens (1969) have demonstrated a method for retrieving cannabis from the fingers and the mouth of users. It is sensitive to exposure to marijuana within the past hour, however, it may mean only that the positive case has handled marijuana or been in a room where it was used.

This latter method has been used in a study of fatally injured accident drivers (Benjamin, 1972) however some difficulties with delayed analyses of skin swabs have been experienced with this method. As well, the method is not quantitative but qualitative in a vague manner. Clearly, the appearance of a reliable, trouble free method for relating recent cannabis use to THC or

metabolite levels in body fluids would greatly facilitate accident research. However its measurements should also relate to actual behavioural impairment.

A further difficulty with cannabis and driving studies is the selection of relevant laboratory or simulator methods for assessing driving skill and its detriments. Some studies with instrumented cars are able to depart somewhat from the artificiality of the laboratory situation in studying alcohol effects (eg. Huntley, 1973). However, many aspects of driving and careless driving are difficult to directly study for drug effects in a real way. Perhaps one example would be the high speed passing manoeuver which has been found to lead to so many fatal crashes. Reluctant to ride with drunk or doped drivers in real situations, researchers have turned naturally enough to psychomotor simulation or closed course studies of alcohol and cannabis impairments. This decision has its own problems. It is also the case that most laboratory, instrumented car and closed course studies of drug effects are made under ideal conditions. That is there is, no rain, snow or fog, the driver is not fatigued, the sessions are short and there is no threatening traffic.

A major difficulty is that one cannot be sure what simple or complex skills interact to produce what may be known as 'safe' or non-accident driving. Nearly all human behaviours may sometimes be involved in driving skills at one time or another including aspects of personality, social behaviour, and cognitive function, as well as the more obvious visual and psychomotor skills eg. vision, reaction time etc. In fact there seems to be no generally accepted set of necessary and unique driving behaviours; the tendency has been to assume from face validity that certain behaviours are involved in safe driving. Some anomalies are obvious in this area. For example, Fergenson (1971) found that drivers with high accident rates did more poorly on a choice reaction test than did non-accident drivers. However, those with high violation rates (and low accidents rates) had the fastest reaction times. The validity of 'simulators' is also in doubt. Edwards, Hahn, and Fleischman (1969) found almost no correspondence between simulator behaviour and actual driving. However Crancer (1968) found that simulator driving was related to 5 year accident records, with the best performers having fewer accidents. Unfortunately, behind the wheel tests such as those that are done in licensing examinations showed no relation to accident rates. These difficulties have led to a decision to see driving as does Moskowitz (1973) i.e. 'primarily a time-shared activity between a visual search and recognition task and a compensatory tracking task'.

Because of the difficulties of interpreting laboratory and simulator studies more emphasis in assessing driving risk and cannabis should be placed upon epidemiological studies of drivers and accident victims. Laboratory and simulator studies are perhaps most valuable for indicating possibly dangerous drugs and what behaviours they might most affect. How ever, real risk studies will most likely come from studies of accident involved populations compared to those not so involved.

EFFECTS OF CANNABIS ON PERSONALITY AND COGNITIVE FUNCTIONS

Theoretically, any number of personality or cognitive effects of cannabis could relate to driving risk. So little information exists about how such behaviours as aggression, risk taking, memory, intellectual performance and the like relate to driving that a complete review of this area is not attempted. The reader is directed to other reviews (eg. Le Dain, 1972) and to other sections of the symposium proceedings for this material. An idiosyncratic selection of relevant research may be of some interest.

In general, many inconsistent results have been found for the cognitive or intellectual effects of marijuana. The value of work on memory and intellectual functions for assessing driving risk is uncertain. However, many studies (eg. Le Dain, 1972; Clark, Hughes and Nakashima, 1970) plus subjective reports indicate a reduction in vigilance, attention and concentration. One of the major clinical effects of cannabis is a tranquillizing or calming one. Users sometimes report difficulties in concentrating or attending to intellectual tasks. In the Le Dain Commission's experiments 'sustained attention was assessed in a 40 minute visual signal detection task which was subjectively boring, and made precise demands on the-subject'. In this study cannabis 'consistently reduced accuracy' as might be expected from subjective reports and clinical studies. However, in a short, 5 minute, Continuous Performance Test Weil et al. (1968) found no effect of two doses of cannabis; it may be that sustained, boring attention tasks will be most affected by cannabis.

Personality studies are also difficult to relate to driving or accident rates. One generally accepted finding is that cannabis does not increase aggressiveness as has sometimes been found for alcohol. Most laboratory studies including those of the Le Dain Commission (1972) and the Addiction Research Foundations long term study (Miles et al, 1972) have found no increase in aggressive behaviour. Most studies (eg. Soueif, 1971; Goode, 1970) have also failed to find that cannabis users engage in aggressive criminal behaviour but that most of their crimes relate directly to drug use. Almost no interest has been taken concerning the effect of cannabis on risk taking but this might be particularly important in driving. Benjamin has stated (1972) that an unpublished study showed an increase in driving related risk after cannabis use, however the author has not seen this report.

Studies of the effects of cannabis on personality and cognitive variables can do no more than suggest that driving hazards do exist. In general, the available data suggest that cannabis would be most likely to cause accidents (if at all) by reducing attentiveness to traffic hazards and least likely by increasing aggressiveness, or speed. It may be that cannabis would contribute to running off the road accidents more than to those involving high speed or passing.

EFFECTS OF CANNABIS ON DRIVING-RELATED SKILLS

It is not easy to decide which of the many effects of cannabis are most relevant to driving skill or accident involvement. As stated above emphasis should probably be placed upon visual attention and recognition tasks, compensatory tracking and the more complex simulator and closed-course studies.

Numerous studies have been made of the effects of cannabis on vision. Allentuck and Bowman (1942) reported nystagmus after use of marijuana. However Caldwell et al. (1968) found no effect upon brightness thresholds at low doses. Effects upon depth perception seem to be small (Clark and Nakashima, 1968; Le Dain Commission, 1972). Sharma and Moskowitz (1972) have demonstrated a dose dependent effect of marijuana on visual autokinetic phenomena. The lights were seen to have complex paths and the authors concluded that 'The results imply that hazards are involved in operating vehicles (driving or flying, for example) at night when under the influence of marijuana'. This effect was also found in the Le Dain Commission studies (1972). A more important effect may be upon peripheral vision in a divided attention task. Moskowitz et al. (1972) found a substantial effect of two cannabis cigarettes on a task requiring fixation on a central task as well as vigilance for peripheral signals. This task would appear to have more relation to driving than simple visual acuity tasks. Some controversy surrounds the effects of cannabis on glare recovery. The original study by Frank et al. (1971) found a delay of several seconds in glare recovery under cannabis. However studies by the Le Dain Commission (1972) have apparently found no cannabis effect on glare recovery after moderate and large doses.

Cannabis effects on pursuit rotor and tracking skills are somewhat more consistent Weil et al. (1968) found a decrement in pursuit-rotor performance for 9 cannabis naive subjects but no decrement for 8 heavy users. A dose response relationship was found. Manno et al. (1970) also found dose-related impairment on a tracking task. As well, they tested alcohol and cannabis together and found a greater impairment than from either above. The Le Dain Commission tested 26 subjects on simple and complex tracking tasks with two doses of alcohol (0.03 and 0.07 per cent B.A.C.) and two doses of marijuana (1.6 and 6.8 mg Δ9-THC). Results were complex, however, alcohol and the higher cannabis dose produced impairment in both simple and complex tracking tasks. The drugs together produced higher impairments than either separately. These data generally suggest that driving impairments may be greatest amongst naive users and on occasions when alcohol has also been used. There is also a possibility that blood alcohol levels will underestimate the amount of behavioural impairment if cannabis has also been used. Therefore breath testing alone is liable to miss some impaired drivers. It might also be noted that at least one study (Soueif, 1971) found a suggestion of chronic psychomotor

impairments. Soueif found that prisoners in Egypt arrested for hashish (chiefly very heavy users) performed more poorly than did prisoners arrested on other charges. Long term effects of this type could however have a number of explanations and more chronic studies should be done.

Of great interest to those concerned with driving risk are the studies of cannabis and simulator or instrumented car performance. The first of these studies was done by Crancer et al. (1969) and it unfortunately has been taken in journalistic reports to indicate no cannabis impairment. Briefly, the authors attempted to determine the effect of a 'normal social high' on driving simulator performance. All 36 subjects were experienced users and drivers. Subjects smoked 2 marijuana cigarettes of approximately 0.09 per cent each but apparently Ti-IC content was not assessed (it was assumed to be about 22mg THC in total) or received the equivalent of 6 ounces of 86 proof liquor in 30 minutes. This was intended to achieve a B.A.C. of about 0.10 per cent at the time of testing. It was found that accelerator, brake, signal, steering and total errors under marijuana were not greater than under control conditions but that those for alcohol were much higher. Total speedometer errors under marijuana were higher than in the control condition.

Kalant (1969) and Rafaelson et al. (1973) have pointed out several problems with the Crancer et al. study. Kalant criticized the lack of a dose-response design and he has argued that the high alcohol dose should have achieved 0.13 per cent B.A.C. rather than 0.10 and was therefore not a 'normal social high'. Rafaelson et al. (1973) have argued that tests of the same batch of marijuana as used by Crancer have produced estimates of 3 to 8mg THC content not 22mg. If this were the case then the effects may have worn off by the time testing was done (30 to 60 minutes after smoking).

Rafaelson et al. (1973) also studied cannabis effects on a driving simulator. However, they used 'cannabis cakes' which were eaten. The rationale for oral administration was that it is a 'more reliable and reproducible method than smoking and that it reduces variations in dosage between subjects'. Eating of(annabis is rare in western countries and results in slower absorption and more extended effects, so the practical importance of Rafaelson's study is uncertain. He also used 70g of 96 - per cent ethanol which generated blood levels of about lg per litre or 0.10 per cent at testing. Both cannabis and alcohol increased the time required to brake (in response to red lights) and start. Alcohol increased and cannabis decreased the number of gear changes but neither affected speed.

A more interesting study of cannabis and driving was conducted by the Le Dain Commission (1972). They investigated two cannabis doses and a single alcohol dose (0.07 per cent B.A.C.)

in 16 regular users of both drugs. The high cannabis dose was similar to the regular 'high' of users and the 0.07 per cent level is that at which accident risk seems to exceed the sober level (Borkenstein et al., 1964). Subjects were tested under all conditions including non-alcoholic drinks and a 'placebo' cigarette. Testing was done on a 1.1 mile track and a driving course with poles and plastic cones. Tasks were lap driving, parking and manoeuvring. Subjects with the low cannabis dose did not make more manoeuvering errors than under placebo. However, the higher doses of both drugs produced more errors. Driving speeds were not affected, however, awkward or 'rough' handling occurred under both drug conditions.

The available data would appear to suggest that 'highness' under marijuana is liable to decrease sensory, motor and tracking performances associated with driving. The effects of 'sub-high' doses are probably smaller and not significant. Effects are probably greatest with naive users and when even small amounts of alcohol have been taken (0.03 B.A.C.). It should be noted here that a number of useful studies have not yet been done in this area. Subjects are almost always driving and drug-experienced, well-adjusted college students (or soldiers) in excellent health. Their performance may be more refractory to cannabis effects than that of young, driving and drug naive high school students perhaps having their first cannabis and liquor on the same occasion. It is also the case that simulator and instrumented car studies have not been done in dense traffic situations, at high speeds or under fatigue conditions. It could be argued that laboratory trials are established to find simple and large drug effects and not drug-situation interactions which may be rare but fatal in real driving situations.

CANNABIS USE AMONG DRIVERS, ACCIDENT DRIVERS AND VICTIMS

Anecdotal reports of cannabis use among drivers and accident drivers are not difficult to assemble. However epidemiological studies of cannabis use in accident drivers or victims are scarce.

Many reports have been made of driving under cannabis. McGlothlin et al. (1970) in their study of 247 persons who had also used LSD found one case of accident attributed to a cannabis 'flashback'. Hollister (1971) asked 'high' subjects in his experimental studies whether they could drive in the 'high' condition, but none said they could. However, Klein et al. (1971) reported that two experienced marijuana smokers drove through Miami while 'stoned' on marijuana. Many reports collected by the Le Dain Commission in Canada show that about 50 per cent of cannabis users sometimes drive after cannabis but nearly the same number refuse to drive until a 'high' is well past. Certainly sufficient cannabis users do drive while high, to expect some cannabis-related accidents.

Studies of how much and how confidently cannabis users drive have not been very frequent. However, this problem was studied incidentally by Haines and Green (1970). They studied marijuana use among 131 heavy and moderate cannabis users, almost all of whom (94 per cent) used marijuana at least once a week. Of this number 81 stated that they drove while high on marijuana. Most of those who did not were recent users. Of the 81, 63 said they drove frequently while high and 67 said they drive as well or better than when 'straight'. Some mentioned that their concentration was improved, fewer distractions were found and reactions were improved.

Another study by Klein, Davis and Blackbourne (1971) enquired about marijuana and driving among some 571 college students. It is not stated what proportion drove while high and the focus was on subjective effects on driving skills. More users found effects on time judgement than on any other skill. However, reaction time, speed estimation, distance perception and emergency handling capability were all said to be impaired. Generally, 2 to 3 times as many infrequent users as frequent users said that these skills were impaired.

It is unfortunate that so few studies have been made of cannabis use among accident drivers or victims. The only study found so far has been reported by Berg et al. (1971) but it has a number of important limitations. Berg et al. studied drug use among accident victims seen in a university health service and comparable groups of students seen for non-accidental illnesses and for routine physical examinations. The experimental sample was small (n=24) and it is unlikely that marijuana use would often be detected in so few people. In any case no difference in reported drug use was found and no case of cannabis use was chemically detected in the experimental group. However results were based on blood analyses rather than the more sensitive swab methods suitable for cannabis detection. Laboratory tests were done for all commonly used psychoactive drugs including cannabis.

Benjamin (1972) has described a large scale study financed by the National Highway Traffic Safety Administration which attempted to determine the incidence of cannabis use among fatally injured drivers. A skin swab method was used which has a lower reliability for analyses done some time after collection. It appears that since swab samples were mailed to a single centre for analysis there was a considerable delay and consequent unreliability in the data collected. Results from this study have apparently not been reported. Presently, there is almost no knowledge of how many drivers, accident drivers or victims have recently been under the influence of cannabis. A study of a large sample of accidents where drivers and/or victims were asked to report recent cannabis use and allow skin swabs, would reduce our ignorance considerably. This, of course, should include a comparable group of controls not involved in accidents, eg. passing the scene of a prior accident.

INVOLVEMENT OF CANNABIS USERS IN ACCIDENTS

Although cannabis use in accident drivers has rarely been studied the accident and violation rates of cannabis users have excited more interest and at least 6 studies are available.

Somewhat contradictory results have been found concerning the involvement of marijuana users in accidents. One of the first and best studies in this series was reported by Waller (1965). For this study records of 231 drivers convicted for illegal possession or use of 'addicting drugs were searched. There were cases under review by the California Dept. of Motor Vehicles for possible license suspension. The sample probably contained
many heroin and marijuana users and few users of prescription drugs. Drug users had only the expected accident rate per mile driven but 1.8 times the violation rate. In a later paper Waller (1971) noted that the high violation
rates of drug users commonly preceded their use of drugs, thereby suggesting that drug use could not have caused the excessive violations. Waller and Goo (1969) studied the type of accident for the drug user groups from 1965. They showed that the accidents and violations of drug users were similar to those of younger drivers in general and not peculiar to drug users. They found that drug users (as were persons of their age) were more often at fault and involved in more crashes due to excessive speed, weaving, and being on the wrong side of the road.

Similar results to Waller's were found by McGlothlin, Arnold and Rowan (1970) in a study of adult marijuana users who volunteered for LSD. They did not have elevated accident experiences when high. Similarly, Haines and
Green (1970) studied moderate to heavy users: none of the marijuana users who drove when Ilign reported accidents when 'stoned'.

A study by Moser et al. (1971) of some 1889 arrestees for serious crimes also investigated accident and violation rates for drug users of various types. In this study hashish and marijuana users appeared not to differ in accident or violation rate from non-drug users. However, exposure for miles driven was not controlled in this study.

Klein et al. (1971) found that marijuana users (especially heavy users) admitted more violations and license revocations than non-users but is not known whether the driving errors occurred while 'high'. They found that 18 per cent of infrequent users and 53 per cent of heavy users had been stopped by police while under the influence of marijuana. However being 'high' may not be the reason they were stopped. This finding is of some interest in that frequent users were more

confident of their abilities under marijuana, but managed to attract much more police attention than did infrequent users. Excessive driving confidence under marijuana may be worth some investigation. -

Klein et al. also presented sufficient case history material relating marijuana use to accidents to suggest the need for further research. However, accident rates were not presented in terms of miles driven, nor were there comparable accident or violation data for non-users.

Somewhat different results for accident rates have been found by Crancer and Quiring (1968). They studied 160 marijuana users drivers known to the Seattle Police Dept. The marijuana users had accident rates 39.2 per cent and violation rates 180.4 per cent higher than a comparable sample of non-users in Washington. Unfortunately, no control for exposure in terms of miles driven was performed.

A study of high school students in Virginia (Ferguson and Howard, 1971) reported that 2.93 per cent of students admitted involvement in an accident as driver or victim in which marijuana 'may have been a cause'. This would appear to suggest considerable driving risk but without more complete knowledge about the contribution of marijuana it is impossible to interpret.

Although interesting and suggestive, these studies do not provide unambiguous information about the role of drugs in accident causation. The frequency of accidents and driving offences after marijuana use is - still not known for any group. Drug users are typically also alcohol users and assigning their accident experience to the effects of a particular drug is often difficult to do. There is no indication of how many accidents or violations occur per unit of exposure, eg. number of 'stoned' or intoxicated occasions. Lastly, no study has looked in detail at accident rates both before and after drug use began, consequently, drug use may be only tangentially related to high accident involvement. At present strong evidence that marijuana users have higher accident rates than non-users does not exist. Most studies have used small, rather limited samples (eg. illegal users known to the police) and studies of larger or more varied groups are needed before clear statement could be made.

A paper by Smart (1974) reported a survey of 293 college students which attempted to answer the following questions:
1. How often do students drive after marijuana use?
2. How often do students drive after having used both alcohol and marijuana?
3. How frequent are driving charges and accidents after marijuana use?

4. How frequent are driving charges and accidents after alcohol use?
5. What is the relative risk potential of marijuana and alcohol in relation to driving?

About 42 per cent of college student drivers in Smart's study reported marijuana use but only 61 per cent of those reported driving soon after that use. For
most users the number of occasions was small, much smaller than the number of occasions for drinking and driving. Very few students reported that their accidents or moving violations involved prior marijuana use. Far more (3
times as many) reported violations or accidents after alcohol use. However, the frequency of marijuana-driving occasions in the past year was reported to be about 30 per cent of the frequency of alcohol-driving occasions.

The results do suggest, however, that for this population, marijuana use contributes to very few accidents and charges. It probably contributes at most to only about one-third of those for alcohol. However, marijuana and driving occasions are much less numerous than alcohol and driving occasions. Problems arise when actual contribution of each drug state to accidents has to be assessed. On some marijuana and driving occasions users were also under the influence of alcohol and perhaps this was also true at the time of their accidents. There is no guarantee that for the respondents the levels of impairment after alcohol and marijuana were similar on the average. A further problem is that measures of exposure could involve comparisons of miles driven when 'marijuana influenced' and when 'alcohol intoxicated'. Smart's study did not inquire about this comparison but it would be worth doing so later. The data do suggest, however, the need to study the infrequency of marijuana-related accidents in relation to the low level of actual exposure. If driving occasions after marijuana use were increased, as a result of legalization or increased popularity, it may not turn out to be safer than driving after alcohol use.

Conclusions

The following tentative conclusions can be supported about cannabis and driving risk:
1. Methodological problems concerning both easy cannabis testing and laboratory analysis of the driving task have hindered the development of knowledge in this area.
2. The effects of cannabis on cognitive functions suggest that major decrements in attention may occur in driving situations, particularly if it is a long or boring journey.
3. Cannabis effects on personality and attention suggest that cannabis related accidents may more often be rear-enders or running-off-the-road than high speed passing accidents.
4. Laboratory studies of vision indicate a major cannabis effect on peripheral vision or divided visual scanning tasks and less effect on depth perception, glare recovery, or visual acuity. This is a major concern since these scanning tasks together with tracking seem most important in

driving.
5. Compensatory tracking tasks are impaired by 'high' dose levels of cannabis, particularly for naive users and where even small amounts of alcohol are also given.
6. Simulator and instrumented car performance decrements occur for braking and starting but effects on speed seem minor. Some studies have shown a lowering of speed after cannabis.
7. Numerous artificialities exist in the typical laboratory or simulator study which mitigate against too much confidence in the results as applied to actual driving.
8. At least half of cannabis users sometimes drive after cannabis use. Driving after cannabis use is more frequent among frequent users.
9. Absolutely nothing is known of the extent or recent (within an hour?), cannabis use among accident drivers, victims or pedestrians.
10. Some samples of cannabis users would appear to have higher violation rates than do non-users.
11. It is uncertain whether cannabis users have higher accident rates (per unit of exposure) than do non-users. The importance of social and personality factors exclusive of drug use have not been assessed.
12. It would appear that marijuana on its own contributes to very few accidents or charges among college students as most such occasions also involve prior alcohol use.
13. Part of the apparently low frequency of marijuana accidents may be due to the infrequency of marijuana and driving occasions.
14. Countermeasures against cannabis and driving are probably not needed at this time. Impaired driving after cannabis use is illegal in Many western countries at present under general 'drugs and driving' legislation. Without an easy roadside testing device a credible countermeasure is not likely to be developed.

SUGGESTIONS FOR FURTHER RESEARCH

These suggestions are almost limitless but a few seem particularly important:
1. Developmental research on reliable roadside cannabis testers whose results correlate with impairment will be needed for many driving studies.
2. It would be of interest to study the type of accident occurring under cannabis effects - somewhat fewer high speed passing accidents would be expected for instance.
3. A large sample study should be made of cannabis swabs from a variety of accident victims including drivers, passengers, pedestrians and non-accident drivers. Some assessment of driving errors would also be needed in this study.
4. Interview studies of large groups of young people would be useful in assessing the frequency of driving-marijuana risk and the frequency of accidents.
5. Simulator and closed course studies of less experienced drivers under various conditions and drug combinations (especially with higher alcohol levels) would be of interest.
6. It would be of interest to see some studies of cannabis and driving risk in traditional cannabis using countries, eg. Jamaica, India, North Africa. There are suggestions of rather different effects of cannabis in different countries and most driving related studies have been done in

Western countries.
7. Much cannabis research is concerned with decrements in performance. It would be of interest to overcome this bias in some driving research, perhaps on the facilitating effects of cannabis-induced anxiety reduction. It should be possible to look for beneficial cannabis and driving effects on some drivers under some circumstances.

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DISCUSSION

RESEARCH TOOLS

Dr Edwards suggested that the reason why the epidemological approach paid off in the Grand Rapids studies of drinking and driving was that they related level of dose to likelihood of accident. 'The fact that you could get beyond saying that people who had had alcohol were more likely to have an accident was very important, since the average drinker may in important respects be different from the non-drinker, and this personality difference may itself bear on accident proneness. The important finding in the alcohol studies was that the level of blood alcohol was related to the chance of an accident. But I can't see how this can be met in the forseeable future in the case of cannabis, because we lack a test of levels of cannabis in the body.'

Much discussion centred on the likelihood of development of a roadside test for cannabis. Professor Paton reported that work in Oxford had established that in small animals, the levels of THC and its first metabolites were similar in the brain and in the blood. Because the vapour pressure of cannabis is so low, a test for cannabis would have to involve body fluid in distinction to the breath test for alcohol. Dr Miller pointed out that saliva could not form the basis of a test, since saliva would be directly affected by cannabis smoke. Dr Tinklenberg reported that body swabs and nasal swabs did not at present provide reliable evidence of recent use, let alone providing a test of levels in the body. Professor Paton thought that with the use of gas liquid chromatography, mass spectrometry and other specialised techniques, a test might be developed in a year or two for use in research laboratories but that it might well be ten years before a roadside test was available. It was agreed that a test would have to use biological fluids and there was some discussion about the difficulties of gaining driver's consent to blood tests. Dr Cahal suggested that if an appropriate reagent could be developed, then a spin assay technique would require only microlitres, or a pinprick. He agreed that a roadside test might be

available in ten years.

Dr Smart pointed out that 'blood alcohol tests were available for a very long time before breath alcohol tests and they contributed almost nothing to accidents tests, simply because they were blood tests'.

This experimental work may be more useful than roadside testing of drivers in determining the relationship between amount of cannabis consumed and accident proneness.

TYPES OF ACCIDENT

There was agreement that accidents in which cannabis was involved were characteristically low speed shunts and cross-road accidents, associated with lapses of attention, rather than being high speed passing accidents, as are some alcohol accidents. There is some experimental evidence that drivers drive slightly more slowly (one study found a 7 per cent lowering of speed) under the influence of cannabis. Also, cannabis users themselves state that they tend to drive more slowly when stoned. Dr Miller noted the question of speedometer errors and wondered whether illegality itself would make users more careful.

Dr Somekh pointed out that some investigators had found a direct relation between level of dose of cannabis and ability to detect peripheral stimuli. This has been shown to be due to central processes, that is, a funnelling of attention rather than a tunnelling of vision. The importance of these findings, Somekh said, 'is that deficits may be more clearly shown in those tasks where processing capacity is being used up to its maximum.'

Smart pointed out that driving is not a very difficult task for most of the time. 'Most drivers have an enormous spare capacity for most of the time. Where you need your spare capacity is where someone comes out of a side street.' He also suggested that the cannabis user seems to be 'tuning in and out: he sees a lot of the stimuli, and doesn't see others.'

OTHER DRUGS

Dr Tinklinberg reported that in California there is an increase in accidents in seasons when there is a high pollen count, when many people are using antihistamines. Not only the antihistamines, but also their interactions with other drugs may be involved. He also reported that in the prison study conducted by the Stanford group, 'We have asked a question about driving under the influence of cannabis, and found that in this deviant group, most said that they did drive under the influence of cannabis. Most said they have had accidents, mostly under alcohol and barbiturates rather than under cannabis alone. But it is difficult to extrapolate from prison to other populations.'

GENERAL

Studies of different geographical areas at different times when the availability of cannabis differed would also be helpful. Epidemiological studies of motor vehicles in relation to bumps, scratches, etc might also furnish helpful data.

Editorial footnote

The World Health Organisation convened a meeting - of Experts in Geneva late 1973 on the subject of the detection of drugs in biological fluids. This report is shortly to be published, and includes consideration of cannabis.