

**An Evaluation of the Efficiency of Sobriety Testing to Detect
Blood Levels of Cannabis and Impaired Driving Ability**

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Declaration

I declare that this thesis does not incorporate without written acknowledgement any material previously submitted for a degree in any University, College or Advanced Education, or other educational institution; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

I further declare that the ethical principles and procedures specified in the Swinburne University of Technology Human Research Ethics' document on human research and experimentation have been adhered to in the presentation of this thesis.

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List of Abbreviations

SFSTs	Standardised Field Sobriety Tests
HGN	Horizontal Gaze Nystagmus
W AT	Walk and Turn
OLS	One Leg Stand
RB	Romberg Balance
FTN	Finger to Nose
LSP	Lack of Smooth Pursuit of the Eyes
NMax	Nystagmus at Maximum Deviation
N45	Nystagmus at 45 degrees
VGN	Vertical Gaze Nystagmus
BS	Body Swaying
HM	Head Movements
HJ	Head Jerks
HMJ	Head Moves and/or Jerks
NB	No Balance During the Instruction Stage
STS	Starts Too Soon
SW	Stops Walking During the Test
MHT	Misses Heel to Toe While Walking the Straight Line
SOL	Steps Off the Line
AB	Arms Used to Maintain Balance
IT	Improper Turn
S	Swaying
H	Hopping
FD	Foot Down
FNT	Feet Not Together
ANBS	Arms Not By Side
HNT	Head Not Tilted as Demonstrated
EO	Eyes Open
ANE	Arms Not Fully Extended
ANSH	Arms Not Shoulder Height
IFN	Index Finger Not Pointed

ANR	Arms Not Returned to Original Position
MTN	Misses Tip of Nose

Abstract

Road fatalities related to marijuana intoxication have steadily increased over the last 10 years (Drummer, 1994; Drummer, 1998; Drummer & Gerostamoulos, 1999). This has led to the introduction of sobriety testing in Victoria, Australia to test for driving impairment caused by marijuana and other psychotropic drugs. Surveys have reported an increase in community concern in Australia over the use of marijuana and an increase in the prevalence and use of marijuana (National Campaign Against Drug Abuse Survey; 1985, 1988, 1991, 1993; National Drug Household Survey; 1995, 1998). Commensurate with the increase in the use of marijuana in society, road statistics indicated that the number of road accidents and deaths involving the presence of THC (the active ingredient in marijuana) in driver specimens has also increased (Drummer & Gerostamoulos, 1999). Consistent with these mortality statistics, past research examining the effects of THC on driving ability indicate that THC impairs both car control (Moskowitz, 1985), and the maintenance of the lateral position of a vehicle (Ramaekers et al., 2000). Intoxication by THC is more likely to result in the crashing into obstacles on a driving course than when not intoxicated (Hansteen et al., 1976).

These findings indicate that marijuana impairs driving ability and since the prevalence of marijuana use is increasing this poses a significant risk on our roads. It is essential therefore, that a tool that detects levels of THC in drivers, similar to breath analysis instruments used for the detection of alcohol in drivers, is introduced. To date, there is no such reliable instrument, that could be used on the roadside, and that accurately measures the level of THC in humans. For this reason, some government departments have considered the use of sobriety tests to detect impaired driving. In particular, the Standardised Field Sobriety test (SFSTs) that comprises the Horizontal Gaze Nystagmus test (HGN), Walk and Turn test (WAT) and the One Leg Stand test (OLS) were implemented in Victoria, Australia from December 1st 2000. The validity of these tests have been previously examined by other researchers and their conclusions suggest that sobriety tests have a varied accuracy in detecting impairment caused by drugs, ranging from 44% to 94% (Heishman et al., 1996; Compton, 1986). The present study examines the efficiency of sobriety tests to detect impairment in driving caused by marijuana. The SFSTs were examined, as well as the Romberg Balance test (RB) and

the Finger to Nose test (FTN) taken from the Drug Evaluation and Classification Program (DECP) (Los Angeles Police Department, USA).

The present study was conducted by Swinburne University, Victoria, Australia. The National Institute on Drug Abuse in the USA (NIDA) provided the marijuana cigarettes. The major objectives of the study were to examine the influence of cannabis on driving performance and on performance on the sobriety tests. The relationship between simulated driving performance and sobriety test performance was then examined to establish the accuracy of sobriety tests to predict driving ability. The present study also examined whether any differences in performance either on the driving tests or on the sobriety tests exist between regular cannabis users and non-regular cannabis users. Driving stress was an additional variable assessed to establish whether individuals with low, normal or high driver stress perform differently on the driving task after the consumption of a low and high dose of cannabis.

We tested 40 participants comprising 14 females and 26 males. All participants completed a medical examination questionnaire, demographics questionnaire, Frequency of Cannabis Use Questionnaire and Intoxication Rating Questionnaire. All participants completed 3 marijuana sessions involving the administration of a placebo cigarette (0% THC, weight 702mg, .000gm Δ -9-THC; 0.0mg/kg THC), the administration of a low THC cigarette (1.74% THC, weight 779mg, .813gm Δ -9-THC; 0.2mg/kg THC) and the administration of a high THC marijuana cigarette (2.93% THC, weight 790mg, 1.776gm Δ -9-THC; 0.73mg/kg THC). All sessions were randomised (using Latin-square design), counter-balanced and double-blind. In each session, participants completed 3 sobriety tests and 2 driving simulator tests. Sobriety tests were scored by allocating a score of 1 for each sign (error, e.g., hopping during test performance to maintain balance) observed by the administrator. Generally, a score of 2 or more constituted impairment to a degree equivalent to a blood alcohol concentration (BAC) above 0.10%. The driving simulator test comprised 36 variables. Each time the participant performed an error, a loading factor was added to the corresponding variable (e.g., collision (variable) loading factor is 10, if a collision occurred twice a score of 20 was allocated to this variable). The sum of all 36 variables constituted the level of overall driving impairment. Blood samples were taken throughout each session approximately 20 minutes apart.

Intoxication Rating Questionnaires revealed that participants reported that the subjective effect of placebo cigarettes was much weaker than the cigarettes that they usually smoke and that no psychological (such as time distortion) and physiological (such as increased heart rate) changes were experienced. For the low THC cigarettes most participants described the strength, and the effects, as similar to cannabis that they usually smoke. The high THC cigarette was described by most participants as being much stronger, and having some different symptoms, when compared to cannabis that they usually smoked. There were however, some differences in the description of the low THC and the high THC cannabis cigarettes between regular and non-regular cannabis users. Regular users reported that the high THC cigarette was more similar to the cannabis that they usually smoke, whereas non-regular users stated that this was more likely to be the case for the low THC cigarette.

Results from the driving simulator task revealed that THC impaired the driving variables: 'straddling the solid line' and 'straddling the barrier line'. The results indicated that increasing levels of THC increasingly impaired the ability to maintain the steady position of a vehicle within the correct traffic lane. The consumption of low and high doses of THC resulted in two or more wheels of the vehicle moving over a solid line marked out for traffic moving in the opposite direction. Low and high doses of THC also resulted in two or more wheels of the vehicle moving over a broken/barrier line marked out for traffic moving in the same direction. Increasing levels of THC appear to impair both balance and attention required to control the position of a vehicle in traffic. These results are consistent with past research that indicates that THC impairs car control (Moskowitz, 1985) and increases the standard deviation of the lateral position of a vehicle (Smiley et al., 1981; Ramaekers et al., 2000). Research into the effects of THC on brain cannabinoid receptors indicate that THC interferes with normal functioning of the cerebellum, the brain region responsible for balance, posture, and the coordination of movement (Childers & Breivogel, 1998). When driving ability was impaired the level of THC in the blood was between 3 and 5 ng/ml. These findings are consistent with previous research that has reported that driving is maximally impaired by THC plasma levels of 13 ng/ml (approximately 8ng/ml in blood, using a multiplication factor of 1.6 (Giroud, et al., 2001) (Berghaus et al., 1995).

The results of the present study also indicated that THC impairs performance on sobriety tests with more individuals impaired with increasing levels of THC (e.g., at Time 1; placebo: 2.5%, low THC: 23.1%, and high THC: 46.2%). Performances on the sobriety tests RB and FTN were unrelated to the level of THC. The test most related to the level of THC was the OLS test, where almost all signs of this test were observed, after the consumption of both low and high THC cigarettes. The accuracy of a 'new' sign in the scoring procedure of the HGN test: head moves/jerks (HMJ) was also identified. Including HMJ increased the percentage of individuals scored as impaired after the consumption of low and high THC cigarettes (e.g., at Time 1; placebo: 2.5%, low THC: 38.5% and high THC: 56.4%). Including HMJ as a sign significantly improved the accuracy of the SFSTs to detect impairment associated with the level of THC. The mean level of THC in the blood, when the highest number of participants were classified as impaired, was 70 ng/ml.

Differences in performance were observed between regular cannabis users and non-regular cannabis users. Non-regular cannabis users were more impaired on the driving simulator task after the consumption of low and high levels of THC when compared to regular users. Non-regular users recorded significantly longer RTs to emergency situations, more collisions, and shorter distances between the vehicle and an object (after an emergency stop) when compared to regular cannabis users. Signs exhibited during sobriety test performance were related to the level of THC more often for non-regular users compared to regular users. The level of THC in the blood was higher in regular users, compared to non-regular users, at all times in both THC conditions.

When driving ability was impaired and significantly related to the level of THC, the SFSTs were also related to level of THC. Sobriety test performance was related to driving impairment, because, as driving impairment increased with the level of THC, so did the number of signs present during the performance of the sobriety tests. Since non-regular users performed more poorly on the driving task compared to regular users, it is no surprise that they exhibited a larger number of signs during the sobriety testing.

Although there was a positive linear relationship between driving ability and sobriety tests, such as the relationship between straddling barrier lines and the OLS test, the validity of sobriety tests to predict driving impairment in part depends upon the size of

this relationship. Using performance on the SFSTs to assess “impairment”, 46.7% of individuals in the high THC condition were impaired. A discriminant analysis was performed to determine whether the remaining 53.3% of participants were also impaired but not classified as impaired, or whether the SFSTs correctly classified them as not impaired. The results indicated that the sobriety tests (SFSTs; HGN, WAT and OLS) correctly assessed 76.3% of participants in the high THC condition as either impaired on driving or not impaired on driving. Specifically, this percentage included the correct identification of 84% of impaired drivers as impaired, but only 61.5% of unimpaired drivers as unimpaired. The best predictor of driving impairment was the OLS test. In the low THC condition the sobriety tests correctly classified 100% of impaired drivers as impaired, but this occurred at the expense of falsely classifying most unimpaired drivers as also impaired. This finding suggests that sobriety tests detect the presence of THC even when driving is not impaired.

Examining the utility of including the ‘new’ sign HMJ in the SFSTs indicated that when identifying impairment on the driving task performed at Time 2, in both the low and high THC condition, the SFSTs were a better predictor of driving impairment when HMJ was included than when the sign was not included. This finding suggests that the inclusion of HMJ in SFSTs scoring procedure increases the likelihood of detecting drivers who are impaired by THC.

In conclusion, the results suggest that THC impairs driving ability by reducing one’s ability to maintain a safe position in traffic. At this time THC blood levels are between 3 and 5 ng/ml. THC also impairs driving ability differently for non-regular and regular users of cannabis, where non-regular users are more impaired by THC than regular users. When this occurs, THC blood levels in non-regular users are between 2 and 12 ng/ml, and in regular users between 5 and 16 ng/ml. Performance on the sobriety tests is also impaired by increasing levels of THC. The OLS test is the most sensitive test in detecting the presence of THC. In the present study the SFST battery and each individual test that it comprises are moderate predictors of driving impairment but do misclassify 16% of impaired individuals and 38.5% of not impaired individuals. In addition, the results suggest that sobriety tests are more sensitive to the presence of THC than actual driving impairment. This was revealed by the large number of individuals judged as impaired on driving in the low and high THC conditions even

when driving was unaffected. It is important to note that when this occurred, the sobriety tests were accurate in detecting 100% of impaired individuals. Finally, the introduction of the ‘new’ sign HMJ is likely to increase the accuracy of the SFSTs to detect individuals impaired by THC and this sign should be considered for inclusion by policing agencies.

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Chapter One: Introduction

This chapter outlines the main aims and hypotheses of the project. An overview of the method is also reported. A literature review of previous research in the area are discussed in later section of this thesis.

1.1 Project aims

The aim of the project was to examine the accuracy of sobriety tests to detect impairment caused by cannabis consumption. This was achieved by examining the;

- effects of cannabis consumption on sobriety test performance
- effects of cannabis consumption on driving ability
- relationship between sobriety test performance and driving performance
- differences between the effects of cannabis on performance between regular and non-regular cannabis users
- relationship between the level of THC (the active ingredient in cannabis) in blood and performance on sobriety tests and a driving task

1.2 Hypotheses

Based on previous research a number of hypotheses were generated regarding the relationship between cannabis consumption, driving ability and sobriety test performance.

1.2.1 Cannabis